From: Wright, Dana K
To: Bohn, Cynthia
Cc: Chen, Linus Y; Niemi, Katie
Subject: Re: high priority - please review CBRA options paper
Date: Friday, October 18, 2019 10:02:51 AM
Attachments: USFWS_Signed_Memo_3April 1998.pdf
USACE_Signed__Jan_26_1998.pdf
USFWS_Signed_Jan_9_1998.pdf
USFWS_Signed_April_2_1998.pdf
USFWS_Signed_Sept 2006.pdf
Importance: High

HQ's records on this (at least the digital records) pretty much end with the Corps' 1999 position paper. The only thing we have after that is a 2006 cover sheet that shows the FO transmitting the position paper to HQ with a short note. I've also attached some letters we have that pre-date the 1999 paper. I have a hard copy file at the office that I can look at next Tuesday, but I doubt that it will have anything additional.

I agree that I don't think DOI changed its position. I do recall seeing a FWS SC field office letter from the early 1990's (92 or 93?) that indicated that sand mining could be done within the CBRS, but I think a similar request for another project that followed that letter for prompted someone to request the DOI review that resulted in the 1994 SOL opinion. To my knowledge, we haven't issued any consultations that contradict the 1994 opinion since its issuance.

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Fri, Oct 18, 2019 at 9:56 AM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

> Linus, I'll check this afternoon (b) (6) [redacted]. If you need it sooner, Dana may have something. c
>
> Cynthia Bohn
> Regional Coastal Program Coordinator
> Coastal Barrier Resources Act Regional Coordinator
> USFWS
> 1875 Century Blvd, Room 200
> Atlanta, GA 30345
> Phone: 404-679-7122
> Fax: 404-679-7081
> cynthia_bohn@fws.gov
>
> Learn more about the Coastal Barrier Resources Act

On Fri, Oct 18, 2019 at 9:48 AM Chen, Linus <linus.chen@sol.doi.gov> wrote:

Hi Cindy,

Thanks for sharing this. To my knowledge, this is the first time I've seen this. b5-ACP [redacted] I don't think DOI changed their position on this previously to 1994, but rather clarified it after 1994 (but I could be wrong). I'll try to take another look in my files to see if there's anything that addresses this ACOE position paper. In the meantime, do you have anything in your files that responds to this position paper in case there are questions from Van Drews or the Secretary that raise these position paper points?

Linus

On Thu, Oct 17, 2019 at 11:34 AM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

Hi Katie, I agree this looks great.

As another point: On option one, the discussion of the Corps other choices, one could always mention that the Wilmington Corps decided in 1999 that they disagreed with our legal interpretation and decided to continue the NC projects that we had determined were inconsistent with CBRA (one of these being the Carolina Beach Project which now needs to be reauthorized.) This may be too much information for this memo, but I believe it is something that is important to the conversation, the Corps has a precedent of "overriding" the Service's CBRA consultation recommendation and has continued to implement projects for the last 20 years. I've attached the Corps 1999 Position Paper.

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Wed, Oct 16, 2019 at 10:38 PM Schrading, Eric <eric_schrading@fws.gov> wrote:

Katie,

Sorry to review this late. Two proposed changes...but I did not do this on the google doc.

1. Remove "to argue" -2nd sentence last paragraph on page three (repeated twice).

2. Capitalize or don't capitalize "Section" throughout paper...both are used (consistency).

Otherwise looks great!!!!!

On Wed, Oct 16, 2019 at 1:31 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Hi Folks,
> We recently learned that Secretary Bernhardt is meeting with Rep. Van Drew (NJ-2) next Monday. Gary Frazer asked that we prepare an options paper on the CBRA sand mining issue for Margaret. Please see the GoogleDocs file and offer any revisions in "Suggesting" mode. I told Gary we'd have the options paper to him by today so any feedback you can provide this afternoon would be appreciated. Sorry for the short turn-around time.
>
> https://drive.google.com/file/d/1G_wAC-gJAFHhZ1famNc84Mv4CZTdo0kR/view?usp=sharing
>
> Thanks!
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071

--
Eric Schrading, CWB
Field Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Suite 4
Galloway, New Jersey 08205-4465
P: (609) 382-5272
Cell: (609) 576-3400
Fax: (609) 646-0352

Follow us on Facebook: https://www.facebook.com/USFWSNewJerseyFieldOffice

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

In Reply Refer To:
FWS/R4/AES/RANC

April 3, 1998

Memorandum

To: Geographic Assistant Regional Director, Area II, Atlanta, GA

From: Field Supervisor, FWS, Raleigh, NC

Re: Elevating a CBRA Consistency Disagreement for Resolution

Attached for your review is my April 2, 1998 letter to Colonel Youngbluth regarding conflicting interpretations of the CBRA. The Wilmington District recently consulted with this office regarding the consistency of a proposed action with the Coastal Barrier Resources Act (CBRA). Based on a careful reading of the proposal, the law and legislative history, a verbal Solicitor's Opinion, previous consultations in this Region (dating back to 1983), and statements included in the Congressional Record during the introduction of this bill, we concluded that the proposed action was not consistent with the CBRA.

The Wilmington District disagreed with our interpretation, and has commenced work. We believe the issues are global in nature and should be elevated beyond the Field Office/District level. Two issues must be addressed: (1) the consistency of removing material from a System unit for use outside the unit, and (2) the source of terminology used during consistency determinations (i.e., the District relies on the "navigation" exception because the action is partially authorized and funded as a navigation project. However, mobilization, demobilization, the critical funding, and borrow area selection and scope are specifically linked to beach renourishment for a coastal city outside the System; further the authorized dimensions of the navigation channel are significantly less than the proposed borrow sites dimensions.

The first issue was, in our opinion, resolved at the Assistant Secretary level several years ago. However, the District now contends that because the Corps never responded affirmatively (or at all, for that matter), the issue was one of "agreeing to disagree." They do not believe the written determination from the Assistant Secretary has standing. Therefore, we recommend the Regional Director seek a third party to arbitrate this issue.

The CBRA provides the Office of Budget and Management (OMB) an oversight role for all Federal actions in System units. In our opinion, this agency would be the ideal arbitrator for this issue. The CBRA is intended to minimize the loss of human life, wasteful expenditures of Federal revenues, and damage to fish, wildlife, and other natural resources associated with coastal barriers. Section 7 of the CBRA provides that "The Director of the Office of Management and Budget shall... make written certification that each agency has complied with the provisions of this Act [CBRA]." Therefore, we believe that the OMB has a mandate to determine the consistency of Federal actions with the CBRA if there is a disagreement between the Service and any Federal action agency.

Thank you for the opportunity to bring this matter to your attention. We look forward to working with the Region as you pursue this issue with the South Atlantic Division.

FWS/R4:KMoody:KM:04/02/98:919/856-4520 ext. 19:\fondry2.wpd

cc:
FWS, Brian Cole

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

January 9, 1998

Colonel Terry R. Youngbluth
District Engineer, Wilmington District
U.S. Army Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Attention: Hugh Hiene

Dear Colonel Youngbluth:

The U.S. Fish and Wildlife Service (Service) has reviewed the proposed Environmental Assessment, Finding of No Significant Impact (EA/FONSI) for the proposed sand mining operation in Masonboro Inlet, New Hanover County, North Carolina. Jetties constructed by the U.S. Army Corps of Engineers (Corps) inhibit longshore sediment transport, which is predominantly southwards, from Wrightsville Beach, across the inlet, and to Masonboro Island. A significant sand deficit has severely restricted the plan and profile of the beach on Masonboro Island. The proposed sand source is in Coastal Barrier Resources System (CBRS) unit L09; material is to be placed on the oceanfront beaches of Masonboro Island (on the CBRS unit) and Wrightsville Beach (not in the CBRS unit). The activities are planned to last well into June, 1998.

This is the report of the Service pursuant to and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.; ESA) and the Coastal Barrier Resources Act of 1982 as amended by the Coastal Barrier Improvement Act of 1990 (CBRA).

In our opinion, the proposed activities are detrimental to aquatic resources of National significance, and inconsistent with the CBRA. We do not concur with the FONSI, and recommend immediately implementing procedures which will correct the failed sand bypassing scheme. The Corps should hire and empower a panel of experts to determine the factors that are causing Masonboro Island to erode at a rate that exceeds the replacement schedule and sand allocation scheme, what trust resources have been lost, and what corrective actions can be taken.

The proposed activities include the reasonable and prudent nesting sea turtles[1] and sea beach

[1] loggerhead, *Caretta caretta*, and green, *Chelonia mydas*, sea turtles

amaranth[2] protection measures developed with slightly different perceptions of the scope of the proposed activities (the Service's, May 19, 1997, Biological Opinion was based on the channel realignment proposal). Incidental take of Federally-protected nesting sea turtles was authorized on the condition the identified reasonable and prudent measures be observed. However, the plan to conduct beach disturbing activities well into June will have significant adverse impacts to the beach strand habitat and ecosystem.

Further, the proposed activities are, in essence, sand mining. The sand bypassing program associated with the jetties at Masonboro Inlet has been ineffective at maintaining the island's biogeochemical integrity. In our opinion, the sand mining can not legitimately be considered a CBRA exception under § 6(a)(2) "Navigation." Finally, the practice of removing material from within CBRS units, and placing it in non-CBRS units, is inconsistent with the purposes of the CBRA. Dr. John H. Zirschky, Acting Assistant Secretary for Civil Works, and Major General Stanley G. Genega, Directorate of Public Works, were separately informed of this opinion (General Genega was asked to clarify the issue for the Corp's Divisions and Districts) in letters dated June 12, 1995 and June 2, 1994, respectively (enclosure No. 1).

SAND BYPASSING

The sand bypassing program at the Masonboro Inlet jetties has been ineffective. Littoral processes, particularly longshore transport, generally moves sand southward in this system (an estimated 60 to 70 percent of the annual gross drift is southward). The Corps has developed varying estimates of sediment budgets for the area (e.g., the 1978 Evaluation Report, and a 1983 Feasibility Report). Our records show that since 1980, sand bypassing has been irregular and disproportionate. The relative gross drift has been artificially reversed with no justification. Table No. 1 clarifies this concern.

Table 1

17 year (1980 to 1997) Total Volume of Sand in cubic yards					
Target Beach	1978 Report	1983 Report	Actually Bypassed	% of natural budget	% of artificial budget;
Wrightsville Beach	2,635,000	2,210,000	2,400,000 in 1986, 1991, and 1995	30 - 40	53
Masonboro Island	3,128,000	2,125,000	2,100,000 in 1986 and 1995	60 - 70	47

---

[2] Sea beach amaranth, *Amaranthus pumilus*

There are further concerns. One rationale for the south jetty was that it would reduce the northwards longshore currents and sediment movement which was supposedly causing shoaling south of the north jetty and in the navigation channel. Again, our review of the data indicates that shoaling has not decreased, that dredging cycles, emergency dredging, and the implementation of a channel "widener" scheme in Masonboro Inlet is no different than those same factors in inlets with no jetties.

COASTAL BARRIER RESOURCES ACT
In our opinion, the proposed activities can not be considered a CBRA § 6(a)(2) exception ("maintenance or construction of improvements of existing federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties))." The proposed activities are sand mining to mitigate for the failed sand by-pass system and to enhance the beach plan and profile at Wrightsville Beach.

There is, however, precedent for using sediments from a CBRS unit to stabilize the shoreline in the same CBRS unit (see enclosure No. 1). Such an activity could be consistent with the CBRA under § 6(a)(6)(G) exceptions: "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilizing system."

ENDANGERED SPECIES ACT
Planning to work well into June is not consistent with obligations to minimize incidental take of Federally-listed sea turtles. It is contrary to the first conservation measure identified in the May 19, 1997 letter (p. 31): "Construction activities... should be planned to take place outside the main part of the sea turtle nesting and hatching season," and to the first condition listed in the May 30, 1997 coastal zone consistency letter from Roger Schecter of the Division of Coastal Management (p. 1): "Sand must be placed on the beach between November 30 and April 30 to avoid impacts on sea turtles during the nesting season."

We reiterate our opinion that the District Engineer is complying with the letter of the law, but not it's spirit. The ESA was intended to protect habitats and communities on which threatened and endangered species rely. Listed species were meant to be "miner's canaries" or red flags of ecosystem distress. Monitoring the beach for sea turtle nests and relocating eggs does not protect the myriad other components of the beach strand ecosystem (e.g., fish, shellfish, birds, and plants).

The ESA requires the District Engineer to provide the same level of protection for birds covered under the Migratory Bird Treaty Act as Federally-listed threatened and endangered species. A significant number of migratory waterfowl, migratory shorebirds, and colonial nesting waterbirds will be affected by the proposed activities. Beach strand dependent migratory birds will suffer reduced forage, loafing, and/or nesting grounds until the beach ecosystem recovers, which may take from months to years following replenishment.

CONCLUSIONS
The Service regrets that the failure of the sand bypassing program at Masonboro Inlet has created the current situation. We could concur with an EA/FONSI if the following recommendations were adapted:

- The Corps should use this budget and equipment availability as an opportunity to stabilize the disappearing shoreline of Masonboro Island (which is consistent with the CBRA and obligatory per previous agreements). This limited work should be accomplished prior to the sea turtle nesting season, avoiding the ESA concerns.

- In recognition that the sand-bypassing program has not been successful, the District Engineer should convene an emergency meeting of interested experts, review the problems, and find a more effective resolution. This should be done within the next few months so that any research needed can be initiated this summer and so that we can have an improved sand-bypassing scheme or jetty removal proposal in place by next fiscal year.

The inconsistency of the proposed activities with the CBRA § 6(a)(2) exception for navigation is, in our opinion, not so easily resolved.

We appreciate the opportunity to comment on this matter. Please call Kevin Moody of my staff at (919) 856-4520 extension 19.

Sincerely,

John M. Hefner
Field Supervisor

enclosure (1)

cc:
DCM, Raleigh, NC (John Parker)
DCM, Wilmington, NC (Bob Stroud)
DCM, Morehead City, NC (Charles Jones)
DMF, Wilmington, NC (Fritz Rohde)
DWQ, Raleigh, NC (John Dorney)
WRC, Raleigh, NC (Frank McBride)
WRC, Kinston, NC (Bennett Wynne)
WRC, Marshallberg, NC (Ruth Boettcher)
EPA, Wetlands Regulatory Branch, Atlanta, GA (Thomas Wellborn)
EPA, Office of Environmental Assessment, Atlanta, GA (Heinz J. Mueller)

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

April 2, 1998

Colonel Terry R. Youngbluth
District Engineer, Wilmington District
U.S. Army Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Attention: Brooke Lamson

Dear Colonel Youngbluth:

The U.S. Fish and Wildlife Service (Service) has received your January 26, 1998, letter regarding the proposed "Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina." The Service interprets the proposed activities to be inconsistent with the Coastal Barrier Resources Act (CBRA). Because the Wilmington District (District) has concluded that it does not concur with this position, and because of the significant implications of this dispute between our two agencies, we recommend that the disputed issues be elevated for consideration and resolution.

There appear to be two issues for consideration. First, the District has determined that the "navigation portions" of the project meet the exception at 16 U.S.C. § 3505(a)(2). Second, the District believes that the remainder of the proposed project, the "Shore and Hurricane Wave Protection project" is allowable under 16 U.S.C. § 3505(a)(6)(G). As we have indicated previously, the Service disagrees with both assumptions.

With regard to the first issue, the Service does not concur with the District's claim that the proposed project is associated with the "maintenance of existing channel improvements" such that it would be exempt under § 3505(a)(2) of CBRA. Indeed, this assertion belies the District's own language in the Environmental Assessment and Finding of No Significant Impact, Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina (EA/FONSI), dated December 1997. The District states that the December 1997 EA/FONSI is intended to amend the "previously coordinated" EA/FONSI regarding channel realignment and maintenance dredging for Masonboro Inlet. Prior to the December 1997 amendment, the project was characterized as merely moving the channel's centerline northward to

ease the sharp turn that boaters were required to make, and to reduce the erosive currents that appear to be undermining the south jetty. However, the December 1997 EA/FONSI augmented that proposal to encompass expansion and deepening of "the existing borrow area in Masonboro Inlet" for the purpose of obtaining the additional 1,185,000 cubic yards of sand necessary to satisfy the current renourishment needs for Wrightsville Beach and sand bypassing to Masonboro Island. Of the estimated 1.41 million cubic yards of sand needed for the project, only 0.12 million cubic yards will be dredged during the channel realignment phase. The bulk of the material must be dredged from the expanded borrow site. Thus, clearly, the primary scope of the amended project is beach nourishment.

This is further emphasized by the alternatives section of the December 1997 EA/FONSI, which states that opting for the "no-action alternative" would "result in a shortfall of about 670,000 cubic yards of sand for the current renourishment needs of Wrightsville Beach and Masonboro Island." This statement does not reflect that there would be any consequence to the navigation channel or existing channel improvements should this alternative be pursued. Likewise, the second alternative, captioned "Alternative Borrow Areas," focuses on the lack of feasibility of using alternative sources of beach quality sand. Thus, by the District's own terms, the expansion and deepening of the inlet encompassed in the proposed project is not for the purposes of maintaining or improving the existing channel, but to expand the source of beach quality material needed for renourishment. For this reason, the "navigation exception"to CBRA at § 3505(a)(2) is inapplicable to this project.

Furthermore, because the U.S. Army Corps of Engineers (Corps) is undertaking this project to recover sand for beach renourishment, rather than to maintain or improve the existing navigation channel, the Corps may not rely on § 3505(a)(2) to authorize disposal of the dredged materials within the Coastal Barrier Resources System (System). Section 3505(a)(2) allows dredged materials "related to such maintenance or construction" to be disposed within the System. However, because the dredged materials are being mined for renourishment, rather than for channel maintenance, use of the "navigation exception" to authorize disposal of the dredged materials in the System is misplaced.

On the other hand, the Corps may rely upon the "shoreline stabilization" exception at § 3505(a)(6)(G) to justify placement of sand on beaches within the System under certain circumstances. However, the Service does not concur with the District's assertion that the exception also authorizes the proposed renourishment of Wrightsville Beach utilizing sand obtained from within the System. The boundary of System Unit L09 was modified in 1995 to reflect minor and technical changes in the unit's size and location; this office received the revised maps reflecting that change in late summer 1997. Based on those revised maps, it is apparent that almost the entire expanded borrow site is within the System. In correspondence dating back

several years, the Secretary of the Interior has consistently construed the § 3505(a)(6)(G) exception to apply only to projects to stabilize the shoreline of a unit of the System; it does not apply to projects to stabilize shorelines outside the system.

As a general matter, the exceptions to the funding limitations in CBRA apply to projects "within the Coastal Barrier Resources System," not to projects outside the System (16 U.S.C. § 3505(a)). Moreover, the "shoreline stabilization" exception must be considered within the context of the CBRA legislative history which demonstrates that Congress considered Federally-financed shoreline projects wasteful Federal expenditures which have had significant negative effects on fragile coastal barriers, while at the same time encouraging development of those areas. See, for example, *"Statements on Introduced Bills and Joint Resolutions: A Bill to Protect and Conserve Fish and Wildlife Resources, and for Other Purposes," S. 1018, Before Senate Committee on Environment and Public Works*, 97th Congress, 1st Session (1981; Statement of Senator Chafee); H.R. Rep. No. 841, Part 1, 97th congress, 2d Session 7-11 (1982). Because the entire impetus behind CBRA was to place limits on Federal subsidization of activities that negatively impact the natural resources of the designated coastal barrier units, the "shoreline stabilization" exception must be narrowly construed, applying only to projects to stabilize beaches within the System.

Furthermore, the types of projects described in the exceptions enumerated in § 3505(a)(6) are permissible only if the proposed project is "consistent with the purposes of this chapter," 16 U.S.C. § 3505(a)(6), which include minimizing wasteful Federal expenditures and damage to fish, wildlife, and other natural resources associated with coastal barriers by restricting Federal expenditures that have the effect of encouraging development of coastal barriers. Thus, even if the "shoreline stabilization" exception did apply to projects to renourish beaches outside the System, the project would have to be undertaken in furtherance of the purposes of CBRA. It is difficult to imagine how beach nourishment outside the System that does not benefit the beaches within the System could be consistent with these CBRA purposes.

The facts of this situation compel a conclusion that the proposed project is inconsistent with the purposes of CBRA. Here, the borrow area is located almost completely within the System, and the jetties constructed by the Corps inhibit longshore sediment transport across the inlet to Masonboro Island, which is also within the System. A significant sand deficit has severely restricted the plan and profile of the beach on Masonboro Island. The emphasis of the proposed project is being placed on renourishing Wrightsville Beach, while stabilization of "sand-starved" Masonboro Island is being neglected. Clearly, even if the Service construed the "shoreline stabilization" exception as applying to projects to renourish beaches outside the System, these aspects of the District's proposal demonstrate that the exception would be inapplicable because the project is inconsistent with the purposes of CBRA.

We appreciate your consideration of our request to elevate this matter beyond our offices to the next level within our respective organizations. The compelling nature of these issues and their potential impact on future consultations between our agencies merits this action. Please call Kevin Moody of my staff at (919) 856-4520 extension 19 if you have any questions or comments.

Sincerely,

John M. Hefner
Field Supervisor

cc:
DCM, Raleigh, NC (Steve Benton)

bc:
USDOI, SOL, Atlanta, GA (Margaret Fondry)
FWS, Charleston, SC (Ed EuDaly)
FWS, Washington, DC (Steve Glomb)
FWS, Alanta, GA (Ronnie Haynes)

FWS/R4:MFondry:KMoody:KM/04/01/98:919/856-4520 extension 19:\fondry.wpd

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

9-18-06

Rachel,

As we discussed today, I am sending you our files on the Masonboro Inlet dredging Project of the late 1990's. The controversy prompted the Wilmington Corps to issue a legal "Position Paper" in September 1999. Our only copy is the fax of 1-10-00 which I have enclosed.

Howard

Howard F. Hall
U. S. Fish and Wildlife Service
Ecological Services
P. O. Box 33726
Raleigh, North Carolina 27636-3726

Ph: 919-856-4520, ext. 27
Fax: 919-856-4556
e-mail: howard_hall@fws.gov

From:	Bohn, Cynthia
To:	Chen, Linus Y
Cc:	Niemi, Katie; Wright, Dana K
Subject:	Re: high priority - please review CBRA options paper
Date:	Friday, October 18, 2019 10:04:35 AM
Attachments:	USACE_Signed_Jan 1998.pdf USFWS_Signed_2April 1998.pdf USFWS_Signed_Jan1998.pdf
Importance:	High

Linus, here is the communications that led up to their positions paper if it helps. I'll keep looking for anything we have in response.

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Fri, Oct 18, 2019 at 9:48 AM Chen, Linus <linus.chen@sol.doi.gov> wrote:

> Hi Cindy,
>
> Thanks for sharing this. To my knowledge, this is the first time I've seen this. b5-ACP [redacted] I don't think DOI changed their position on this previously to 1994, but rather clarified it after 1994 (but I could be wrong). I'll try to take another look in my files to see if there's anything that addresses this ACOE position paper. In the meantime, do you have anything in your files that responds to this position paper in case there are questions from Van Drews or the Secretary that raise these position paper points?
>
> Linus
>
> On Thu, Oct 17, 2019 at 11:34 AM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:
>
>> Hi Katie, I agree this looks great.
>>
>> As another point: On option one, the discussion of the Corps other choices, one could always mention that the Wilmington Corps decided in 1999 that they disagreed with our legal interpretation and decided to continue the NC projects that we had determined were inconsistent with CBRA (one of these being the Carolina Beach Project which now needs to be reauthorized.) This may be too much information for this memo, but I believe it is something that is important to the conversation, the Corps has a precedent of "overriding"

the Service's CBRA consultation recommendation and has continued to implement projects for the last 20 years. I've attached the Corps 1999 Position Paper.

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Wed, Oct 16, 2019 at 10:38 PM Schrading, Eric <eric_schrading@fws.gov> wrote:

Katie,

Sorry to review this late. Two proposed changes...but I did not do this on the google doc.

1. Remove "to argue" -2nd sentence last paragraph on page three (repeated twice).

2. Capitalize or don't capitalize "Section" throughout paper...both are used (consistency).

Otherwise looks great!!!!!

On Wed, Oct 16, 2019 at 1:31 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

Hi Folks,
We recently learned that Secretary Bernhardt is meeting with Rep. Van Drew (NJ-2) next Monday. Gary Frazer asked that we prepare an options paper on the CBRA sand mining issue for Margaret. Please see the GoogleDocs file and offer any revisions in "Suggesting" mode. I told Gary we'd have the options paper to him by today so any feedback you can provide this afternoon would be appreciated. Sorry for the short turn-around time.

https://drive.google.com/file/d/1G_wAC-gJAFHhZ1famNc84Mv4CZTdo0kR/view?usp=sharing

Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service

Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

--

Eric Schrading, CWB
Field Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Suite 4
Galloway, New Jersey 08205-4465
P: (609) 382-5272
Cell: (609) 576-3400
Fax: (609) 646-0352

Follow us on Facebook: https://www.facebook.com/USFWSNewJerseyFieldOffice

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

April 2, 1998

Colonel Terry R. Youngbluth
District Engineer, Wilmington District
U.S. Army Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Attention: Brooke Lamson

Dear Colonel Youngbluth:

The U.S. Fish and Wildlife Service (Service) has received your January 26, 1998, letter regarding the proposed "Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina." The Service interprets the proposed activities to be inconsistent with the Coastal Barrier Resources Act (CBRA). Because the Wilmington District (District) has concluded that it does not concur with this position, and because of the significant implications of this dispute between our two agencies, we recommend that the disputed issues be elevated for consideration and resolution.

There appear to be two issues for consideration. First, the District has determined that the "navigation portions" of the project meet the exception at 16 U.S.C. § 3505(a)(2). Second, the District believes that the remainder of the proposed project, the "Shore and Hurricane Wave Protection project" is allowable under 16 U.S.C. § 3505(a)(6)(G). As we have indicated previously, the Service disagrees with both assumptions.

With regard to the first issue, the Service does not concur with the District's claim that the proposed project is associated with the "maintenance of existing channel improvements" such that it would be exempt under § 3505(a)(2) of CBRA. Indeed, this assertion belies the District's own language in the Environmental Assessment and Finding of No Significant Impact, Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina (EA/FONSI), dated December 1997. The District states that the December 1997 EA/FONSI is intended to amend the "previously coordinated" EA/FONSI regarding channel realignment and maintenance dredging for Masonboro Inlet. Prior to the December 1997 amendment, the project was characterized as merely moving the channel's centerline northward to

ease the sharp turn that boaters were required to make, and to reduce the erosive currents that appear to be undermining the south jetty. However, the December 1997 EA/FONSI augmented that proposal to encompass expansion and deepening of "the existing borrow area in Masonboro Inlet" for the purpose of obtaining the additional 1,185,000 cubic yards of sand necessary to satisfy the current renourishment needs for Wrightsville Beach and sand bypassing to Masonboro Island. Of the estimated 1.41 million cubic yards of sand needed for the project, only 0.12 million cubic yards will be dredged during the channel realignment phase. The bulk of the material must be dredged from the expanded borrow site. Thus, clearly, the primary scope of the amended project is beach nourishment.

This is further emphasized by the alternatives section of the December 1997 EA/FONSI, which states that opting for the "no-action alternative" would "result in a shortfall of about 670,000 cubic yards of sand for the current renourishment needs of Wrightsville Beach and Masonboro Island." This statement does not reflect that there would be any consequence to the navigation channel or existing channel improvements should this alternative be pursued. Likewise, the second alternative, captioned "Alternative Borrow Areas," focuses on the lack of feasibility of using alternative sources of beach quality sand. Thus, by the District's own terms, the expansion and deepening of the inlet encompassed in the proposed project is not for the purposes of maintaining or improving the existing channel, but to expand the source of beach quality material needed for renourishment. For this reason, the "navigation exception"to CBRA at § 3505(a)(2) is inapplicable to this project.

Furthermore, because the U.S. Army Corps of Engineers (Corps) is undertaking this project to recover sand for beach renourishment, rather than to maintain or improve the existing navigation channel, the Corps may not rely on § 3505(a)(2) to authorize disposal of the dredged materials within the Coastal Barrier Resources System (System). Section 3505(a)(2) allows dredged materials "related to such maintenance or construction" to be disposed within the System. However, because the dredged materials are being mined for renourishment, rather than for channel maintenance, use of the "navigation exception" to authorize disposal of the dredged materials in the System is misplaced.

On the other hand, the Corps may rely upon the "shoreline stabilization" exception at § 3505(a)(6)(G) to justify placement of sand on beaches within the System under certain circumstances. However, the Service does not concur with the District's assertion that the exception also authorizes the proposed renourishment of Wrightsville Beach utilizing sand obtained from within the System. The boundary of System Unit L09 was modified in 1995 to reflect minor and technical changes in the unit's size and location; this office received the revised maps reflecting that change in late summer 1997. Based on those revised maps, it is apparent that almost the entire expanded borrow site is within the System. In correspondence dating back

several years, the Secretary of the Interior has consistently construed the § 3505(a)(6)(G) exception to apply only to projects to stabilize the shoreline of a unit of the System; it does not apply to projects to stabilize shorelines outside the system.

As a general matter, the exceptions to the funding limitations in CBRA apply to projects "within the Coastal Barrier Resources System," not to projects outside the System (16 U.S.C. § 3505(a)). Moreover, the "shoreline stabilization" exception must be considered within the context of the CBRA legislative history which demonstrates that Congress considered Federally-financed shoreline projects wasteful Federal expenditures which have had significant negative effects on fragile coastal barriers, while at the same time encouraging development of those areas. See, for example, *"Statements on Introduced Bills and Joint Resolutions: A Bill to Protect and Conserve Fish and Wildlife Resources, and for Other Purposes," S. 1018, Before Senate Committee on Environment and Public Works*, 97th Congress, 1st Session (1981; Statement of Senator Chafee); H.R. Rep. No. 841, Part 1, 97th congress, 2d Session 7-11 (1982). Because the entire impetus behind CBRA was to place limits on Federal subsidization of activities that negatively impact the natural resources of the designated coastal barrier units, the "shoreline stabilization" exception must be narrowly construed, applying only to projects to stabilize beaches within the System.

Furthermore, the types of projects described in the exceptions enumerated in § 3505(a)(6) are permissible only if the proposed project is "consistent with the purposes of this chapter," 16 U.S.C. § 3505(a)(6), which include minimizing wasteful Federal expenditures and damage to fish, wildlife, and other natural resources associated with coastal barriers by restricting Federal expenditures that have the effect of encouraging development of coastal barriers. Thus, even if the "shoreline stabilization" exception did apply to projects to renourish beaches outside the System, the project would have to be undertaken in furtherance of the purposes of CBRA. It is difficult to imagine how beach nourishment outside the System that does not benefit the beaches within the System could be consistent with these CBRA purposes.

The facts of this situation compel a conclusion that the proposed project is inconsistent with the purposes of CBRA. Here, the borrow area is located almost completely within the System, and the jetties constructed by the Corps inhibit longshore sediment transport across the inlet to Masonboro Island, which is also within the System. A significant sand deficit has severely restricted the plan and profile of the beach on Masonboro Island. The emphasis of the proposed project is being placed on renourishing Wrightsville Beach, while stabilization of "sand-starved" Masonboro Island is being neglected. Clearly, even if the Service construed the "shoreline stabilization" exception as applying to projects to renourish beaches outside the System, these aspects of the District's proposal demonstrate that the exception would be inapplicable because the project is inconsistent with the purposes of CBRA.

We appreciate your consideration of our request to elevate this matter beyond our offices to the next level within our respective organizations. The compelling nature of these issues and their potential impact on future consultations between our agencies merits this action. Please call Kevin Moody of my staff at (919) 856-4520 extension 19 if you have any questions or comments.

Sincerely,

John M. Hefner
Field Supervisor

cc:
DCM, Raleigh, NC (Steve Benton)

bc:
USDOI, SOL, Atlanta, GA (Margaret Fondry)
FWS, Charleston, SC (Ed EuDaly)
FWS, Washington, DC (Steve Glomb)
FWS, Alanta, GA (Ronnie Haynes)

FWS/R4:MFondry:KMoody:KM/04/01/98:919/856-4520 extension 19:\fondry.wpd

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

January 9, 1998

Colonel Terry R. Youngbluth
District Engineer, Wilmington District
U.S. Army Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Attention: Hugh Hiene

Dear Colonel Youngbluth:

The U.S. Fish and Wildlife Service (Service) has reviewed the proposed Environmental Assessment, Finding of No Significant Impact (EA/FONSI) for the proposed sand mining operation in Masonboro Inlet, New Hanover County, North Carolina. Jetties constructed by the U.S. Army Corps of Engineers (Corps) inhibit longshore sediment transport, which is predominantly southwards, from Wrightsville Beach, across the inlet, and to Masonboro Island. A significant sand deficit has severely restricted the plan and profile of the beach on Masonboro Island. The proposed sand source is in Coastal Barrier Resources System (CBRS) unit L09; material is to be placed on the oceanfront beaches of Masonboro Island (on the CBRS unit) and Wrightsville Beach (not in the CBRS unit). The activities are planned to last well into June, 1998.

This is the report of the Service pursuant to and in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.; ESA) and the Coastal Barrier Resources Act of 1982 as amended by the Coastal Barrier Improvement Act of 1990 (CBRA).

In our opinion, the proposed activities are detrimental to aquatic resources of National significance, and inconsistent with the CBRA. We do not concur with the FONSI, and recommend immediately implementing procedures which will correct the failed sand bypassing scheme. The Corps should hire and empower a panel of experts to determine the factors that are causing Masonboro Island to erode at a rate that exceeds the replacement schedule and sand allocation scheme, what trust resources have been lost, and what corrective actions can be taken.

The proposed activities include the reasonable and prudent nesting sea turtles[1] and sea beach

---

[1] loggerhead, *Caretta caretta*, and green, *Chelonia mydas*, sea turtles

amaranth[2] protection measures developed with slightly different perceptions of the scope of the proposed activities (the Service's, May 19, 1997, Biological Opinion was based on the channel realignment proposal). Incidental take of Federally-protected nesting sea turtles was authorized on the condition the identified reasonable and prudent measures be observed. However, the plan to conduct beach disturbing activities well into June will have significant adverse impacts to the beach strand habitat and ecosystem.

Further, the proposed activities are, in essence, sand mining. The sand bypassing program associated with the jetties at Masonboro Inlet has been ineffective at maintaining the island's biogeochemical integrity. In our opinion, the sand mining can not legitimately be considered a CBRA exception under § 6(a)(2) "Navigation." Finally, the practice of removing material from within CBRS units, and placing it in non-CBRS units, is inconsistent with the purposes of the CBRA. Dr. John H. Zirschky, Acting Assistant Secretary for Civil Works, and Major General Stanley G. Genega, Directorate of Public Works, were separately informed of this opinion (General Genega was asked to clarify the issue for the Corp's Divisions and Districts) in letters dated June 12, 1995 and June 2, 1994, respectively (enclosure No. 1).

SAND BYPASSING

The sand bypassing program at the Masonboro Inlet jetties has been ineffective. Littoral processes, particularly longshore transport, generally moves sand southward in this system (an estimated 60 to 70 percent of the annual gross drift is southward). The Corps has developed varying estimates of sediment budgets for the area (e.g., the 1978 Evaluation Report, and a 1983 Feasibility Report). Our records show that since 1980, sand bypassing has been irregular and disproportionate. The relative gross drift has been artificially reversed with no justification. Table No. 1 clarifies this concern.

Table 1

17 year (1980 to 1997) Total Volume of Sand in cubic yards					
Target Beach	1978 Report	1983 Report	Actually Bypassed	% of natural budget	% of artificial budget;
Wrightsville Beach	2,635,000	2,210,000	2,400,000 in 1986, 1991, and 1995	30 - 40	53
Masonboro Island	3,128,000	2,125,000	2,100,000 in 1986 and 1995	60 - 70	47

[2] Sea beach amaranth, *Amaranthus pumilus*

There are further concerns. One rationale for the south jetty was that it would reduce the northwards longshore currents and sediment movement which was supposedly causing shoaling south of the north jetty and in the navigation channel. Again, our review of the data indicates that shoaling has not decreased, that dredging cycles, emergency dredging, and the implementation of a channel "widener" scheme in Masonboro Inlet is no different than those same factors in inlets with no jetties.

COASTAL BARRIER RESOURCES ACT

In our opinion, the proposed activities can not be considered a CBRA § 6(a)(2) exception ("maintenance or construction of improvements of existing federal navigation channels (including the Intracoastal Waterway) and related structures (such as jetties))." The proposed activities are sand mining to mitigate for the failed sand by-pass system and to enhance the beach plan and profile at Wrightsville Beach.

There is, however, precedent for using sediments from a CBRS unit to stabilize the shoreline in the same CBRS unit (see enclosure No. 1). Such an activity could be consistent with the CBRA under § 6(a)(6)(G) exceptions: "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilizing system."

ENDANGERED SPECIES ACT

Planning to work well into June is not consistent with obligations to minimize incidental take of Federally-listed sea turtles. It is contrary to the first conservation measure identified in the May 19, 1997 letter (p. 31): "Construction activities... should be planned to take place outside the main part of the sea turtle nesting and hatching season," and to the first condition listed in the May 30, 1997 coastal zone consistency letter from Roger Schecter of the Division of Coastal Management (p. 1): "Sand must be placed on the beach between November 30 and April 30 to avoid impacts on sea turtles during the nesting season."

We reiterate our opinion that the District Engineer is complying with the letter of the law, but not it's spirit. The ESA was intended to protect habitats and communities on which threatened and endangered species rely. Listed species were meant to be "miner's canaries" or red flags of ecosystem distress. Monitoring the beach for sea turtle nests and relocating eggs does not protect the myriad other components of the beach strand ecosystem (e.g., fish, shellfish, birds, and plants).

The ESA requires the District Engineer to provide the same level of protection for birds covered under the Migratory Bird Treaty Act as Federally-listed threatened and endangered species. A significant number of migratory waterfowl, migratory shorebirds, and colonial nesting waterbirds will be affected by the proposed activities. Beach strand dependent migratory birds will suffer reduced forage, loafing, and/or nesting grounds until the beach ecosystem recovers, which may take from months to years following replenishment.

CONCLUSIONS

The Service regrets that the failure of the sand bypassing program at Masonboro Inlet has created the current situation. We could concur with an EA/FONSI if the following recommendations were adapted:

- The Corps should use this budget and equipment availability as an opportunity to stabilize the disappearing shoreline of Masonboro Island (which is consistent with the CBRA and obligatory per previous agreements). This limited work should be accomplished prior to the sea turtle nesting season, avoiding the ESA concerns.

- In recognition that the sand-bypassing program has not been successful, the District Engineer should convene an emergency meeting of interested experts, review the problems, and find a more effective resolution. This should be done within the next few months so that any research needed can be initiated this summer and so that we can have an improved sand-bypassing scheme or jetty removal proposal in place by next fiscal year.

The inconsistency of the proposed activities with the CBRA § 6(a)(2) exception for navigation is, in our opinion, not so easily resolved.

We appreciate the opportunity to comment on this matter. Please call Kevin Moody of my staff at (919) 856-4520 extension 19.

Sincerely,

John M. Hefner
Field Supervisor

enclosure (2) 1

cc:
DCM, Raleigh, NC (John Parker)
DCM, Wilmington, NC (Bob Stroud)
DCM, Morehead City, NC (Charles Jones)
DMF, Wilmington, NC (Fritz Rohde)
DWQ, Raleigh, NC (John Dorney)
WRC, Raleigh, NC (Frank McBride)
WRC, Kinston, NC (Bennett Wynne)
WRC, Marshallberg, NC (Ruth Boettcher)
EPA, Wetlands Regulatory Branch, Atlanta, GA (Thomas Wellborn)
EPA, Office of Environmental Assessment, Atlanta, GA (Heinz J. Mueller)

From:	Wright, Dana K
To:	Chen, Linus Y
Cc:	Bohn, Cynthia; Niemi, Katie
Subject:	Re: high priority - please review CBRA options paper
Date:	Tuesday, October 22, 2019 6:53:19 AM
Importance:	High

Sure - just let me know if there is any need to reach out.

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Mon, Oct 21, 2019 at 3:35 PM Chen, Linus <linus.chen@sol.doi.gov> wrote:

> Thanks for looking. No rush (for now). We can look in to FO next week or later.
>
> On Mon, Oct 21, 2019 at 3:32 PM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:
>
>> Linus, I don't have anything else. We could go to the FO and ask them if needed. I'm going to be out of the office on annual leave for the rest of this week until next Tuesday when I'm attending a meeting.
>>
>> Dana/Katie: would you all mind to contact Raleigh if Linus needs? I doubt that there is much more than Dana already has, but I am not certain. Thanks, Cindy
>>
>> Cynthia Bohn
>> Regional Coastal Program Coordinator
>> Coastal Barrier Resources Act Regional Coordinator
>> USFWS
>> 1875 Century Blvd, Room 200
>> Atlanta, GA 30345
>> Phone: 404-679-7122
>> Fax: 404-679-7081
>> cynthia_bohn@fws.gov
>>
>> Learn more about the Coastal Barrier Resources Act
>>
>>
>>
>> On Fri, Oct 18, 2019 at 10:03 AM Wright, Dana <dana_wright@fws.gov> wrote:

HQ's records on this (at least the digital records) pretty much end with the Corps' 1999 position paper. The only thing we have after that is a 2006 cover sheet that shows the FO transmitting the position paper to HQ with a short note. I've also attached some letters we have that pre-date the 1999 paper. I have a hard copy file at the office that I can look at next Tuesday, but I doubt that it will have anything additional.

I agree that I don't think DOI changed its position. I do recall seeing a FWS SC field office letter from the early 1990's (92 or 93?) that indicated that sand mining could be done within the CBRS, but I think a similar request for another project that followed that letter for prompted someone to request the DOI review that resulted in the 1994 SOL opinion. To my knowledge, we haven't issued any consultations that contradict the 1994 opinion since its issuance.

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

[Learn more about the Coastal Barrier Resources Act]

On Fri, Oct 18, 2019 at 9:56 AM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

Linus, I'll check this afternoon (b) (6) [redacted]. If you need it sooner, Dana may have something. c

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

[Learn more about the Coastal Barrier Resources Act]

On Fri, Oct 18, 2019 at 9:48 AM Chen, Linus <linus.chen@sol.doi.gov> wrote:

Hi Cindy,

Thanks for sharing this. To my knowledge, this is the first time I've seen this.

b5-ACP [redacted]

b5-ACP
[redacted] I don't think DOI changed their position on this previously to 1994, but rather clarified it after 1994 (but I could be wrong). I'll try to take another look in my files to see if there's anything that addresses this ACOE position paper. In the meantime, do you have anything in your files that responds to this position paper in case there are questions from Van Drews or the Secretary that raise these position paper points?
Linus

On Thu, Oct 17, 2019 at 11:34 AM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

> Hi Katie, I agree this looks great.
>
> As another point: On option one, the discussion of the Corps other choices, one could always mention that the Wilmington Corps decided in 1999 that they disagreed with our legal interpretation and decided to continue the NC projects that we had determined were inconsistent with CBRA (one of these being the Carolina Beach Project which now needs to be reauthorized.) This may be too much information for this memo, but I believe it is something that is important to the conversation, the Corps has a precedent of "overriding" the Service's CBRA consultation recommendation and has continued to implement projects for the last 20 years. I've attached the Corps 1999 Position Paper.
>
> Cynthia Bohn
> Regional Coastal Program Coordinator
> Coastal Barrier Resources Act Regional Coordinator
> USFWS
> 1875 Century Blvd, Room 200
> Atlanta, GA 30345
> Phone: 404-679-7122
> Fax: 404-679-7081
> cynthia_bohn@fws.gov
>
> Learn more about the Coastal Barrier Resources Act
>
>
>
> On Wed, Oct 16, 2019 at 10:38 PM Schrading, Eric <eric_schrading@fws.gov> wrote:
>
>> Katie,
>>
>> Sorry to review this late. Two proposed changes...but I did not do this on the google doc.
>>
>> 1. Remove "to argue" -2nd sentence last paragraph on page three (repeated twice).
>>
>> 2. Capitalize or don't capitalize "Section" throughout paper...both are used (consistency).

Otherwise looks great!!!!!

On Wed, Oct 16, 2019 at 1:31 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

Hi Folks,
We recently learned that Secretary Bernhardt is meeting with Rep. Van Drew (NJ-2) next Monday. Gary Frazer asked that we prepare an options paper on the CBRA sand mining issue for Margaret. Please see the GoogleDocs file and offer any revisions in "Suggesting" mode. I told Gary we'd have the options paper to him by today so any feedback you can provide this afternoon would be appreciated. Sorry for the short turn-around time.

https://drive.google.com/file/d/1G_wAC-gJAFHhZ1famNc84Mv4CZTdo0kR/view?usp=sharing

Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

--
Eric Schrading, CWB
Field Supervisor
U.S. Fish and Wildlife Service
New Jersey Field Office
4 East Jimmie Leeds Road, Suite 4
Galloway, New Jersey 08205-4465
P: (609) 382-5272
Cell: (609) 576-3400
Fax: (609) 646-0352

Follow us on Facebook: https://www.facebook.com/USFWSNewJerseyFieldOffice

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

From: Bohn, Cynthia
To: Niemi, Katie
Cc: Shultz, Gina; BalisLarsen, Martha; Shaughnessy, Michelle; Kodis, Martin; Gustavson, Angela; Simon, Spencer; Eustis, Christine; Peters, Kristen E; Wright, Dana K; Phinney, Jonathan T; Eversen, Michelle; Valenta, Aaron; Frazer, Gary D
Subject: Re: New SOL CBRA memo
Date: Thursday, October 31, 2019 1:12:32 PM
Importance: High

Thanks Katie, yes, this will require some guidance and direction to the field and other federal agencies. b5-DPP [redacted] We will want input from Service HQ and SOL.

Katie, I'll give you a call next week when I'm back in the office.
Thanks everyone. Cindy

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Thu, Oct 31, 2019 at 9:09 AM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Please see attached and below for the new SOL CBRA memo on sand mining and beach nourishment. At the program level we have a lot of questions about how this new policy will be rolled-out and implemented.
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071
>
> ---------- Forwarded message ---------
> From: **Parramore, Laury** <laury_parramore@fws.gov>

Date: Wed, Oct 30, 2019 at 4:26 PM
Subject: QUESTION: CBRA memo
To: Jonathan Phinney <jonathan_phinney@fws.gov>, Katie Niemi <katie_niemi@fws.gov>
Cc: Gavin Shire <gavin_shire@fws.gov>

Hi Jonathan and Katie,
Please see below and attached, of which I'm sure you are aware. Could we chat about the communications issues that may surround this? Brian H, our PAO who would normally handle this, is out at NCTC this week. Thanks.

Laury Marshall

---------- Forwarded message ---------
From: **Newell, Russell** <russell_newell@ios.doi.gov>
Date: Wed, Oct 30, 2019 at 2:49 PM
Subject: CBRA
To: Schroeder, Darin <darin_schroeder@ios.doi.gov>, Shire, Gavin <gavin_shire@fws.gov>
Cc: Barbara Wainman <barbara_wainman@fws.gov>, Parramore, Laury <laury_parramore@fws.gov>

Hi guys - this came up in our 11:30 and I want to follow up. I subsequently received this memo from SOL. I'm told by OCL that a letter based on this from the Secretary to Members may go out as soon as today or tomorrow. I asked what the comms plan is and am waiting to hear how proactive we'll be. I'll let you know when I hear more. Let me know if you have any further insight.

Russell

I think I have everyone who wanted a copy of the CBRA legal memo. I understand Cole is taking the lead in responding to inquiries on this subject.

Sent from my iPhone

Begin forwarded message:

> **From:** "Romanik, Peg" <peg.romanik@sol.doi.gov>
> **Date:** October 30, 2019 at 11:44:44 AM EDT
> **To:** Karen Budd-Falen <karen.budd-falen@sol.doi.gov>
> **Subject: Fwd: scanned memo**
>
> Karen, two printers and a scanner wouldn't work so MG had to scan this for me. Here it is! I will email to Margaret and give her hard copy tomorrow when she gets into the office. Do you want me to email to others - happy to do so.
> Peg
>
> Peg Romanik

Associate Solicitor
Division of Parks and Wildlife
Office of the Solicitor
U.S. Department of the Interior
Office: (202)208-5578
Cell: (202)515-1000

On Wed, Oct 30, 2019 at 11:36 AM Caminiti, Mariagrazia
<marigrace.caminiti@sol.doi.gov> wrote:

> attached
>
> --
>
> Marigrace Caminiti
>
> Executive Assistant to the Solicitor
> US Department of the Interior
> 1849 C Street, NW, Rm. 6352
> Washington, DC 20240
> 202-208-4423 - main number
> 202-208-3111 - direct
> 202-208-5584 - fax
> 202-528-0486 or 202-359-2949 -cell/wcell
>
> ^^
>
>

--

Russell Newell
Senior Advisor
Fish & Wildlife & Parks
(202) 208-6232
@RobWallace_FWP

From:	Niemi, Katie
To:	BalisLarsen, Martha
Cc:	Shaughnessy, Michelle; Phinney, Jonathan T; Wright, Dana K
Subject:	Fwd: New SOL CBRA memo
Date:	Thursday, October 31, 2019 2:48:30 PM

Martha,
Please see the Google Doc for initial questions Dana and I have after receiving the new SOL memo on sand mining and beach nourishment today.
https://docs.google.com/document/d/1MhUPlHBDj1_YBf9Q-sXrexoZq7wny8fRGXJlCgfteNw/edit?usp=sharing

Please forward that file to Gary and Gina once you've reviewed. As you can see, we have a lot of questions about how this new policy will be interpreted and implemented. I think before we brief Margaret, we should have internal discussions with SOL as well as Regions 4 and 5. (b) (6) [redacted]

Can you ask Gary if we can brief Margaret the week of Nov. 11? We have a lot of issues to consider and discuss with the lawyers and Regions before we're ready to brief Margaret on the next steps. Right now we have more questions than answers.

Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

---------- Forwarded message ---------
From: **Frazer, Gary** <gary_frazer@fws.gov>
Date: Thu, Oct 31, 2019 at 1:09 PM
Subject: Re: New SOL CBRA memo
To: Niemi, Katie <katie_niemi@fws.gov>
Cc: Gina Shultz <Gina_Shultz@fws.gov>, BalisLarsen, Martha <martha_balislarsen@fws.gov>, Michelle Shaughnessy <michelle_shaughnessy@fws.gov>, Wright, Dana <dana_wright@fws.gov>, Jonathan Phinney <jonathan_phinney@fws.gov>

Thanks. Just get those to me when you're done.

Margaret wants to sit down with us next week to talk about next steps, so also think through any changes to our existing guidance or need for future guidance that will result from this new legal interpretation.

As background for that meeting, we will need to lay out in a briefing paper our plans/recommendations for how we incorporate this into our operational activities. So add that to your to do list, too, altho I assume you'd tackle that after we discuss your initial list of questions/concerns. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

On Thu, Oct 31, 2019 at 9:46 AM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Gary,
> Dana and I are working on questions that we have for SOL, CLA/OCL, Regions, and External Affairs. Thanks.
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071
>
> On Thu, Oct 31, 2019 at 9:34 AM Frazer, Gary <gary_frazer@fws.gov> wrote:
>
>> Katie -- If you get questions from the Regions or field about this, pls just advise that we can't provide any advice or views about implications until after we've had a chance to review thoroughly and discuss with SOL.
>>
>> Pls review carefully and provide me a list of your questions or concerns regarding the opinion and its implications to our advisory role. -- GDF
>>
>> *Gary Frazer*
>> *Assistant Director -- Ecological Services*
>> *U.S. Fish and Wildlife Service*
>> *(202) 208-4646*
>>
>> On Thu, Oct 31, 2019 at 9:09 AM Niemi, Katie <katie_niemi@fws.gov> wrote:
>>
>>> Please see attached and below for the new SOL CBRA memo on sand mining and beach nourishment. At the program level we have a lot of questions about how this new policy will be rolled-out and implemented.
>>>
>>> Katie
>>>
>>> Katie Niemi
>>> Coastal Barriers Coordinator
>>> U.S. Fish & Wildlife Service
>>> Ecological Services, MS: ES
>>> 5275 Leesburg Pike
>>> Falls Church, VA 22041-3803
>>> Tel (703) 358-2071
>>>
>>> ---------- Forwarded message ---------
>>> From: **Parramore, Laury** <laury_parramore@fws.gov>

Date: Wed, Oct 30, 2019 at 4:26 PM
Subject: QUESTION: CBRA memo
To: Jonathan Phinney <jonathan_phinney@fws.gov>, Katie Niemi <katie_niemi@fws.gov>
Cc: Gavin Shire <gavin_shire@fws.gov>

Hi Jonathan and Katie,
Please see below and attached, of which I'm sure you are aware. Could we chat about the communications issues that may surround this? Brian H, our PAO who would normally handle this, is out at NCTC this week. Thanks.

Laury Marshall

---------- Forwarded message ---------
From: **Newell, Russell** <russell_newell@ios.doi.gov>
Date: Wed, Oct 30, 2019 at 2:49 PM
Subject: CBRA
To: Schroeder, Darin <darin_schroeder@ios.doi.gov>, Shire, Gavin <gavin_shire@fws.gov>
Cc: Barbara Wainman <barbara_wainman@fws.gov>, Parramore, Laury <laury_parramore@fws.gov>

Hi guys - this came up in our 11:30 and I want to follow up. I subsequently received this memo from SOL. I'm told by OCL that a letter based on this from the Secretary to Members may go out as soon as today or tomorrow. I asked what the comms plan is and am waiting to hear how proactive we'll be. I'll let you know when I hear more. Let me know if you have any further insight.

Russell

I think I have everyone who wanted a copy of the CBRA legal memo. I understand Cole is taking the lead in responding to inquiries on this subject.

Sent from my iPhone

Begin forwarded message:

> **From:** "Romanik, Peg" <peg.romanik@sol.doi.gov>
> **Date:** October 30, 2019 at 11:44:44 AM EDT
> **To:** Karen Budd-Falen <karen.budd-falen@sol.doi.gov>
> **Subject: Fwd: scanned memo**
>
> Karen, two printers and a scanner wouldn't work so MG had to scan this for me. Here it is! I will email to Margaret and give her hard copy tomorrow when she gets into the office. Do you want me to email to others - happy to do so.
> Peg
>
> Peg Romanik
> Associate Solicitor
> Division of Parks and Wildlife

Office of the Solicitor
U.S. Department of the Interior
Office: (202)208-5578
Cell: (202)515-1000

On Wed, Oct 30, 2019 at 11:36 AM Caminiti, Mariagrazia <marigrace.caminiti@sol.doi.gov> wrote:

> attached
>
> --
>
> Marigrace Caminiti
>
> Executive Assistant to the Solicitor
> US Department of the Interior
> 1849 C Street, NW, Rm. 6352
> Washington, DC 20240
> 202-208-4423 - main number
> 202-208-3111 - direct
> 202-208-5584 - fax
> 202-528-0486 or 202-359-2949 -cell/wcell
>
> ^^^
>
>

--
Russell Newell
Senior Advisor
Fish & Wildlife & Parks
(202) 208-6232
@RobWallace_FWP

From:	BalisLarsen, Martha
To:	Frazer, Gary D
Cc:	Shultz, Gina; Niemi, Katie; Wright, Dana K; Phinney, Jonathan T; Shaughnessy, Michelle
Subject:	Re: New SOL CBRA memo
Date:	Thursday, October 31, 2019 5:14:47 PM
Attachments:	Questions re 10 30 19 CBRA SOL Memo.docx
Importance:	High

Gary, attached is the initial questions that Katie and Dana have identified regarding the new SOL memo on sand mining and beach nourishment.

Since Katie will be out the early part of next week, can we look to briefing Margaret the week of November 11? Katie and Dana would like to discuss with SOL and Regions 4 and 5 before the briefing with Margaret.

Martha

Initial Questions from CBRA Program concerning 10/30/19 SOL Memo

A memo from the Associate Solicitor in the Division of Parks and Wildlife to the U.S. Fish and Wildlife Service Principal Deputy Director dated October 30, 2019, concluded that the CBRA exception at 16 U.S.C. 3505(a)(6)(G) is *not* limited to shoreline stabilizations projects that occur within the Coastal Barrier Resources System (CBRS). Thus, sand from within a System Unit may be used to renourish a beach that is located outside of the CBRS. This memo reverses a long-standing legal interpretation that was established in 1994. Questions regarding this memo and its implications are below.

Q for SOL: The exception at 16 U.S.C. 3505(a)(6)(G) is for "nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system" that are also consistent with the purposes of the Act. Those purposes are to minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers and by considering the means and measures by which the long-term conservation of these fish, wildlife, and other natural resources may be achieved.

The memo states (bottom of page 3) "That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to 'mimic, enhance, or restore natural stabilizations systems.' 16 U.S.C. *Id.* § 3505 (a)(6(G)." (b) (5) [redacted]

Q for SOL: Refer to the above question. B5-ACP-DPP [redacted]

Q for SOL: The Service's advisory guidelines on CBRA (48 FR 45664) and CBRA's legislative history both specifically identify Corps Storm Damage Reduction Projects as projects that will be limited by CBRA. The *Federal Register* notice identifies the following as a specific example of prohibited activities: "Construction and financial assistance involving beach erosion control, hurricane protection, flood control works, and new or expanded navigation projects." The legislative history (House Report 97-841 Part 1) states: "The intent of this legislation is that all forms of direct Federal assistance for projects...be precluded. Federal assistance for erosion control would also be prohibited, except where an emergency threatens life, land, or property immediately adjacent to a System unit." B5-ACP-DPP [redacted]

Q for SOL: b5-ACP [redacted]

Q for SOL: Page 1, paragraph 2 of CBRA memo states the following:

> "However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects."

B5-ACP-DPP [redacted]

Q for SOL: Paragraph 1 under the "Discussion" section of the memo (page 2) states the following:

> "The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g., Hays v. Sebelius,* 589 F.3d. 1279, 1281 (D.C. Circ. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.")

B5-ACP-DPP [redacted]

[redacted]

[redacted]

[redacted]

Q for SOL: B5-ACP-DPP [redacted]

[redacted]

[redacted]

B5-ACP-DPP [redacted]

[redacted]

[redacted]

[redacted]

Question for SOL: (b) (5) [redacted] "Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act." (b) (5) [redacted]

Q for FWS leadership: What is the plan to inform the Corps? In the past, letters were sent from the Assistant Secretary for Fish and Wildlife and Parks to the Assistant Secretary for Civil Works and from the Service's Deputy Director to the Corps' Directorate of Civil Works.

The CBRA program has many questions for the Corps and how they will interpret this policy change. We would like to coordinate with our contacts at Corps' Headquarters (Senior Policy Advisor and someone from the Office of the Chief Counsel) if/when possible. Please advise.

Q for FWS leadership: There are currently no CBRA consultations pending with the Service on this matter. **Will the North Atlantic-Appalachian and South Atlantic-Gulf Regions be advising the Corps to initiate new CBRA consultations with the Service on their affected projects (e.g. Stone Harbor, Wrightsville Beach, Carolina Beach, Folly Beach)?** We also have consultations on file regarding this issue from the early 1990's for Tybee Island, Pawleys Island, and Little St. Simons Island, but we haven't heard anything on these projects (at HQ) for decades.

Q for FWS leadership: b5-DPP [redacted]

Q for FWS leadership: Will there be any communication to the public regarding the status of our consultation process (i.e., if we are not doing CBRA consultations in some regions can we make that clear on the consultations page of our website)?

Discussion point for FWS leadership: b5-DPP [redacted]

Discussion point for FWS leadership: b5-DPP [redacted]

Discussion point for FWS leadership: Page 1, paragraph 2 of CBRA memo states: "However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects." [redacted]

b5-DPP

[redacted]

From: Berg, Elizabeth A
To: Niemi, Katie; Wright, Dana K; Phinney, Jonathan T; BalisLarsen, Martha
Subject: Fwd: CBRA memo
Date: Tuesday, November 5, 2019 3:19:51 PM
Attachments: 11.04.19 Bernhardt CBRA Response (3) (1) (1).pdf
11.04.19 based on previous CBRA interest - Burr, Dunn, Lamborn, Pallone, Tillis, Weber.pdf

---

Hi Katie and Dana,

Do you have a plan to update any publicly available resources to reflect the new CBRA Solicitor's Opinion? OCL is asking us how and when our resources will be updated - Taylor Playforth initiated the question and looped in Karen Budd-Falen, Katie Mills, Amanda Hall, Margaret Everson, and Melissa Beaumont.

I know that you were working on CBRA and Hereford Inlet Q&As that included information on the Solicitor's Opinion in the 1990s. Were those ever posted?

Thank you,
Liz

---------- Forwarded message ---------
From: **Gustavson, Angela** <angela_gustavson@fws.gov>
Date: Tue, Nov 5, 2019 at 2:44 PM
Subject: Fwd: CBRA memo
To: Elizabeth Berg <elizabeth_berg@fws.gov>
Cc: Martin Kodis <Martin_Kodis@fws.gov>

Hi Liz,

Can you please work with the CBRA team to get a response to Taylor's question in his email below? Please note for them that Taylor has looped Margaret and Karen Budd-Falen into this email chain so it would be good to have a timely response and also make sure it's appropriately cleared.

Thanks,

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

---------- Forwarded message ---------
From: **Playforth, Taylor** <taylor_playforth@ios.doi.gov>
Date: Tue, Nov 5, 2019 at 2:29 PM

Subject: Re: CBRA memo
To: Gustavson, Angela <angela_gustavson@fws.gov>
Cc: Amanda Hall <amanda_hall@ios.doi.gov>, Martin Kodis <martin_kodis@fws.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>, Katie Mills <katie_mills@ios.doi.gov>, Budd-Falen, Karen <karen.budd-falen@sol.doi.gov>, Margaret Everson <Margaret_E_Everson@fws.gov>

+ Karen and Margaret

In providing the response to Congress, one follow up question I received is when and how FWS will be updating their publically available resources to reflect the updated guidance?

On Tue, Nov 5, 2019 at 2:14 PM Playforth, Taylor <taylor_playforth@ios.doi.gov> wrote:

> Apologies for the delay, sharing the Van Drew, Rouzer, Graves letter and the based on previous interest letters as well.
>
> On Tue, Nov 5, 2019 at 1:51 PM Gustavson, Angela <angela_gustavson@fws.gov> wrote:
>
>> Thanks, Amanda. Our correspondence office was just able to track down copies of this letter so I have it now.
>>
>> Angela
>>
>> Angela Gustavson
>> Deputy Chief
>> Division of Congressional and Legislative Affairs
>> U.S. Fish and Wildlife Service
>> Office: 703-358-2253
>> Mobile: 202-909-5105
>> angela_gustavson@fws.gov
>>
>> On Tue, Nov 5, 2019 at 1:47 PM Amanda Hall <amanda_hall@ios.doi.gov> wrote:
>>
>>> Looping in Taylor who's been the lead on this effort.
>>>
>>> On Nov 5, 2019, at 1:45 PM, Gustavson, Angela <angela_gustavson@fws.gov> wrote:
>>>
>>> Hi Amanda,
>>>
>>> We saw there was a letter sent from the Secretary to Rep. Van Drew on November 4 that's shown in this news release from Rep. Van Drew, but the news release doesn't include the full letter. This is related to the new SOL memo on sand mining in CBRA areas. Do you have a copy of that letter that you can share with us?
>>>
>>> Thanks,
>>>
>>> Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

On Thu, Oct 31, 2019 at 4:14 PM Martin Kodis <martin_kodis@fws.gov> wrote:

> Ok. Thanks. We will sit tight.
>
> Sent from my iPhone
>
> On Oct 31, 2019, at 4:13 PM, Hall, Amanda <amanda_hall@ios.doi.gov> wrote:
>
> Hello - Yes OCL will take care of Hill outreach on this. I'll let you know who we reach out to when that's more solidified. Thank you for offering to help!
>
> Best,
>
> Amanda
>
> On Thu, Oct 31, 2019 at 2:23 PM Kodis, Martin <martin_kodis@fws.gov> wrote:
>
>> Hi Amanda,
>>
>> I hope your day is going well.
>>
>> I understand that there is a new SOL memo on sand mining in CBRA areas. Is OCL planning to do any Hill notification on this change? Can you please confirm and also let me know if there's anything we can do to help you on this. We'd appreciate to know, for our awareness, which offices are contacted if OCL is doing so.
>>
>> Thank you,
>>
>> Marty
>>
>> --
>> Martin Kodis
>> Chief, Division of Congressional and Legislative Affairs
>> U.S. Fish and Wildlife Service
>>
>> 5275 Leesburg Pike

Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax

--
Amanda Hall
Advisor, Office of Congressional and Legislative Affairs
U.S. Department of the Interior

NOTE: Every email I send or receive is subject to release under the Freedom of Information Act.

--
Taylor Playforth
Senior Advisor
US Department of the Interior
Office of Congressional & Legislative Affairs
(202) 795-0977

--
Taylor Playforth
Senior Advisor
US Department of the Interior
Office of Congressional & Legislative Affairs
(202) 795-0977

--
Elizabeth Berg
Congressional and Legislative Affairs Knauss Fellow
U.S. Fish and Wildlife Service
Office: 703-358-2225
elizabeth_berg@fws.gov

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Richard Burr
United States Senate
Washington, DC 20510

Dear Senator Burr:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Neal Dunn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Dunn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Doug Lamborn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Lamborn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Frank Pallone
U.S. House of Representatives
Washington, DC 20515

Dear Representative Pallone:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Thom Tillis
United States Senate
Washington, DC 20510

Dear Senator Tillis:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Randy Weber
U.S. House of Representatives
Washington, DC 20515

Dear Representative Weber:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

From: Berg, Elizabeth A
To: BalisLarsen, Martha
Cc: Niemi, Katie; Wright, Dana K; Phinney, Jonathan T
Subject: Re: CBRA memo
Date: Wednesday, November 6, 2019 8:16:27 AM

Thank you, Martha.

On Tue, Nov 5, 2019 at 4:34 PM BalisLarsen, Martha <martha_balislarsen@fws.gov> wrote:

> + Gary & Gina
>
> Liz, Gary has asked us to wait until after he discusses our questions regarding the impacts and changes to existing guidance with Margaret. Due to the Directorate meeting next week, we are not expecting that meeting to occur for a couple of weeks. Following that discussion, we will make a plan for updating the publicly available documents. I will defer to Gary as to whether he wants to propose a timeline.
>
> Re: Hertford Inlet information, we did not post the Q&A that had been in development.
>
> Martha
>
> On Tue, Nov 5, 2019 at 3:20 PM Berg , Elizabeth <elizabeth_berg@fws.gov> wrote:
>
>> Hi Katie and Dana,
>>
>> Do you have a plan to update any publicly available resources to reflect the new CBRA Solicitor's Opinion? OCL is asking us how and when our resources will be updated - Taylor Playforth initiated the question and looped in Karen Budd-Falen, Katie Mills, Amanda Hall, Margaret Everson, and Melissa Beaumont.
>>
>> I know that you were working on CBRA and Hereford Inlet Q&As that included information on the Solicitor's Opinion in the 1990s. Were those ever posted?
>>
>> Thank you,
>> Liz
>>
>> ---------- Forwarded message ---------
>> From: **Gustavson, Angela** <angela_gustavson@fws.gov>
>> Date: Tue, Nov 5, 2019 at 2:44 PM
>> Subject: Fwd: CBRA memo
>> To: Elizabeth Berg <elizabeth_berg@fws.gov>
>> Cc: Martin Kodis <Martin_Kodis@fws.gov>
>>
>> Hi Liz,

Can you please work with the CBRA team to get a response to Taylor's question in his email below? Please note for them that Taylor has looped Margaret and Karen Budd-Falen into this email chain so it would be good to have a timely response and also make sure it's appropriately cleared.

Thanks,

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

---------- Forwarded message ---------
From: **Playforth, Taylor** <taylor_playforth@ios.doi.gov>
Date: Tue, Nov 5, 2019 at 2:29 PM
Subject: Re: CBRA memo
To: Gustavson, Angela <angela_gustavson@fws.gov>
Cc: Amanda Hall <amanda_hall@ios.doi.gov>, Martin Kodis <martin_kodis@fws.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>, Katie Mills <katie_mills@ios.doi.gov>, Budd-Falen, Karen <karen.budd-falen@sol.doi.gov>, Margaret Everson <Margaret_E_Everson@fws.gov>

+ Karen and Margaret

In providing the response to Congress, one follow up question I received is when and how FWS will be updating their publically available resources to reflect the updated guidance?

On Tue, Nov 5, 2019 at 2:14 PM Playforth, Taylor <taylor_playforth@ios.doi.gov> wrote:

> Apologies for the delay, sharing the Van Drew, Rouzer, Graves letter and the based on previous interest letters as well.
>
> On Tue, Nov 5, 2019 at 1:51 PM Gustavson, Angela <angela_gustavson@fws.gov> wrote:
>
>> Thanks, Amanda. Our correspondence office was just able to track down copies of this letter so I have it now.
>>
>> Angela
>>
>> Angela Gustavson
>> Deputy Chief
>> Division of Congressional and Legislative Affairs

U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

On Tue, Nov 5, 2019 at 1:47 PM Amanda Hall <amanda_hall@ios.doi.gov> wrote:

Looping in Taylor who's been the lead on this effort.

On Nov 5, 2019, at 1:45 PM, Gustavson, Angela <angela_gustavson@fws.gov> wrote:

Hi Amanda,

We saw there was a letter sent from the Secretary to Rep. Van Drew on November 4 that's shown in this news release from Rep. Van Drew, but the news release doesn't include the full letter. This is related to the new SOL memo on sand mining in CBRA areas. Do you have a copy of that letter that you can share with us?

Thanks,

Angela

Angela Gustavson
Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

On Thu, Oct 31, 2019 at 4:14 PM Martin Kodis <martin_kodis@fws.gov> wrote:

Ok. Thanks. We will sit tight.

Sent from my iPhone

On Oct 31, 2019, at 4:13 PM, Hall, Amanda <amanda_hall@ios.doi.gov> wrote:

Hello - Yes OCL will take care of Hill outreach on this. I'll let you know who we reach out to when that's more solidified. Thank you for offering to help!

Best,

Amanda

On Thu, Oct 31, 2019 at 2:23 PM Kodis, Martin <martin_kodis@fws.gov> wrote:

Hi Amanda,

I hope your day is going well.

I understand that there is a new SOL memo on sand mining in CBRA areas. Is OCL planning to do any Hill notification on this change? Can you please confirm and also let me know if there's anything we can do to help you on this. We'd appreciate to know, for our awareness, which offices are contacted if OCL is doing so.

Thank you,

Marty

--
Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax

--
Amanda Hall
Advisor, Office of Congressional and Legislative Affairs
U.S. Department of the Interior

NOTE: Every email I send or receive is subject to release under the Freedom of Information Act.

--
Taylor Playforth
Senior Advisor
US Department of the Interior
Office of Congressional & Legislative Affairs
(202) 795-0977

> > --
> > Taylor Playforth
> > Senior Advisor
> > US Department of the Interior
> > Office of Congressional & Legislative Affairs
> > (202) 795-0977
> >
> > --
> > Elizabeth Berg
> > Congressional and Legislative Affairs Knauss Fellow
> > U.S. Fish and Wildlife Service
> > Office: 703-358-2225
> > elizabeth_berg@fws.gov

--
Elizabeth Berg
Congressional and Legislative Affairs Knauss Fellow
U.S. Fish and Wildlife Service
Office: 703-358-2225
elizabeth_berg@fws.gov

From:	Kodis, Martin
To:	Frazer, Gary D
Cc:	Huggler, Matthew; Wainman, Barbara W; Gustavson, Angela; BalisLarsen, Martha; Shaughnessy, Michelle; Niemi, Katie; Wright, Dana K; Shultz, Gina
Subject:	Re: CBRA memo
Date:	Friday, November 8, 2019 1:15:46 PM
Importance:	High

Thanks all.

On Fri, Nov 8, 2019 at 12:58 PM Frazer, Gary <gary_frazer@fws.gov> wrote:

> See my edits below. -- GDF
>
> *Gary Frazer*
> *Assistant Director -- Ecological Services*
> *U.S. Fish and Wildlife Service*
> *(202) 208-4646*
>
> On Thu, Nov 7, 2019 at 3:34 PM Kodis, Martin <martin_kodis@fws.gov> wrote:
>
>> Gary, Barbara, Matt:
>>
>> Please see the train below. DOI wants to know when we'll make adjustments to our public facing platforms to reflect the new SOL guidance. We'd like respond to Katie Mills' below before too much time passes, and are cognizant that Karen BF and Margaret on are the address list so want to make sure we get it right.
>>
>> I'd like to say something like this:
>>
>> *We have been in touch with program leadership. They are still assessing the effect of the SOL memo. They need to meet with SOL to ensure they properly understand the memo, and then assess whether and how to relay guidance to the field. ~~That all should be done before making public notifications. We can't make a commitment on timing until that happens.~~ The program has, to date, not had information on their website that spoke directly to this specific issue of sand mining within the CBRS for beach nourishment outside the System, i.e., the 1994 SOL memo was not posted on the website and there was no other associated guidance because the memo spoke for itself. Accordingly, there is nothing on the website to update. They will assess whether to post materials relating to the recent memo and any implementation guidance that may be needed after discussing the memo with SOL. They can't make a commitment on timing at this juncture.*
>>
>> Thoughts?
>>
>> Marty
>>
>> ---------- Forwarded message ---------
>> From: **Mills, Katie** <katie_mills@ios.doi.gov>
>> Date: Wed, Nov 6, 2019 at 9:20 AM
>> Subject: Re: CBRA memo
>> To: Gustavson, Angela <angela_gustavson@fws.gov>
>> Cc: Playforth, Taylor <taylor_playforth@ios.doi.gov>, Amanda Hall

<amanda_hall@ios.doi.gov>, Martin Kodis <martin_kodis@fws.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>, Budd-Falen, Karen <karen.budd-falen@sol.doi.gov>, Margaret Everson <Margaret_E_Everson@fws.gov>

Thank you, Angela. Once you speak with the CBRA program, can you let us know a timeline of when the website and publicly available resources are expected to be updated? Thank you!

On Tue, Nov 5, 2019 at 3:30 PM Gustavson, Angela <angela_gustavson@fws.gov> wrote:

> Hi Taylor,
>
> Thanks for sending us these congressional letters.
>
> We're checking with the CBRA program on when and how we will update our publicly available resources to reflect the new SOL memo.
>
> Angela
>
> Angela Gustavson
> Deputy Chief
> Division of Congressional and Legislative Affairs
> U.S. Fish and Wildlife Service
> Office: 703-358-2253
> Mobile: 202-909-5105
> angela_gustavson@fws.gov
>
> On Tue, Nov 5, 2019 at 2:29 PM Playforth, Taylor <taylor_playforth@ios.doi.gov> wrote:
>
>> + Karen and Margaret
>>
>> In providing the response to Congress, one follow up question I received is when and how FWS will be updating their publically available resources to reflect the updated guidance?
>>
>> On Tue, Nov 5, 2019 at 2:14 PM Playforth, Taylor <taylor_playforth@ios.doi.gov> wrote:
>>
>>> Apologies for the delay, sharing the Van Drew, Rouzer, Graves letter and the based on previous interest letters as well.
>>>
>>> On Tue, Nov 5, 2019 at 1:51 PM Gustavson, Angela <angela_gustavson@fws.gov> wrote:
>>>
>>>> Thanks, Amanda. Our correspondence office was just able to track down copies of this letter so I have it now.
>>>>
>>>> Angela
>>>>
>>>> Angela Gustavson

Deputy Chief
Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service
Office: 703-358-2253
Mobile: 202-909-5105
angela_gustavson@fws.gov

On Tue, Nov 5, 2019 at 1:47 PM Amanda Hall <amanda_hall@ios.doi.gov> wrote:

> Looping in Taylor who's been the lead on this effort.
>
> On Nov 5, 2019, at 1:45 PM, Gustavson, Angela <angela_gustavson@fws.gov> wrote:
>
> Hi Amanda,
>
> We saw there was a letter sent from the Secretary to Rep. Van Drew on November 4 that's shown in this news release from Rep. Van Drew, but the news release doesn't include the full letter. This is related to the new SOL memo on sand mining in CBRA areas. Do you have a copy of that letter that you can share with us?
>
> Thanks,
>
> Angela
>
> Angela Gustavson
> Deputy Chief
> Division of Congressional and Legislative Affairs
> U.S. Fish and Wildlife Service
> Office: 703-358-2253
> Mobile: 202-909-5105
> angela_gustavson@fws.gov
>
> On Thu, Oct 31, 2019 at 4:14 PM Martin Kodis <martin_kodis@fws.gov> wrote:
>
>> Ok. Thanks. We will sit tight.
>>
>> Sent from my iPhone
>>
>> On Oct 31, 2019, at 4:13 PM, Hall, Amanda <amanda_hall@ios.doi.gov> wrote:
>>
>> Hello - Yes OCL will take care of Hill outreach on this. I'll let you know who we reach out to when that's more solidified. Thank you for offering to

help!

Best,

Amanda

On Thu, Oct 31, 2019 at 2:23 PM Kodis, Martin <martin_kodis@fws.gov> wrote:

> Hi Amanda,
>
> I hope your day is going well.
>
> I understand that there is a new SOL memo on sand mining in CBRA areas. Is OCL planning to do any Hill notification on this change? Can you please confirm and also let me know if there's anything we can do to help you on this. We'd appreciate to know, for our awareness, which offices are contacted if OCL is doing so.
>
> Thank you,
>
> Marty
>
> --
> Martin Kodis
> Chief, Division of Congressional and Legislative Affairs
> U.S. Fish and Wildlife Service
>
> 5275 Leesburg Pike
> Falls Church, VA 22041
>
> 703-358-2241 ph
> 703-358-2245 fax

--
Amanda Hall
Advisor, Office of Congressional and Legislative Affairs
U.S. Department of the Interior

--

Taylor Playforth
Senior Advisor
US Department of the Interior
Office of Congressional & Legislative Affairs
(202) 795-0977

--
Taylor Playforth
Senior Advisor
US Department of the Interior
Office of Congressional & Legislative Affairs
(202) 795-0977

--
Katie E. Mills
Counselor to the Assistant Secretary for Fish and Wildlife and Parks
U.S. Department of the Interior
Katie_Mills@ios.doi.gov
202-208-4591-Office
202-802-2114-Cell

--
Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax

--
Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax

From:	Zosh, Jennifer M
To:	Frazer, Gary D; Jesup, Benjamin C; Floom, Kristen B; Wright, Dana K; Niemi, Katie; Shaughnessy, Michelle; BalisLarsen, Martha; Chen, Linus Y; Romanik, Peg A
Subject:	CBRA documents - attorney/client privilege
Date:	Tuesday, November 12, 2019 2:41:25 PM
Attachments:	Materials for CBRA Sand Mining and Beach Renourishment Discussion_11.12.2019.pdf

Hello Everyone,

Katie asked me to send you the attached set of questions concerning the new SOL memo on CBRA and some additional documents. Hard copies will be provied at the 3:00 pm meeting.

Thanks.

--
Jennifer Zosh

Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2429 (office)
703-358-1800 (fax)

Materials for CBRA Sand Mining and Beach Renourishment Discussion

November 12, 2019

A. CBRA Program Questions

B. October 30, 2019 SOL Memo

C. 16 U.S.C. 3501 et seq.

D. CBRA of 1982 Legislative History

   I. House Report 97-841 Part I

   II. Conference Report 97-928

E. CBRA Advisory Guidelines - April 25, 1983 (48 FR 17592)

F. Select pages from: Inventory of Habitat Modifications to Sandy Oceanfront Beaches in the U.S. Atlantic Coast Breeding Range of the Piping Plover as of 2015: Maine to North Carolina, Terwilliger Consulting, Inc., 2017

G. Natural and Human-Induced Variability in Barrier-Island Response to Sea Level Rise, *Geophysical Research Letters*, Miselis and Lorenzo-Trueba, 2017

H. Select pages from: Status of the Species – piping plover, U.S. Fish and Wildlife Service, 2017

I. Sample consultation letter for Corps beach nourishment activities in N. Wildwood, NJ. U.S. Fish and Wildlife Service, 2008

J. Example of Corps storm damage reduction project that contains numerous structural elements: pages from Townsends Inlet to Cape May Inlet Final Feasibility Report, Environmental Impact Statement, 1997

K. Sample CBRA consultation letter for Corps sand borrowing and beach renourishment at Folly Beach, SC. U.S. Fish and Wildlife Service, 1998

L. Select pages from: sample section 7 ESA consultation and Biological Opinion for Corps Folly Beach Shore Protection Project. U.S. Fish and Wildlife Service, 2018.

M. CBRS locator map for Texas

N. Corps Coastal Texas Protection and Restoration Study maps

Initial Questions from CBRA Program concerning 10/30/19 SOL Memo

A memo from the Associate Solicitor in the Division of Parks and Wildlife to the U.S. Fish and Wildlife Service Principal Deputy Director dated October 30, 2019, concluded that the CBRA exception at 16 U.S.C. 3505(a)(6)(G) is *not* limited to shoreline stabilizations projects that occur within the Coastal Barrier Resources System (CBRS). Thus, sand from within a System Unit may be used to renourish a beach that is located outside of the CBRS. This memo reverses a long-standing legal interpretation that was established in 1994. Questions regarding this memo and its implications are below.

1. Question for SOL: (b) (5) [redacted] "Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act." (b) (5) [redacted]

2. Q for FWS leadership: b5-DPP [redacted] We also have consultations on file regarding this issue from the early 1990's for Tybee Island, Pawleys Island, and Little St. Simons Island, but we haven't heard anything on these projects (at HQ) for decades.

3. Q or SOL: Can the 10/30/19 SOL memo be shared publicly, and/or put up on the DOI website?

4. Q for SOL: Page 1, paragraph 2 of CBRA memo states the following:

> "However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects."

B5-ACP-DPP [redacted]

B5-ACP-DPP [redacted]

5. B5-ACP [redacted]

6. Q for SOL: Paragraph 1 under the "Discussion" section of the memo (page 2) states the following:

> "The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g., Hays v. Sebelius,* 589 F.3d. 1279, 1281 (D.C. Circ. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.")

B5-ACP-DPP [redacted]

[redacted]

[redacted]

[redacted]

7. Q for SOL: The exception at 16 U.S.C. 3505(a)(6)(G) is for "nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system" that are also consistent with the purposes of the Act. Those purposes are to minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers and by considering the means and measures by which the long-term conservation of these fish, wildlife, and other natural resources may be achieved.

The memo states (bottom of page 3) "That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to 'mimic, enhance, or restore natural stabilizations systems.' 16 U.S.C. *Id.* § 3505 (a)(6(G)." (b) (5) [redacted]

8. Discussion point for FWS leadership: b5-DPP [redacted]

9. Discussion point for FWS leadership: b5-DPP [redacted]

10. Q for SOL: B5-ACP-DPP [redacted]

B5-ACP-DPP [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

B5-ACP-DPP [redacted]

11. Q for SOL: Refer to question 6 above. B5-ACP-DPP [redacted]

12. Q for SOL: b5-ACP [redacted]

13. Q for FWS leadership: What is the plan to inform the Corps? In the past, letters were sent from the Assistant Secretary for Fish and Wildlife and Parks to the Assistant Secretary for Civil Works and from the Service's Deputy Director to the Corps' Directorate of Civil Works.

The CBRA program has many questions for the Corps and how they will interpret this policy change. We would like to coordinate with our contacts at Corps' Headquarters (Senior Policy Advisor and someone from the Office of the Chief Counsel) if/when possible. Please advise.

14. Q for FWS leadership: Will there be any communication to the public regarding the status of our consultation process (i.e., if we are not doing CBRA consultations in some regions can we make that clear on the consultations page of our website)?

15. Discussion point for FWS leadership: Page 1, paragraph 2 of CBRA memo states: "However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects." b5-DPP [redacted]

b5-DPP [redacted]

16. Discussion point for FWS leadership: Chairman Grijalva of the House Natural Resources Committee sent a letter to the Directors of the Service and USGS on June 24, 2019, requesting a study on the impacts of sand/sediment removal from the CBRS. The Service and USGS have initiated discussions on this study b5-DPP [redacted]. As the new SOL memo states that the Service must evaluate consistency of sand mining/beach nourishment projects with the purposes of CBRA through the 6(a)(6)(G) exception, this study would be extremely useful. The draft response to this letter was held in the Director's office for two months and was recently sent to CCU to hold. What is the status of this matter?

17. Q for FWS leadership: b5-DPP [redacted]

United States Department of the Interior

OFFICE OF THE SOLICITOR
Washington, D.C. 20240

IN REPLY REFER TO:

To: Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Peg Romanik, Associate Solicitor, Division of Parks and Wildlife

Re: Coastal Barrier Resources Act

Date: October 30, 2019

Introduction

You have requested our opinion as to whether Section 6(a)(6)(G) of the Coastal Barrier Resources Act ("CBRA" or "Act"), 16 U.S.C. § 3505(a)(6)(G), permits Federal funding for utilizing sand removed from a Coastal Barrier Resources System ("System") unit to renourish beaches located outside the System.

After considering the plain language of the Act, we conclude that the exemption in Section 6(a)(6)(G) is not limited to shoreline stabilization projects occurring within the System. Thus, sand from within a System unit may be used to renourish a beach that is located outside of the System. However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects.

Background

When it enacted the CBRA, Congress found that coastal barriers contain significant cultural and natural resources, including wildlife habitat and spawning areas, and function as natural storm protective buffers. *See* 16 U.S.C. § 3501(a). Congress further found that coastal barriers are generally unsuitable for development. *Id.* § 3501(a)(3). It enacted the CBRA to restrict Federal expenditures that encourage development of coastal barriers, thus minimizing the loss of human life and damage to natural resources within those areas. *Id.* § 3501(b). Section 5(a) of the Act prohibits most new Federal expenditures and financial assistance for activities occurring within the System. *Id.* § 3504(a). Section 6 of the Act sets forth exceptions to the prohibition, including "[n]onstructural projects for shoreline stabilization that are designed to

mimic, enhance, or restore natural stabilization systems," if such projects are consistent with the purposes of the Act. *Id.* § 3505(a)(6)(G).

A 1994 legal memorandum from then Assistant Solicitor - Branch of Fish and Wildlife interpreting Section 6(a)(6)(G) concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit, and not to projects to renourish beaches outside the System. The 1994 opinion "interpret[s] section 6(a)(6) to refer to projects designed to renourish solely a beach within the [System unit]." We understand that local communities and members of Congress have recently raised concerns about their inability to receive Federal funds for beach nourishment and have asked the Department to revisit this issue

<u>Discussion</u>

Section 6 of the Act sets forth certain exceptions to the limitations on Federal expenditures within the System. The introductory paragraph of the Section provides that a Federal agency, after consultation with the Secretary, "may make Federal expenditures or financial assistance available within the [System]" for certain enumerated activities. 16 U.S.C. § 3505(a). The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g., Hays v. Sebelius*, 589 F.3d. 1279, 1281 (D.C. Cir. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.") (citation omitted). Thus, the phrase applies solely to where the Federal expenditures or financial assistance may be applied. In this case, that means Federal funds associated with removing sand from a unit within the System.

By contrast, Section 3505(a)(6) does not contain language specifying that excepted actions must occur "within the [System]." That section permits certain "actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act." *Id.* § 3505(a)(6). Among those actions are "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G). The phrase "within the [System]" does not appear either in the introductory language to subsection 6 or in the subpart addressing shoreline stabilization projects. In sum, there is no express limitation on removing sediment from within the System and applying it to areas outside of the System for the purpose of shoreline stabilization.

The statutory language reflects that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Other provisions in Section 3505(a) indicate that Congress envisioned that the excepted activities might occur outside of the System. For example, Section 3505(a)(2) allows for the dredging of existing Federal navigation channels within the System, and the disposal of the dredge materials does not have to occur within the System. The House and Senate Reports specify that the "disposal site need not … be consistent with the purposes of the Act" as the dredge materials may contain contaminants, and

returning the contaminants to the system would not further the purposes of the CBRA.[1] Within Section 3505(a)(6), subparts (A) and (D) are similar in providing an exception for research for barrier resources, including fish and wildlife, which may require the study site to extend beyond the System to be most effective.

Alternatively, to the extent the statutory language could be viewed as ambiguous, our interpretation is reasonable and it furthers the purposes of the Act. There is no indication that Congress intended to conserve coastal barrier resources only within the System. Indeed, in calling for "coordinated action by Federal, State, and local governments," Congress appears to have envisioned the protection of broad swaths of coastal land. *Id.* § 3501(a)(1)(5). Our interpretation of Section 6(a)(6)(G) gives Federal agencies more flexibility to permit or undertake shoreline stabilization projects that will protect coastal resources, even if those resources are located outside of the System. These resources, identified in the CBRA's purpose, are "of significant value to society,"[2] providing over $1 billion in 1980 dollars for commercial fisheries, and high recreational value for people participating in sport fishing and waterfowl and duck hunting.[3]

Our interpretation also allows for projects that indirectly benefit coastal barrier resources within the System. For example, the U.S. Army Corps of Engineers ("Corps"), could use sand from a unit within the System to renourish a beach that is adjacent to that unit, but outside of the System. Stabilizing the adjacent beach could have positive effects on habitat located within the unit. The interpretation of Section 6(a)(6)(G) in the 1994 memorandum would preclude this project despite its beneficial effect on coastal barriers within the System.

Our interpretation does not alter the Service's (nor the action agency's) responsibility to consider on a case-by-case basis whether the proposed project is consistent with the purposes of the Act. *See id.* § 3505(a)(6). For example, the removal of the sand from within the System may not frustrate the "long-term conservation of these fish, wildlife, and other natural resources" associated with coastal barriers. *Id.* §3501(b). Thus, the Service should consider whether the sand could be removed without damage[4] to the natural resources within the System. Likewise, the project should not encourage development of coastal barriers in a manner that could result in "threats to human life, health, and property." *Id.* § 3501(a)(4). In addition, the Service should review whether the proposed project meets the limitations of the exception. That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to "mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G).

---

[1] CBRA Senate Report (May 26, 1982) at 7, and CBRA House Report (September 21, 1982) at 16.

[2] CBRA House Report (September 21, 1982) at 8.

[3] CBRA Senate Report (May 26, 1982) at 2, CBRA House Report (September 21, 1982) at 8.

[4] We note that "damage" here would have to cause more than insignificant impact to the natural resources. That is, it would have to be damage that would frustrate the purposes of the Act in some meaningful manner.

Conclusion

We recognize that our interpretation is a change from the conclusion presented in the 1994 legal memorandum. As noted above, however, that memorandum contained no analysis. After reviewing the legislative history and reading the plain language of the Act, we conclude a more reasoned interpretation is that the exception for shoreline stabilization projects is not expressly limited to projects occurring wholly within the System. And, to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act.

COASTAL BARRIER RESOURCES ACT

SEPTEMBER 21, 1982.—Ordered to be printed

Mr. JONES of North Carolina, from the Committee on Merchant Marine and Fisheries, submitted the following

REPORT

together with

ADDITIONAL VIEWS

[To accompany H.R. 3252]

[Including cost estimate of the Congressional Budget Office]

The Committee on Merchant Marine and Fisheries, to whom was referred the bill (H.R. 3252) a bill to establish the Coastal Barrier Resources System, and for other purposes, having considered the same, report favorably thereon with an amendment and recommend that the bill as amended do pass.

The amendment is as follows:

Strike out all after the enacting clause and insert the following:

SECTION 1. SHORT TITLE

This Act may be cited as the "Coastal Barrier Resources Act".

SEC. 2. FINDINGS AND PURPOSE.

(a) FINDINGS.—The Congress finds that—

(1) coastal barriers along the Atlantic and Gulf coasts of the United States and the adjacent wetlands, marsnes, estuaries, inlets and nearshore waters provide—

(A) habitats for migratory birds and other wildlife; and

(B) habitats which are essential spawning, nursery, nesting, and feeding areas for commercially and recreationally important species of finfish and shellfish, as well as other aquatic organisms such as sea turtles;

(2) coastal barriers contain resources of extraordinary scenic, scientific, recreational, natural, historic, archeological, cultural, and economic importance; which are being irretrievably damaged and lost due to development on, among, and adjacent to, such barriers;

(3) coastal barriers serve as natural storm protective buffers and are generally unsuitable for development because they are vulnerable to hurricane and other storm damage and because natural shoreline recession and the movement of unstable sediments undermine manmade structures;

(4) certain actions and programs of the Federal Government have subsidized and permitted development on coastal barriers and the result has been

89-006 O

areas. Disposing sewage effluents, dredging canals and channels, filling wetlands, leveling dunes, clearing vegetation, constructing hurricane and erosion control projects, stabilizing inlets, and other activities often spell trouble for the coastal barrier ecosystems that protect and sustain natural resources of immense aesthetic and economic value.

However, at the same time that the Federal Government has encouraged development on coastal barriers, it has recognized their unique natural resources and has sought, through traditional means, to preserve undisturbed examples of these natural systems. The Federal Government, as well as state and local governments and private conservation organizations, have made significant investments in acquiring coastal barrier acreage for recreation and conservation purposes.

THE OMNIBUS RECONCILIATION ACT OF 1981

Public policy has both encouraged development and fostered protection. Within the last few years, there has been a recognition that these Federal programs are working at cross purposes and that the cost of development, including the threats to man and natural resources, are more significant than were previously understood. Legislation was introduced in the 96th Congress which attempted to address these problems but final action was not completed prior to the end of the session. In 1981, the Omnibus Budget Reconciliation Act (OBRA) became public law. Section 341(d) of the OBRA adds a new Section 1321 to the National Flood Insurance Act of 1968 to prohibit the issuance of Federal flood insurance coverage, beginning October 1, 1983, for new construction or substantial improvements of existing structures on undeveloped coastal barriers as defined by the OBRA and as designated by the Secretary of the Interior. In response to this directive, the Secretary of the Interior established the Coastal Barrier Task Force, an interdepartmental group of professionals representing various agencies in the Department. Proposed delineations of undeveloped coastal barriers were released for final public review on August 16, 1982, pursuant to a Notice of Proposed Rulemaking published in the Federal Register.

Copies were distributed to affected Members of Congress, Governors, local governments, and other interested parties. The formal comment period on these proposed delineations ends November 15, 1982. The Department of the Interior used a density threshold of one structure per five acres of fastland to categorize a coastal barrier as developed. The term "structure" refers to a legally authorized building larger than 200 square feet in area, regardless of the size or number of housing units it contains. Although the enactment of the OBRA was an important first step in the protection of undeveloped coastal barriers, it only prohibits the issuance of Federal flood insurance coverage and does not limit other types of Federal assistance in these vulnerable coastal areas. In addition, the designations by the Department of the Interior could be subject to law suits for years, blocking both development and protection of coastal barriers.

NEED FOR THE LEGISLATION

The Committee recommends the enactment of H.R. 3252, the proposed Coastal Barrier Resources Act, for the purpose of minimizing

OBRA

SECTION 5—LIMITATIONS ON FEDERAL EXPENDITURES

Section 5(a), which specifies the limitations on new Federal expenditures or financial assistance, must be read in conjunction with the definition of financial assistance in section 3, subsection (b) of this section, and the exceptions specified in section 6. The intent of the legislation is that all forms of direct Federal assistance for projects, including, for example, the construction of structures or related infrastructures, or for constructing airports, roads, bridges, piers, sewers, or other facilities, be precluded. Federal assistance for erosion control would also be prohibited, except where an emergency threatens life, land or property immediately adjacent to a System unit.

The Committee also included an exception for stabilization and erosion control projects in units depicted on maps S01 through S11. These maps identify areas along the coast of Louisiana. This exception addresses the serious erosion problem along that coast. It has been documented that Louisiana is losing over 40 square miles of coastal marshes each year. A major cause of the erosion has been the leveeing and channelization of the Mississippi and Atchafalaya Rivers which prevents the flooding that at one time provided nourishment of the marsh system. This upsets the natural balance between marsh development by the river systems and the natural erosion processes of the Gulf of Mexico. The problem has been exacerbated over the last 50 years by the construction of canals for energy development purposes. In addition to the actual disturbance of the coastal areas by the construction of these canals, salt water intrusion through the canals into freshwater marshes destroys the vegetation that stabilizes the soils, thereby hastening the erosion process.

It should be noted that the Louisiana marshes are some of the most fertile fish and wildlife habitats in the country, providing nutrients and spawning areas for many fish species and wintering habitat for a variety of migratory waterfowl. The State of Louisiana has committed over $40 million over the next three years to address the serious problem of protecting these resources. Because the coastal erosion problem is largely the result of Federal policies and actions and because Louisiana has demonstrated its commitment to combat this problem, the Committee determined that it would be inequitable to deny Federal assistance and involvement in mitigative projects. The Committee intends for this exemption to be read broadly in terms of the types of stabilization projects that may be undertaken. Beach nourishment, groins and jetties, seawalls, riprap and any other method of stabilization are all contemplated as being within the scope of the provision as long as the project is not designed to stimulate development.

It is important to note that Section 5 will not prohibit private lending institutions (including those insured by the Federal Government) from making loans for homes or other forms of construction within the System. The intent of the legislation is that Federal stimuli for development be removed; it is not intended that private financial transactions directed toward the construction of facilities and structures with private funds be in any way impaired. In addition, this legislation should not affect Federal permits for private construction projects. Applications for permits to dispose of dredge materials in wetland areas identified as coastal barriers, for example, should rise

97TH CONGRESS 2d Session | HOUSE OF REPRESENTATIVES | REPORT No. 97-928

COASTAL BARRIER RESOURCES ACT

OCTOBER 1, 1982.—Ordered to be printed

Mr. JONES of North Carolina, from the committee of conference, submitted the following

CONFERENCE REPORT

[To accompany S. 1018]

The committee of conference on the disagreeing votes of the two Houses on the amendment of the House to the bill (S. 1018) to protect and conserve fish and wildlife resources, and for other purposes, having met, after full and free conference, have agreed to recommend and do recommend to their respective Houses as follows:

That the Senate recede from its disagreement to the amendment of the House and agree to the same with an amendment as follows:

In lieu of the matter proposed to be inserted by the House amendment insert the following:

SEC. 1. SHORT TITLE.

This Act may be cited as the "Coastal Barrier Resources Act".

SEC. 2. FINDINGS AND PURPOSE.

(a) FINDINGS.—The Congress finds that—

(1) coastal barriers along the Atlantic and Gulf coasts of the United States and the adjacent wetlands, marshes, estuaries, inlets and nearshore waters provide—

(A) habitats for migratory birds and other wildlife; and

(B) habitats which are essential spawning, nursery, nesting, and feeding areas for commercially and recreationally important species of finfish and shellfish, as well as other aquatic organisms such as sea turtles;

(2) coastal barriers contain resources of extraordinary scenic, scientific, recreational, natural, historic, archeological, cultural, and economic importance; which are being irretrievably damaged and lost due to development on, among, and adjacent to, such barriers;

H563-31

sional Committees and, if appropriate, an amendment to the legislation may be acted upon by the Congress.

There is one exception to this approach. The Conferees agreed to an amendment added to the Senate bill during initial Floor consideration. Section 4(a)(2) allows for additions to the Coastal Barrier Resources System at the request of those who own appropriate areas. As explained when introduced, this provision is a straightforward attempt to deal with a difficult situation. Quite simply, it permits landowners to join the System even though they may not technically qualify. This provision is not designed to serve as a vehicle to stop an otherwise eligible Federal project through the purposeful inclusion of an area not specifically included by the Congress within the Coastal Barrier Resources System.

Section 5. Limitations on Federal Expenditures Affecting The System

Section 5 specifies the limitations on new Federal financial expenditures or assistance. The Conferees agreed to provisions appearing in both the Senate bill and the House amendment and modified a provision of the House amendment concerning stabilization and erosion control projects in Louisiana. As modified, section 5(a)(3) provides a limited exception to the prohibition of expenditures for stabilization projects. Expenditures for such projects are permissible within the units designated pursuant to Section 4 on maps numbered SO1 through SO8 if such projects are for purposes other than encouraging development and, within all units, in cases where an emergency threatens life, land, and property immediately adjacent to the unit in question.

The limitations contained in Section 5 apply to areas within the Coastal Barrier Resources System as well as certain other facilities that may extend into a System unit, such as a bridge or a causeway. There need not be a showing that the expenditure would stimulate development. Except as provided in the Section 5(a)(3) exception, the fact that a particular project may be designed to benefit a non-coastal barrier is not significant.

Section 6. Exceptions

Section 6 of the Conference report outlines the specific exceptions to the general prohibition on new Federal expenditures or financial assistance.

Under Section 6(a) of the Senate bill the appropriate Federal officer would be authorized to make those specific Federal expenditures after providing written notification to the Secretary. The Conferees agreed to accept the House provision which requires the appropriate Federal officer to consult with the Secretary before making any Federal expenditures or financial assistance available under the provisions of Section 6.

Section 6(a)(1) provides an exception for energy projects in or adjacent to coastal areas. Both the Senate bill and the House amendment contained similar provisions and the Conferees agreed to adopt the House language. Federal assistance or expenditures may be made available for "any use or facility necessary for the exploration, extraction, or transportation of energy resources which can

DEPARTMENT OF THE INTERIOR

Office of the Secretary

43 CFR Subtitle A

Coastal Barrier Resources Act; Advisory Guidelines

AGENCY: Department of the Interior, Office of the Secretary.

ACTION: Rule-related notice and request for comments.

SUMMARY: This document sets forth the Department's general statement of policy and advisory guidelines regarding the provisions of the Coastal Barrier Resources Act (CBRA) that address limitations on Federal expenditures and financial assistance, and exceptions to the limitations.

DATES: Comments on this document will be accepted through May 12, 1983. The prohibitions on new Federal financial expenditures and assistance other than flood insurance were effective upon enactment of CBRA (October 18, 1982). The prohibition on the sale of new Federal flood insurance for new structures or substantial improvements will be effective October 1, 1983. The Federal Emergency Management Agency, which administers the National Flood Insurance Program, will issue instructions relating to this provision in the near future.

ADDRESS: Comments should be directed to Mr. Ric Davidge, Chairman, Coastal Barriers Task Force, U.S. Department of the Interior, Washington, D.C. 20240.

FOR FURTHER INFORMATION CONTACT: Mr. Frank McGilvrey, Coastal Barriers Coordinator, U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C. 20240; (202-343-5000).

SUPPLEMENTARY INFORMATION: On October 18, 1982, President Reagan signed the Coastal Barrier Resources Act (CBRA) into law (Pub. L. 97-348). The law establishes the Coastal Barrier Resources System as referred to and adopted by Congress, and prohibits all new Federal expenditures and financial assistance within the units of that System unless specifically excepted by the Act. These provisions of the Act became effective immediately. The Act also amends and conforms the Federal flood insurance provisions of the Omnibus Budget Reconciliation Act of 1981 (OBRA) pertaining to undeveloped coastal barriers. The statutory ban on the sale of new Federal flood insurance for new construction or substantial improvements in these areas will go into effect on October 1, 1983.

On November 19, 1982, the Department of the Interior published interpretive guidelines and a general statement of policies pertaining to that portion of the Department's responsibilities which concerned the coastal barrier resource system maps (47 FR 52388). Two actions were undertaken at that time: (1) Filing, distribution and availability of the Coastal Barrier Resources System maps, and (2) adoption of the Department's policy in administering these maps, specifically in regard to minor and technical boundary changes which may be made prior to April 18, 1983.

These guidelines elaborate on the definition of expenditures and financial assistance, the definition of "new" expenditures and financial assistance and prescribe guidelines for consultation with the Department. As stated by the Director of the Office of Management and Budget in a letter dated March 7, 1983 to the Secretary: "(OMB) fully agree(s) that questions regarding the limitations on financial expenditures be interpreted by all agencies in a consistent manner. Therefore (OMB) will look to the Department of the Interior to develop guidelines and definitions which all agencies, including OMB, can use."

1. *Environmental Effects:* These guidelines describe the procedures Federal agencies should follow in consulting with the Department of the Interior prior to making an expenditure on or providing assistance to activities excepted under Section 6 of CBRA. Such activities generally continue the status quo, provide localized environmental benefits or localized emergency disaster assistance. Therefore, the Department has determined that these guidelines will have no significant impact on the environment.

2. *Statement of Effects:* The Department of the Interior has determined that these interpretive guidelines are not a major rule under E.O. 12291 and certifies that this document will not have a significant economic effect on a substantial number of small entities under the Regulatory Flexibility Act. These guidelines will result in minimal cost to Federal agencies and some economic effects on local firms and businesses to the extent that they are engaged in activities excepted by Section 6 of CBRA and paid for or assisted by Federal funds.

3. *Paperwork Reduction Act:* These interpretive guidelines do not contain information collection requirements which require approval by the Office of Management and Budget under 44 U.S.C. 3501 *et seq.*

4. *Authorship Statement:* This document has been prepared by the Coastal Barriers Task Force within the Department of the Interior. The Chairman of the Task Force is Mr. Ric Davidge, Office of the Assistant Secretary for Fish and Wildlife and Parks.

5. *Public Participation:* Interested persons, organizations, Federal agencies and other entities are encouraged to submit comments on these guidelines. Comments will be accepted until May 12, 1983.

6. *Identification of Subjects:* An identification of subjects is not necessary because this document is not designed to be codified in the Code of Federal Regulations.

Coastal Barrier Resources System: Prohibition on New Federal Expenditures and Procedures for Consultation

I. *Definitions and Limitations*

Financial Assistance

The Act removes Federal incentives for development from the System units unless otherwise permitted by CBRA itself.

Section 3(3) provides the generic definition of financial assistance which defines the general scope of the Act: "any form of loan, grant, guaranty, insurance, payment, rebate, subsidy, or any other form of direct or indirect Federal assistance." On October 1, 1983, this definition will also include Federal flood insurance.

Section 5(a) of the Act provides the general prohibition on new Federal expenditures and financial assistance in System units and provides a listing of specifically prohibited expenditures or assistance. Section 5(a) states:

Except as provided in Section 6, no new expenditures or new financial assistance may be made available under authority of any Federal law for any purpose within the Coastal Barrier Resources System, including, but not limited to—

(1) Construction or purchase of any structure, appurtenance, facility or related infrastructure;

(2) Construction or purchase of any road, airport, boat landing facility on, or bridge or causeway to, any System unit;

(3) Assistance for erosion control or other stabilization of any inlet, shoreline, or inshore area, except in certain emergencies.

The Department has identified additional specific examples of Federal program expenditures and financial assistance prohibited in units of the Coastal Barrier Resources System under CBRA. We interpret the Act to include, but not be limited to, the following programs:

Department of Agriculture

Farmers Home Administration

—Loans for rural disaster relief, water systems, wastewater systems, commercial development, community services, subdivision development, and recreational facilities.

Rural Electrification Administration

—Loans for electrical system development.

Department of Commerce

Economic Development Administration

—Grants for planning and administering local economic development programs.

Office of Coastal Zone Management

—CEIP grants—(coastal energy improvement program).

Department of Defense

U.S. Army

Corps of Engineers

—Construction and financial assistance involving beach erosion control, hurricane protection, and flood control works.

Department of Energy

—Energy development programs.

Department of Housing and Urban Development

—Block grants for community development.

—Mortgage insurance, housing assistance or rehabilitation subsidy programs.

—Urban Development Action Grants.

Department of the Interior

National Park Service

—Grants to states for land acquisition and development of protected areas, and for preparation of State Comprehensive Outdoor Recreation Plans through the Land and Water Conservation Fund (where development of coastal barriers is addressed).

—Grants for historic preservation (for construction purposes).

Department of Transportation

Federal Aviation Administration

—Grants for airport planning and development.

Federal Highway Administration

—Federal assistance to states for highway construction.

Urban Mass Transportation Administration

—Capital improvement and operating grants.

Environmental Protection Agency

—Grants for wastewater treatment construction (Sec. 201 grants), water quality management planning (Sec. 208 grants).

Federal Emergency Management Agency

—Federal National Insurance Program.

—Disaster assistance program.

Federal Home Loan Administration

—Guaranteed housing loans.

General Services Administration

—Construction or reconstruction of Federal property.

Small Business Administration

—Loans to small businesses for disaster relief, upgrading of water treatment systems, and other purposes.

—Disaster assistance to homeowners.

Veterans Administration

—Guaranteed housing loans.

"New" Expenditures

CBRA's limitations on Federal expenditures and financial assistance are only applicable to "new" expenditures or "new" financial assistance. Section 5(a) specifically provides that:

Except as provided in section 6, no new expenditures or new financial assistance may be made available under authority of any Federal law for any purpose within the Coastal Barrier Resources System * * *

Section 5(b) articulates when an expenditure or financial assistance is established to be "new" and therefore precluded. Section 5(b) provides:

(b) An expenditure or financial assistance made available under authority of Federal law shall, for purposes of this Act, be a new expenditure or new financial assistance if—

(1) In any case with respect to which specific appropriations are required, no money for construction or purchase purposes was appropriated before the date of the enactment of this Act; or

(2) No legally binding commitment for the expenditure or financial assistance was made before such date of enactment.

As further established by the legislative history, this subsection creates a dual definition. The concept of new expenditures or new financial assistance is defined in terms of actions that require specific appropriations and actions that do not require specific appropriations.

First, a Federal expenditure or financial assistance that does not rest upon a specific appropriation is new, and therefore precluded, unless a legally binding commitment for the site-specific expenditure or financial assistance was made before October 18, 1982, when the President signed the bill into law. The applicable date for Federal flood insurance is October 1, 1983. General intentions, moral obligations, statements of intent or policy are not adequate. A legally binding commitment is one that establishes a right to the funds in question as a matter of law; that is, the right must be an obligation against the United States. Necessarily, such an obligation must rest upon the availability of appropriations in existence prior to the cut-off date of October 18, 1982, or on specific contract authority to obligate funds of the United States in advance of appropriations. There is no general authority to obligate funds of the United States absent the availability of appropriations from the Congress. Such an obligation would be in violation of the Anti-Deficiency Act.

Second, expenditures or financial assistance with respect to which specific appropriations are required are self-evident. These are discrete Federal expenditures—not operating on a general program appropriation as provided above—that are funded by individual line item reference directly within a specific Appropriation Act. This is typically done by recitation of a specific project name. Such a specific appropriation prior to October 18, 1982, permits the Federal expenditure or financial assistance to continue. Absent such a specific appropriation of the funds in question, however, the expenditure or financial assistance would be "new" and would be precluded.

II. *Exceptions and Consultation*

Section 6 of the Act outlines the specific exceptions to the general prohibition on new Federal expenditures or financial assistance. The law grants exceptions for energy projects which can only be carried out within the system; maintenance of channel improvements; maintenance of roads, structures or facilities that are essential links to a larger network or system; military activities essential to national security; and Coast Guard facilities. In addition to these five specific exceptions, Section 6(6) outlines seven other activities that may be excepted if the activity is consistent with the purposes of the Act.

Section 6(a) of the Act requires the appropriate Federal officer to consult with the Secretary before making any Federal expenditures or financial assistance available under the provisions of Section 6. Procedures for consultation follow the discussion of exceptions.

Exceptions

(1) *Energy projects (section 6(a)(1)).* Federal assistance may be made available for energy projects in or adjacent to coastal areas for "any use or facility necessary for the exploration, extraction, or transportation of energy resources which can be carried out only on, in, or adjacent to coastal water

areas because the use or facility requires access to the coastal water body." The legislative history (House Report 97–841) states that "this provision is intended to be read broadly in terms of energy projects. However, the provision should not be interpreted to allow assistance for projects primarily designed to encourage development but which might be carried out in the guise of energy development."

(2) *Channel improvements (section 6(a)(2)).* Maintenance of existing channel improvements and related structures, such as jetties can continue. The use of disposal sites for dredge materials is included under this exception, so long as the sites are related to, and necessary for, the maintenance of an existing project. Section 6(b) requires that an existing channel improvement or an existing related structure be funded, in part or totally, before the date of enactment, i.e., the channel must have existed or have had funds appropriated for construction before October 18, 1982. According to the legislative history, this is not a license or authority for construction of new channels.

The legislative history also states: The criterion for determining whether Federal assistance would or would not be precluded is the existence of the channel at the time of enactment of this legislation. If it is in existence, or if money has been appropriated for its construction, then any Federal financial assistance for activities to maintain it, including, for example, the complete reconstruction of jetties or other structures, would be permitted. It is also the Committee's intent that, because of the unstable nature of barrier islands, existing channels can be relocated periodically. (House Report 97–841).

(3) *Roads Structures or Facilities (section 6(a)(3)).* Maintenance, replacement, reconstruction, or repair, but not expansion, of publicly-owned or publicly-operated roads, structures, or facilities that are *essential links in a larger network or system* can continue. This exception is re-iterated in Section 6(a)(6)(f). However, that provision includes roads structures or facilities which may not be essential links in a larger system or network.

Consistent with the House legislative report on CBRA, the reference to "structures and facilities" appears to be limited to related roadworks, rather than such items as publicly-owned utilities. The legislative history indicates that the Congressional intent to include drains, gutters, curbs and other related roadworks under this exception. The House Report also emphasizes that financial assistance will not be provided for the expansion of such structures, roads or facilities. (House Report 97–840).

(4) *Military activities (section 6(a)(4)).* Military activities *essential to national security* are excepted. We note that the legislative history of this provision specifically provides that "this exemption should be read broadly and that the Department of Defense should be the judge of the essentiality of the actions: (House Report 97–841). The Conference Report (97–928) further clarifies the intent of this exemption by stating: "the determination as to whether military activities are essential to national security must be made in accordance with existing law and procedure."

(5) *Coast Guard (section 6(a)(5)).* Expenditure of funds or provision of financial assistance for the construction, maintenance, operation and rehabilitation of Coast Guard facilities can continue.

(6) *Conservation, navigation, recreation, scientific research, disaster relief, roads, shoreline stabilization (section 6(a)(6)).* The following actions or projects are excepted, *providing the expenditure is consistent with the purposes of the Act* as provided in Section 2(b) (i.e., to minimize loss of human life, wasteful Federal expenditures and damage to fish, wildlife and other natural resources).

(A) Projects for the study, management, protection and enhancement of fish and wildlife resources and habitats, including, but not limited to, acquisition of fish and wildlife habitats and related lands, stabilization projects for fish and wildlife habitats, and recreational projects.

The legislative history states: "This exception recognizes the value of System units as fish and wildlife habitats and is in complete conformity with the purposes of the legislation. It is intended that the full range of Federal financial assistance authorized for protecting and managing fish and wildlife habitats will continue to be available. This includes, where necessary, assistance for stabilization projects to protect valuable habitats. Federal funds for projects involving facilities for fish and wildlife-related recreation would also be allowed. It is intended by the Committee that any development of recreational facilities be consistent with the purposes of the legislation." (House Report 97–841).

The language finally agreed upon by the Conference Committee, however, agreed to accept the House language but qualified it by requiring that such actions must be consistent with the purposes of the Act.

(B) The establishment, operation, and maintenance of air and water navigation aids and devices, and for access thereto.

The legislative history indicates that, in almost every instance, placement and such aids and devices on undeveloped coastal barriers would be appropriate. (House Report 97–841).

(C) Projects under the Land and Water Conservation Fund Act of 1965 (16 U.S.C. 4601–4 through 11) and the Coastal Zone Management Act of 1972 (16 U.S.C. 1451 et seq.).

Clearly the legislative history applied to Section 6(a)(6)(A) would be generally applicable to this provision as well. Recreational use of system units should be encouraged so long as it is accomplished consistent with the purposes of the Act.

(D) Scientific research, including but not limited to aeronautical, atmospheric, space, geologic, marine, fish and wildlife and other research, development, and applications.

(E) Assistance for emergency actions essential to the saving of lives and the protection of property and the public health and safety, if such actions are performed pursuant to sections 305 and 306 of the Disaster Relief Act of 1974 (42 U.S.C. 5145 and 5146) and section 1362 of the National Flood Insurance Act of 1968 (42 U.S.C. 4103) and are limited to actions that are necessary to alleviate the emergency.

Section 305 of the Disaster Relief Act authorizes the President, in a declared emergency, to provide any or all of the assistance available under the Act as the President deems appropriate.

(F) The maintenance, replacement, reconstruction, or repair, but not the expansion, of publicly owned or publicly operated roads, structures, or facilities. There is a distinction between this exception, which may be applied if the action is consistent with the purposes of the Act, and the exception cited in Section 6(a)(3), which requires that the action be one that is an essential link in a larger network or system.

(G) Nonstructural projects for shoreline stabilization that are designated to mimic, enhance, or restore natural stabilization systems.

The legislative history cites the planting of dune grass or other beach nourishment activities as examples of these projects.

While it is the responsibility of the appropriate Federal officer to determine whether an action permitted under this section is consistent with the purposes of the Act, it is equally the Department of the Interior's responsibility to provide technical information and to comment, when asked, on the proposed action in terms of its consistency with those same purposes.

III. *Consultation*

Federal Agencies should consult with the Secretary of the Interior and allow him the opportunity to provide written comment prior to making Federal expenditures or financial assistance available for an action excepted under Section 6 of CBRA within a CBRS unit. Compliance with this provision of the law rests initially on the Federal officer responsible for making the funds or financial assistance available for a permitted action. The Secretary's responsibility is to respond to a consultation request by providing technical information and comments on the question of consistency with CBRA.

Consultation Process

The consultation process will be carried out at two operational levels.

First, discrete projects identified in an agency's budget proposal should be submitted to the Fish and Wildlife Service, Department of Interior, for comment at least 45 days prior to transmittal to OMB. The Fish and Wildlife Service will acknowledge receipt of the transmittal, review the project, consult with the agency as necessary and provide a written response within 30 days through the Assistant Secretary for Fish and Wildlife and Parks.

On projects that are subject to provisions of NEPA, consultation should be accomplished early enough to permit the results to be included in the draft environmental statement or other appropriate environmental document.

Second, consultation requests for maintenance type projects such as channel maintenance or highway repair, that are managed by agency field-level officials should be made through the appropriate Regional Director of the Fish and Wildlife Service.

The Act provides for two levels of exception. Section 6(a)(1–5) clearly allows certain designated Federal activities. When consulting on these activities, the Department will simply provide technical information and register an opinion as to whether the activity in fact is that which the clause allows.

Section 6(a)(6) provides an additional caveat for the included list of exceptions that emphasize the requirement that the action "* * * is consistent with the purposes of this Act."

For activities falling under this subsection, the Department will also comment on the consistency of the proposed action with the purposes of CBRA as stated in Section 2(b): "* * * to minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife and other natural resources associated with coastal barriers along the Atlantic and Gulf coasts."

Several Federal agencies requested clarification of certain exceptions or rendered an opinion as to their interpretation. We propose that bilateral discussions between each affected agency and the Department be initiated to clarify their concerns and to establish procedures for the conduct of consultations.

The Department consultation officer is Mr. Frank McGilvrey, U.S. Fish and Wildlife Service, (202), 343–5000. Each agency affected by the Section 6 exceptions should have its consultation officer contact either Mr. Davidge or Mr. McGilvrey at their earliest convenience.

Dated: April 19, 1983.

J. Craig Potter,

Acting Assistant Secretary for Fish and Wildlife and Parks.

[FR Doc. 83–10758 Filed 4–22–83; 8:45 am]

BILLING CODE 4310–70–M

Office of Hearings and Appeals

43 CFR Part 4

Adoption of Regulations Implementing the Equal Access to Justice Act

AGENCY: Office of Hearings and Appeals, Interior.

ACTION: Final rule with request for comments.

SUMMARY: The Office of Hearings and Appeals in the Department of the Interior is issuing a final rule to implement the Equal Access to Justice Act (Pub. L. 96–481, 5 U.S.C. 504 (Supp. IV 1980)).

DATES: This rule is effective on April 25, 1983.

Written comments must be received on or before June 24, 1983.

ADDRESS: Written comments should be sent to Director, Office of Hearings and Appeals, Department of the Interior, 4015 Wilson Boulevard, Arlington, Virginia 22203.

FOR FURTHER INFORMATION CONTACT: Patrick Sheehy, Office of Hearings and Appeals (703) 235–3750; Deborah Ryan, Office of the Solicitor, (202) 343–5216.

SUPPLEMENTARY INFORMATION: The Equal Access to Justice Act (Pub. L. 96–481, 5 U.S.C. 504 (Supp. IV 1980)) provides for the award of attorneys fees and other expenses to certain parties who prevail over the Federal Government in administrative proceedings conducted under section 554 of the Administrative Procedure Act (5 U.S.C. 554) in which the position of the United States is represented. The Equal Access to Justice Act requires each agency that conducts proceedings covered by the Act to establish uniform procedures for making awards after consultation with the Chairman of the Administrative Conference of the United States.

On March 10, 1981, the Chairman of the Administrative Conference published a draft model rule for Federal agency implementation of the Act and requested public comment on the rule (46 FR 15895). On June 25, 1981, the Chairman issued a model rule for the guidance of Federal agencies in implementing the Act (46 FR 32900). The Office of Hearings and Appeals has followed the model rule as well as guidance provided by the Office of Management and Budget in establishing its procedures for making awards under the Act.

The Department has determined that the requirements for notice and public comment on the rule has been satisfied, because the public had an opportunity to comment on the model rule issued by the Administrative Conference that was used as the basis for this rule. However, consistent with the Department's public participation policy, public comments on the rule are invited. The Department will consider all comments received and make such amendments to the rule as may be appropriate.

Because the Act became effective October 1, 1981, the Department has found that good cause exists for waiving the usual 30-day waiting period before the rule becomes effective. Waiver will allow immediate implementation of the Department's procedures under the Act.

The Department has determined that the rule is not major and does not require a regulatory impact analysis under E.O. 12291, because the rule is not expected to have an annual effect on the economy of $100 million or more or to result in substantial increases in costs or prices for the Department or other parties involved in administrative proceedings conducted by the Office of Hearings and Appeals. The Department has also determined that the rule will

INVENTORY OF HABITAT MODIFICATIONS TO SANDY OCEANFRONT BEACHES IN THE U.S. ATLANTIC COAST BREEDING RANGE OF THE PIPING PLOVER (*CHARADRIUS MELODUS*) AS OF 2015: MAINE TO NORTH CAROLINA

January 2017

revised March 2017

Prepared for the North Atlantic Landscape Conservation Cooperative and U.S. Fish and Wildlife Service

by Terwilliger Consulting, Inc.

Tracy Monegan Rice
tracymrice@yahoo.com

Table 32. A comparison of the extent of sediment placement projects modifying sandy beach habitat in a number of states within the U.S. Atlantic Coast breeding range of the piping plover in the three years following the Ash Wednesday Storm of 1962 and Hurricane Sandy of 2012.

State	Length of Sediment Placement after Ash Wednesday Storm of 1962 (miles)	Length of Sediment Placement after Hurricane Sandy of 2012 (miles)
NY (Atlantic Ocean)	17.21	44.98
New Jersey	42.05	68.36
Delaware	14.18	7.65
Maryland	29.10	10.32
Virginia	19.90	12.68
TOTALS	**143.54**	**165.09**

Artificial dunes are often constructed to protect development along the oceanfront, including more than 72 miles (116 km) of beaches and dunes during the federal Operation Five-High following the Ash Wednesday Storm of 1962 alone. Artificial dunes were constructed along entire barrier islands in the 1950s and 1960s, including both the Maryland and Virginia portions of Assateague Island. Artificial dune lines are maintained and protected by local or state laws in many places. Federal sediment placement projects typically include the construction of artificial dunes. Local communities construct artificial dunes with fill material hauled in by truck or pumped in with dredged material, use armoring to protect dune faces, or scrape sand from the beach to rebuild dunes. Miles of sand fencing and vegetation plantings are used to maintain these artificial dunes in place. Mitteager et al. (2006, p. 892) state that the regulation in New Jersey protecting dunes "is written for shore protection, not habitat, aesthetic or heritage value. Direct disturbance to the dunes that would reduce their dimensions is prohibited, but sand can be added by earth-moving equipment, and vegetation may be planted."

Magliocca et al. (2011, p. 918) describe these type of modifications to sandy oceanfront barrier islands:

> *Interactions between human manipulations and landscape processes can form a dynamically coupled system because landscape-forming processes affect humans, and humans increasingly manipulate landscape-forming processes. Despite the dynamic nature of sandy barrier islands, economic incentive and recreational opportunities attract humans and development. Storm-driven sediment-transport events that build barrier islands constitute hazards to humans and infrastructure, and manipulations aimed at preventing or mitigating such events link human actions and long-term island morphodynamics.*

Magliocca et al. (2011, p. 918) investigated "how the behavior of a natural barrier island differs from one in which humans are dynamic system constituents," focusing on the impacts of removing overwash deposits following storms and rebuilding artificially high and continuous dunes. They conclude that (Magliocca et al. 2011, p. 928):

> (1) *Artificially high dunes filter out high-frequency, small-scale storm impacts, which result in less overwash deposition over time. The introduction of artificially high dunes drives the overwash regime toward less-frequent and higher-amplitude overwash events. Storms that finally overtop artificial dunes impact a back-barrier environment that is lower than it would otherwise have been, which amplifies the severity of the overwash or inundation.*
>
> (2) *The long-term exclusion of overwash from the back-dune environment tends to amplify the effects of sea level rise because island elevation landward of the dune line is fixed despite continuously rising sea levels. Reconstruction of artificial dunes, by mining the overwash deposits, reinforces relatively low island elevations for long periods. In the [human/barrier island] coupled system, flooding frequency increases as the difference between storm-induced water levels and island elevations relative to sea level grows.*
>
> (3) *The obstruction of overwash decreases the availability of on-site sand for dune reconstruction. As the heights of maintained dunes increase, sand must be imported from off-site and at a higher rate …. Road relocation— the consequence of significant coverage or washout of the roadbed due to overwash occurs more frequently as artificial dune height increases ….*
>
> (4) *The natural system migrates landward relatively continuously …, but the [human/barrier island] coupled system's back-barrier shoreline is fixed for long periods. The disruption of overwash promotes thinning of the island as the seaward shoreline migrates landward (caused by sea-level rise, gradients in alongshore sediment flux, and low-frequency overwash events), whereas the back-barrier shoreline moves very little.*

The authors found that the construction and maintenance of artificial dunes block minor and moderate overwash events, resulting in a narrower and lower island in the long-term. Then "when dunes are overtopped, the sediment redistributions are more severe. …Increasing the height of artificially maintained dunes increases the rate of island narrowing and, therefore, infrastructure relocation, and increases the need for sediment to be imported from outside the system" (Magliocca et al. 2011, p. 918).

Large scale sediment placement projects may have similar long-term impacts. Tanski (2012, p. 23) states that for Long Island's oceanfront beaches, "Since inlets are the primary mechanisms for transferring sediment landward along Long Island's barrier island systems, nourishment projects that cover large areas and are maintained for very long periods of time could lower the rate of cross shore sand transport and, eventually, affect barrier island migration … [but] it [is] very difficult to determine how a nourishment project might alter long-term barrier migration rates or how long it would take." These so-called "soft" stabilization methods of using fill material to modify sandy oceanfront beaches and dunes therefore may result in long-term, landscape-level impacts to the natural system.

The preference for nonstructural alternatives[47] to erosion control by most of the states in the U.S. Atlantic Coast breeding range of the piping plover (Table 31) suggests that sediment placement projects, including the building and maintenance of artificial dunes and beach nourishment projects, will increase as sea level continues to rise at an accelerating rate and storm intensity is expected to increase with climate change.

Beach Scraping

Beach scraping alters the profile of the beach and creates dunes that are not structured internally like natural dunes, resulting in artificial dunes that do not function the same as natural dunes. Removing the top layer of sediment from the beach removes the invertebrate prey base for foraging shorebirds, including the piping plover. Beach scraping with bulldozers alters the microtopography of the beach, both by leaving ruts or scrape marks but also by compacting the surface with the heavy equipment. The beach berm profile is lowered, which may increase the vulnerability of shorebird and waterbird nests to flooding. In one study on Bogue Banks, NC, Conaway and Wells (2005) found that beach scraping resulted in altered dune morphology, increased aeolian (windblown) sediment transport rates, modified dune sediment characteristics, and denuded dune faces; long-term potential impacts included accelerated migration of the dunes and a depleted longshore sediment budget. Peterson et al. (2000, p. 368) found that beach scraping reduced the width of the intertidal beach, replacing "it with a wedge of coarser, shellier sand taken from the lower beach." The beach scraping reduced densities of mole crabs (*Emerita talpoida*) by 35-37%, significantly lowered (55-65%) counts of active burrows of ghost crabs (*Ocypode quadrata*), and showed mixed results for densities of *Donax* spp. (Peterson et al. 2000).

At least 68 miles (109 km) of sandy beach habitat from Maine to North Carolina was modified by beach scraping between 2012 and 2015, with the heaviest concentrations occurring along the South Shore of Long Island and in New Jersey (Table 6). In this habitat assessment, beach scraping was found to be rare to nonexistent on beaches backed by bluffs or armor, and much more common on beaches where dunes are present. Some municipalities have 10-year permits to scrape the beach whenever necessary and conditions allow. In other instances, individual property owners, including some state lands, conduct beach scraping to construct artificial dunes in localized areas. Cumulatively these individual and municipal beach scraping activities have modified at least 6% of the sandy beach habitat in the U.S. Atlantic Coast breeding range of the piping plover. Immediately after Hurricane Sandy, overwash material was scraped off of paved surfaces and developed areas in Rhode Island, Connecticut, New York, New Jersey and Delaware, the areas most affected by the storm. This overwash material was almost always returned to the beach, creating artificial dunes from the landward side rather than the seaward

[47] Nonstructural alternatives to hard shoreline stabilization structures (i.e., bulkheads, seawalls, revetments, groins) typically include relocation of structures, elevation of structures, beach fill, dune building or vegetation planting, or the construction of "living shorelines" which include marsh creation, slope grading, creation or restoration of oyster reefs, the installation of offshore sills with marsh plantings and/or fill landward of the sill(s), and may also include the use of coir fiber logs in some states. In several states, including RI, CT, NY, NJ, DE, MD and VA, the use of nonstructural alternatives must be shown to be infeasible or impractical before hard shoreline stabilization alternatives may be considered.

side. The NC DOT regularly scrapes overwash material off of NC 12 on the Outer Banks and reconstructs artificial dunes to protect the roadway. NRC (2014, p. 90) found that "this procedure [scraping overwash material back to the beach] hinders the natural migration of the beach." Both types of scraping modify the natural profile of the beach and eliminate flat, bare sand overwash flats that are highly valuable to shorebirds and waterbirds. As climate changes and sea level rises, with the potential to increase the frequency or magnitude of storm events, the threat of beach scraping to sandy beach habitat is likely to increase.

Sand Fencing

The use of sand fencing to modify sandy beach habitats dates back to the 15th century (Grafals-Soto 2012). While less invasive than other types of habitat modification, since fencing harnesses natural aeolian (windblown) sediment to construct dunes, sand fencing nevertheless alters the beach profile by creating dunes in a location and configuration dictated by humans rather than natural processes. When fences are installed seaward of houses, as they commonly are, the sand fencing displaces the dune crest farther seaward than would naturally occur (Nordstrom and McCluskey 1985). Sand fencing is not often removed after accumulating sediment and can remain in place for long periods of time, becoming exposed and leaving debris on the beach after major storm events. Partially buried sand fencing can alter the distribution of vegetation (Grafals-Soto 2012). The installation of sand fencing in overwash areas following major storms such as Hurricane Sandy hastens the conversion of flat, bare overwash areas to elevated, vegetated dune habitat. The presence of sand fencing on the beach, particularly if oriented in continuous straight lines without gaps, can pose an impediment to the movement of unfledged chicks as well as sea turtles (which may nest in some parts of the Southern Recovery Unit).

Nordstrom and McCluskey (1985, p. 44) found that sand fencing, particularly when located close to houses, "considerably reduce the volume of sand which passes the dune crest," reducing the aeolian sediment budget landward of the beach. The study concludes that "The implementation of controls on house construction and other uses of the dune without consideration of the changes induced by sand fences would be shortsighted, and planners should consider implementing stricter controls on the use of sand fences" (Nordstrom and McCluskey 1985, p. 45).

While Grafals-Soto (2012, p. 45) determined that the impacts of sand fencing can be minimized by prioritizing "the creation of topographically diverse dunes within a restricted space [that] may increase the diversity and density of the vegetation, and the resilience and value of developed [artificially-created] dunes," such a prioritization favors the dune ecosystem rather than the sandy beach ecosystem with sparsely vegetated, flatter topography utilized by beach-nesting birds. Nordstrom et al. (2012) found that sand fencing and beach raking resulted in higher dune crest heights than naturally formed dunes at an unmanaged site, but the volume of sediment within the dune and beach was greater at the site without sand fencing and beach raking; an additional dune ridge was present at the site without sand fencing as well. Species diversity and concentration was higher, particularly in the dune swales, at the site without sand fencing and beach raking; the number and types of microhabitats were greater at the unmanaged sites (Nordstrom et al. 2012).

Sand fencing was identified along sandy beaches in every state of the U.S. Atlantic Coast breeding range of the piping plover between 2012 and 2015, but was rare on narrow beaches backed by bluffs or armor. Where barrier islands dominate the coast, sand fencing was much more common. Altogether at least 246 miles (396 km) of sandy beach habitat was modified by sand fencing between 2012 and 2015, with the heaviest concentrations occurring along the South Shore of Long Island and in New Jersey and Delaware (Table 7).

Habitat Sustainability

A sustainable coastal ecosystem is one which can continue to provide a full suite or range of ecosystem services in the long term with climate change, particularly with sea level rise. Sustainable coastal systems maintain their full mosaic of habitats and ecosystem functions over time, adapting to climate change and sea level rise in particular. Sandy beach habitat is maintained over time, moving or migrating in space as natural processes and conditions warrant. Sustainable coastal systems are physically and ecologically resilient to climate change and sea level rise, able to adapt in location (and potentially size) but always providing the full range of ecosystem services.

Beaches that have been modified with hard shoreline stabilization structures, or armoring, are not sustainable in the long term. As sea level rises, sandy beaches will be lost seaward of shore-parallel structures. Beaches that are armored are slower to recover following a major storm, perhaps not able to recover fully at all (Morton et al. 1994). The presence of the armoring interferes with the natural processes of profile recovery and prevents the landward migration of the beach profile (and thus the habitats along the profile).

Sandy beaches modified with sediment placement may be sustainable in the short-term, but may not be sustainable in the long-term. Beach compatible sediment is a finite resource that is not equally or uniformly distributed along the U.S. coast. As sea level rises, increasing volumes of sediment will be necessary to maintain or sustain a beach in its historical location and dimensions. Barrier islands and spits must increase their elevation to be sustainable with sea level rise – a process that naturally occurs through overwash and Aeolian (windblown) movement of sediment inland. In locations where these natural processes are blocked, through the construction and artificial maintenance of dune ridges or levees (whether that be through sediment placement, beach scraping, sand fencing and/or planting of vegetation), the barrier island or spit will not be naturally elevated as sea level rises and will be less physically resilient to flooding events and storms. In the long term, these locations will need to be artificially elevated as Jones Beach (NY), Long Beach (NY), Miami Beach (FL) and Galveston (TX) were nearly a century ago when they were originally developed (or recovering from a major hurricane in the case of Galveston). The presence of existing infrastructure roadways, recreational facilities, buildings, boardwalks, utilities will make such artificial elevation projects very difficult, if not impossible, to construct. Nevertheless, in a few locations (i.e., Sea Isle City, NJ, and Miami Beach, FL) have begun to artificially elevate low-lying roadways. The extraordinarily high volumes of sediment required to raise the elevation of a barrier island or spit artificially also limits the viability of sediment placement projects to sustain beaches and barrier islands; the elevation of Jones Beach (NY) involved over 40 million cubic yards (30.6 million cubic meters) of sediment, an order of magnitude higher than the typical federal large-scale beach nourishment project. As a result, sediment placement is only likely to be sustainable to maintain sandy beaches in a very small number of locations as sea level rises over the long-term.

The habitat modifications inventoried in this assessment quantify the cumulative impacts to sandy beach habitat from Maine to North Carolina, providing the opportunity to evaluate the sustainability of the habitat as climate changes and sea level rises at an accelerating rate. The cumulative impacts of the habitat modifications evaluated in this habitat assessment are significant, major, widespread and long-term within the U.S. Atlantic Coast breeding range of the piping plover. Future impacts of human modifications to sandy beach ecosystems can be avoided, minimized and mitigated, as described in Rice (2009) and USFWS (2012). Best management practices to avoid impacts from proposed habitat modifications include avoiding the construction of new development, armor or sediment placement projects in areas of sandy beach habitat that support high populations of nesting, foraging or roosting shorebirds, waterbirds, other wildlife of conservation concern, or vulnerable plants. Shore protection projects can be scheduled to avoid seasons of high biological productivity, such as during nesting and migration (NRC 2014). Overwash material can be allowed to remain in place, naturally elevating the back beach and interior areas, reducing the vulnerability of the areas to future flooding events and sea level rise. The artificial closure or opening of new inlets can be avoided, sustaining valuable sandy beach habitat on inlet shoulders and barrier spits. Avoid installation of sand fencing at current or potential piping plover breeding sites (USFWS 1996).

For habitat modifications that cannot be avoided, human impacts to sandy beach habitat can be minimized in a number of ways. Sediment placement episodes can be scheduled farther apart to allow full recovery of all ecosystem functions between placement episodes. Sediment placement projects can be designed to more closely mimic natural geomorphology that includes dune gaps and overwash areas. Constructing large sediment placement projects in several small projects can reduce the magnitude of the impact; the deposition of repeated thin layers of sediment (< 30 centimeters) can minimize the risk of killing all invertebrate fauna with deep burial (Defeo et al. 2009, NRC 2014). Gaps can be incorporated within large sediment placement project areas that can serve as refugia for invertebrate fauna (Bishop et al. 2006, Defeo et al. 2009, Schlacher et al. 2012, NRC 2014). Ensuring that sediment placed on the beach is compatible, or as close as possible in grain size, shape, color and composition, with the native sediment on the beach can minimize impacts of sediment placement projects (Peterson et al. 2006, Defeo et al. 2009, NRC 2014). Groins can be notched or designed to be "leaky" to allow for more passage of sediment from one side of the groin to the other (USACE 2002). Dredged material can be placed in the nearshore or on adjacent beaches to retain the sediment within the local system, minimizing impacts to adjacent sandy beach habitat that may have increased erosion rates resulting from the creation of sediment sinks within dredged inlets. Sand fencing can be installed in a manner that does not block faunal passage and in a location that mimics natural site selection of dune development. Sand fencing and sufficient time can be used to build dunes rather than sediment placement and/or heavy equipment. Cumulative impacts to localized areas can be minimized by avoiding or removing some of the human modifications contributing to those cumulative impacts.

Human modifications to sandy beach habitat also may be mitigated by enhancing or restoring habitat. Peterson and Bishop (2005) called for compensatory mitigation of injury to public trust resources resulting from sediment placement projects and beach scraping, including remediation of sediment placement projects that used incompatible material, which increase the adverse impacts of sediment placement. A compensatory mitigation banking system such as the one used in many states for wetlands could be developed to mitigate human habitat modifications to sandy beach ecosystems (Peterson and Bishop 2005). Mitigation for proposed habitat modifications can include the removal of habitat modifications, ideally as close to the site of new proposed habitat modifications as possible to maximize benefits to species with high site fidelity or limited range.

Armor can be removed as happened in some areas of Rhode Island following Hurricane Sandy. Nordstrom and Jackson (2013, p. 171) state that "Coastal landforms and habitats require space to reform in response to storm damage to increase the likelihood of long-term sustainability." Their study evaluated the removal of hard shoreline stabilization structures to facilitate the migration of landforms and their habitats with rising sea level along the bayside shoreline of a barrier spit in the Sandy Hook Unit of Gateway National Recreation Area in New Jersey. They found that if widespread removal of structures is undertaken, new sediment sources would be restored to the shoreline and the "slightly wider breaches and higher dunes that would form in locations downdrift of new sediment sources would reduce the likelihood of overwash and breaches, which could result in a more homogenous suite of landforms and habitats alongshore and greater sheltering of the coves landward of them" (Nordstrom and Jackson 2013, p. 190). Removal of smaller structures may be costly but "can result in the most rapid reversion to a fully functioning natural ecosystem" (Nordstrom and Jackson 2013, p. 190).

Sandy beach habitat can be restored not only through the removal of hard stabilization structures, but also by the abandonment or purchase of private property and removal of buildings and associated infrastructure. This restoration of the entire barrier spit ecosystem has recently taken place in at least 3 locations between southern Maine and northern Long Island. At what is now Sound Views Dune Park in Southold, NY, the Town of Southold and Suffolk County purchased a 57-acre single family residence in 2008 that had approximately 0.27 miles (0.43 km) of LIS beach shoreline. In 2009 the County and Town sought "to undevelop the entire property" and removed the residential structures, swimming pool, septic tank, underground oil tank and 310 ft (94.49 m) of timber bulkhead that surrounded the residence, which protruded out into Long Island Sound across the beach, acting like a groin (Town of Southold 2012, p. 5). The disturbed areas were subsequently planted with native beach and dune species to restore the double dune system[48]. Further plans have been made (and perhaps implemented) to remove utility poles and the section of the long driveway closest to the beach, restoring even more of the landscape (Town of Southold 2012).

At West Meadow Beach near Stony Brook, NY, there were 94 summer cottages and buildings, a parking lot and a single road on a barrier spit visible in 2004 Google Earth imagery. By 2006-07, only 5 buildings and the road remained with the rest of the spit restored to natural conditions. The Town of Brookhaven owns West Meadow Beach and with the restoration of the southern portion of the barrier spit, the public lands protect 1.34 miles (2.16 km) of contiguous sandy beach habitat.

---

[48] A double dune system occurs where two rows of dunes (primary and secondary) separated by a swale are found at the back of a beach instead of a solitary line of dunes.

More recently, in Connecticut, the Long Beach West Restoration Project restored a barrier spit in Stratford near the Bridgeport town boundary. The 2011 restoration project removed the remnants of 37 cottages, 25 outbuildings, retaining walls, 4 docks, debris and trash from Long Beach West, which is adjacent to the Great Meadows Unit of the Stewart B. McKinney NWR (US DOI 2015). The spit had been cut off from mainland Bridgeport when a bridge connecting the two burned in 1996, eventually necessitating the abandonment of the seasonal cottages and their leases on the spit due to a lack of access for emergency services. Restoration of the spit was a collaborative effort (led by the USFWS) between the federal government, state of CT, Town of Stratford and several private and NGO partners (Motavalli 2012, US DOI 2015).

Other forms of mitigation can include alterations to existing management practices and policies. Management practices can be modified to no longer include installation of sand fencing or the use of beach scraping to construct artificial dunes in overwash areas following storm events, which USFWS (1996) recommends avoiding to the extent possible to allow the characteristics of preferred piping plover habitat to continue unimpeded. Where overwash has been prevented by previous management practices or habitat modifications, dunes can be notched to allow future overwash events, which was done at Assateague Island NS in 2008 and 2009 (Schupp and Coburn 2015). Sand fencing that has been buried can be removed. Where appropriate, thick vegetation can be thinned or removed to restore sparsely vegetated nesting habitat for shorebirds and waterbirds. In areas where all sandy beach habitat has been lost due to armor, and it is not possible to remove the armor or development behind it, sandy beach habitat can be restored through sediment placement projects (NRC 2014). In some locations of New Jersey, such as Sea Bright, sandy beach habitat was lost for a long period of time seaward of armor but was restored through construction of a large, federal sediment placement project.

Sandy beach ecosystems are highly dynamic. Sediment is continually exchanged between the beach and dune systems. Overwash deposits allow barrier islands to migrate and raise their elevation as sea level rises. Inlets open, migrate and close, creating new sediment deposits on the bayside of barrier islands. "Natural dynamism thus is not a threat to maintenance of barrier islands and spits under natural conditions; however, it is a threat to human facilities with a fixed position on inherently mobile landforms" (National Research Council [NRC] 2014, p. 86). If the rate of change increases in the future from accelerating rates of sea level rise, or from declining sediment supplies, sandy beach habitats may be less sustainable and vulnerable to the fragmentation of barrier islands (through new inlet formation) or submergence (Fenster et al. 2011, NRC 2014, Riggs et al. 2011).

The maintenance of development and beaches in place threatens the sustainability of sandy beach habitat as sea level rises. "An important adverse environmental effect of building unnaturally high dunes on barrier islands is that by protecting against overwash, the dunes prevent natural accretion processes that help the island sustain itself. Barrier islands and spits are prevented from keeping pace with sea-level rise or from reestablishing now-rare dynamic habitats, such as washover fans that are favored environments for piping plovers (Maslo et al., 2011; Schupp et al., 2013" (NRC 2014, p. 93). Sims et al. (2013, p. 339) found that sandy beach habitat valuable to the piping plover will be sustainable in Rhode Island, migrating landward, "if unconstrained by future development." The migration, and sustainability, of sandy beach habitat

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER

10.1002/2017GL074811

Key Points:
- Observations combined with a morphodynamic model forecast barrier island response to sea level rise (SLR)
- For a moderate SLR rate, 28% of the barrier island is forecast to be vulnerable to SLR
- Human alterations to barrier estuary geomorphology and sediment fluxes increase vulnerability to SLR and may accelerate drowning

Supporting Information:
- Supporting Information S1

Correspondence to:
J. L. Miselis,
jmiselis@usgs.gov

Citation:
Miselis, J. L., & Lorenzo Trueba, J. (2017). Natural and human induced variability in barrier island response to sea level rise. *Geophysical Research Letters*, *44*, 11,922 11,931. https://doi.org/10.1002/2017GL074811

Received 31 JUL 2017
Accepted 17 NOV 2017
Accepted article online 20 NOV 2017
Published online 11 DEC 2017

Natural and Human-Induced Variability in Barrier-Island Response to Sea Level Rise

Jennifer L. Miselis[1] and **Jorge Lorenzo-Trueba**[2]

[1]U.S. Geological Survey, St. Petersburg, FL, USA, [2]Center for Environmental and Life Sciences, Montclair State University, Upper Montclair, NJ, USA

Abstract Storm-driven sediment fluxes onto and behind barrier islands help coastal barrier systems keep pace with sea level rise (SLR). Understanding what controls cross-shore sediment flux magnitudes is critical for making accurate forecasts of barrier response to increased SLR rates. Here, using an existing morphodynamic model for barrier island evolution, observations are used to constrain model parameters and explore potential variability in future barrier behavior. Using modeled drowning outcomes as a proxy for vulnerability to SLR, 0%, 28%, and 100% of the barrier is vulnerable to SLR rates of 4, 7, and 10 mm/yr, respectively. When only overwash fluxes are increased in the model, drowning vulnerability increases for the same rates of SLR, suggesting that future increases in storminess may increase island vulnerability particularly where sediment resources are limited. Developed sites are more vulnerable to SLR, indicating that anthropogenic changes to overwash fluxes and estuary depths could profoundly affect future barrier response to SLR.

Plain Language Summary Barrier islands, thin strings of islands offshore of mainland coasts, are the first line of defense for protecting estuaries and mainland population centers from storms. They are also important for tourism that drives many coastal economies. Sand movement to the top of and across barrier islands is how they keep pace with sea level rise (SLR), so restrictions to those processes may make barrier islands more vulnerable to SLR effects. In our study, we used observations from New Jersey, USA, as inputs to a model that forecasts barrier island changes in response to SLR. This is particularly important for New Jersey, which is expected to experience rates of relative SLR that are higher than average. We found that 28% of the barrier island was vulnerable to a moderate rate of SLR and 100% of the barrier island was vulnerable to a high rate of SLR. Furthermore, we found that barrier island vulnerability increased in heavily populated locations relative to less populated locations. This suggests that human changes to coastal systems likely impact the lifespan of barrier islands. If some barrier islands degrade faster than others, their ability to protect mainland coasts and sustain coastal communities and economies could be compromised.

1. Introduction

Most barrier islands formed and evolved during the last 6,000 years (McBride et al., 2013) when rates of sea level rise (SLR) were lower compared to the early Holocene (Fleming et al., 1998; Kemp et al., 2011; Khan et al., 2015; Milne et al., 2005). Given increased SLR rates forecast for the future (Church et al., 2013; Jevrejeva et al., 2014; Kopp et al., 2014; Miller et al., 2013), there is interest in predicting how these highly dynamic landforms will respond (Lentz et al., 2016). This is a challenging problem because it requires the integration of episodic, cross-shore processes (e.g., storms; Plant & Stockdon, 2012) with long-term processes (e.g., SLR; Lentz et al., 2016) that are often addressed separately (Roelvink, 2015). Perhaps more important, however, is the recognition that humans interact with these coastal landscapes (Lazarus et al., 2016; McNamara et al., 2011; McNamara & Werner, 2008a, 2008b; Nordstrom, 2000), ultimately altering coastal morphology and sediment fluxes (Miselis et al., 2016; Rogers et al., 2015). This suggests that barrier islands may not evolve as they have over observable geological and historical time scales, further complicating forecasts of future behavior.

In response to these challenges, simplified morphodynamic models have been used to evaluate sensitivity of barrier island response to SLR to controlling factors, such as coastal geology and morphology (Moore et al., 2010; Wolinsky & Murray, 2009), coastal development (McNamara & Werner, 2008a, 2008b; Rogers et al., 2015), and cross-shore sediment fluxes (Lorenzo-Trueba & Ashton, 2014). Simplification of coastal systems is achieved through various assumptions, such as alongshore-uniform morphology, idealized or geometric cross-shore morphology, and/or assuming the dominance of either cross-shore or alongshore sediment transport. These steps may allow for identification of primary influences on rates of barrier retreat (Moore et al., 2010) and exploration of a range of possible response outcomes (Lorenzo-Trueba & Ashton, 2014) and how they change due to land-use-related reductions in overwash flux (Rogers et al., 2015). However, they can also make it difficult to determine the extent to which model results have real-world relevance, particularly for areas with significant spatial variability in coastal development, morphology, and geology.

In this paper, we attempt to bridge the gap between exploratory modeling results (Murray, 2003) and possible real-world outcomes by combining site-specific geomorphological and storm-response observations with a simple, long-term morphodynamic model. In doing so, we are able to explore how alongshore variability in island-estuary geomorphology and sediment fluxes influences modeled barrier response to SLR. The model forecasts millennial-scale (~2,000 years) barrier island behavior given cross-shore fluxes, barrier-estuary morphology, and rates of SLR, and we constrain these values based on empirical pre- and post-Hurricane Sandy observations from coastal New Jersey, USA. Because observations span both natural and developed environments, we evaluate the impact of human alterations to the coastal system on possible long-term barrier behavior. Though the integration of short-term observations and long-term, highly simplified modeling cannot provide explicit outcomes for any location, this exercise explores how varying combinations of coastal geometry, overwash fluxes, and development may contribute to future barrier island vulnerability to SLR.

2. Data and Methods

2.1. Study Area and Observational Data

The study area is located in New Jersey in the Mid-Atlantic Bight on the eastern coast of the U.S. (Figures 1a and 1b). It includes Barnegat Bay, a back-barrier estuary, and Island Beach, a barrier spit, which ends at Barnegat Inlet. Island Beach State Park occupies the southernmost 15 km of Island Beach and represents an undeveloped barrier system relative to the highly developed coast north of the park (Figure 1c). This transition allowed for exploration of spatial differences in island-estuary characteristics and modeled barrier island response regimes between developed and undeveloped coastlines.

Estuarine bathymetry data targeting water depths less than 1.5 m were collected over 4 days between 18 and 26 October 2012, the last survey occurring 3 days before Hurricane Sandy made landfall south of Atlantic City, NJ, on 29 October 2012 (Wright, Troche, Klipp, et al., 2014). Post-Sandy estuarine bathymetry data were collected between 1 November 2012 and 10 January 2013 (Wright, Troche, Kranenburg, et al., 2014). Estuarine depths greater than 1.5 m were mapped during three boat-based surveys from November 2011 to March 2013 (Andrews et al., 2016). In combination, these data sets were used to calculate magnitudes of estuarine deposition resulting from Sandy's impacts to the barrier. Coastal topographic data were collected 3 days prior to and 1–5 days after landfall to estimate beach and dune volume change every 10 m alongshore (Sopkin et al., 2014). Geomorphological characteristics of the coastal system were extracted from a topobathymetric terrain model (Andrews et al., 2015, Figure 1b) along 50 m spaced ocean shoreline-perpendicular transects, which were also used to extract storm-related estuarine deposition and beach and dune volume losses.

2.2. Morphodynamic Model

The morphodynamic model focuses on three coastal components: the active shoreface on the ocean side, the subaerial barrier island, and the back-barrier lagoon on the terrestrial side, where infrequent overwash processes control landward mass fluxes between these different components (Lorenzo-Trueba & Ashton, 2014 or LTA, 2014). Long-term barrier behaviors captured by the model include width drowning, height drowning, and keeping pace with sea level (i.e., rollover). Width drowning occurs when overwash fluxes largely exceed onshore-directed fluxes at the shoreface, which results in rapid shoreline retreat and unsustainable island narrowing. Height drowning occurs when overwash fluxes are insufficient to maintain the subaerial portion of the barrier and the height eventually goes to zero. To keep pace with SLR, overwash and shoreface fluxes are balanced and sufficiently high to maintain barrier geometry as it migrates landward. We modified the model approach presented by LTA (2014) to account for an averaged maximum depth instead of a linear lagoon slope (Figure S2 in the supporting information). In this way, lagoon depth is expressed as a function of the lagoon sedimentation rate γ and the SLR rate $\dot{z}$:

$$D_B = D_{B,0} + (\dot{z} - \gamma) \cdot t, \tag{1}$$

where $D_{B,0} = D_B(t = 0)$ is the initial lagoon depth and t is time.

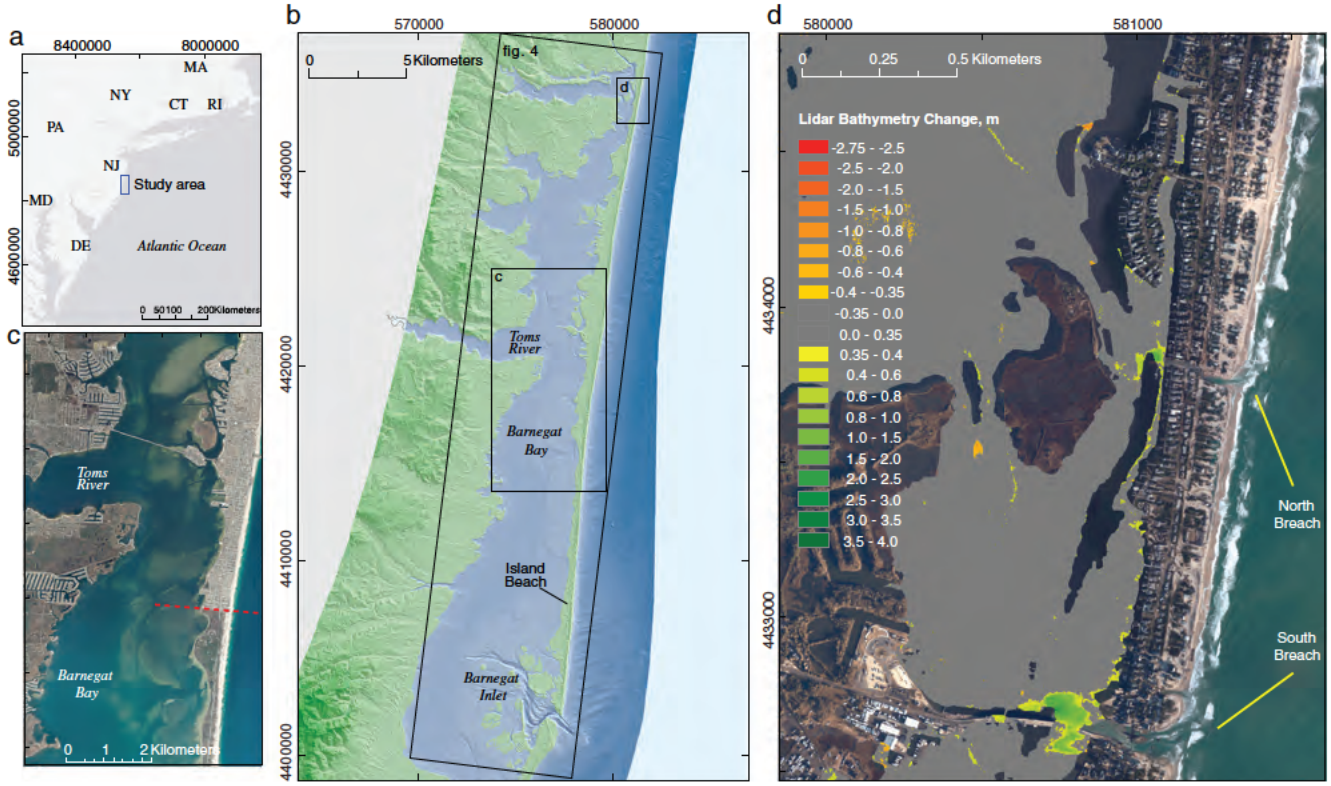


Figure 1. (a) Location of the study area in central New Jersey, spanning the inner shelf, Island Beach (barrier island), and Barnegat Bay (estuary) as shown in a (b) terrain model. (c) Note the distinct transition (red dashed line) from a highly developed barrier to the north to relatively undeveloped barrier to the south. (d) Hurricane Sandy caused erosion of beaches and dunes along the barrier island and the formation of two breaches. Storm related overwash resulted in barrier adjacent deposition in the estuary.

2.3. Parameter Estimation From Geomorphological and Storm-Response Observations

Geomorphology and storm response of the study area were spatially variable and influenced by barrier island development (Figure 2). Back-barrier depths were shallow with regional, undeveloped, and developed averages of 1.7, 1.4, and 1.8 m, respectively. On average, developed barrier island segments were wider and lower than undeveloped segments (Figure 2). Storm-related estuarine gains and barrier island losses also varied with barrier island development. Estuarine deposition adjacent to undeveloped barrier island was less than the regional average, whereas deposition adjacent to developed barrier was greater than the regional average. The opposite was true for beach and dune volume losses; developed regions lost less than the regional average, whereas undeveloped regions lost more. Both of these trends persist when volumes associated with breaches in the barrier island are removed from the analysis though the magnitude of the difference between developed and undeveloped regions decreases. The cause of the difference in trends is unknown; previous work suggests that the presence of back-barrier marshes in the undeveloped region allows the barrier to retain more sediment subaerially via frictional dissipation of cross-barrier flow (Miselis et al., 2016) relative to developed regions in which roads and sidewalks can serve as sediment transport conduits across the island (Miselis et al., 2016; Rogers et al., 2015).

Detailed descriptions of observational parameterizations are provided in Table S2 in the supporting information. Observed island widths, island heights, maximum estuarine depths, and overwash volumes ranged from 225 to 1,650 m, 2.8 to 9.7 m, 0.25 to 9 m, and 50 to 3,000 m^3/m (not including breaches), respectively (Figure 2). To calculate overwash fluxes, we estimated the recurrence interval for large storm events. Scileppi and Donnelly (2007) used geologic evidence of historical storm events on Long Island, NY, and identified preserved overwash deposits for four historical hurricanes since 1693. Assuming these storms had surge comparable to that measured during Hurricane Sandy and that equivalent storm surges occurred 5 times in 319 years, the return interval is 64 years. For simplicity, we divide observed overwash volumes by

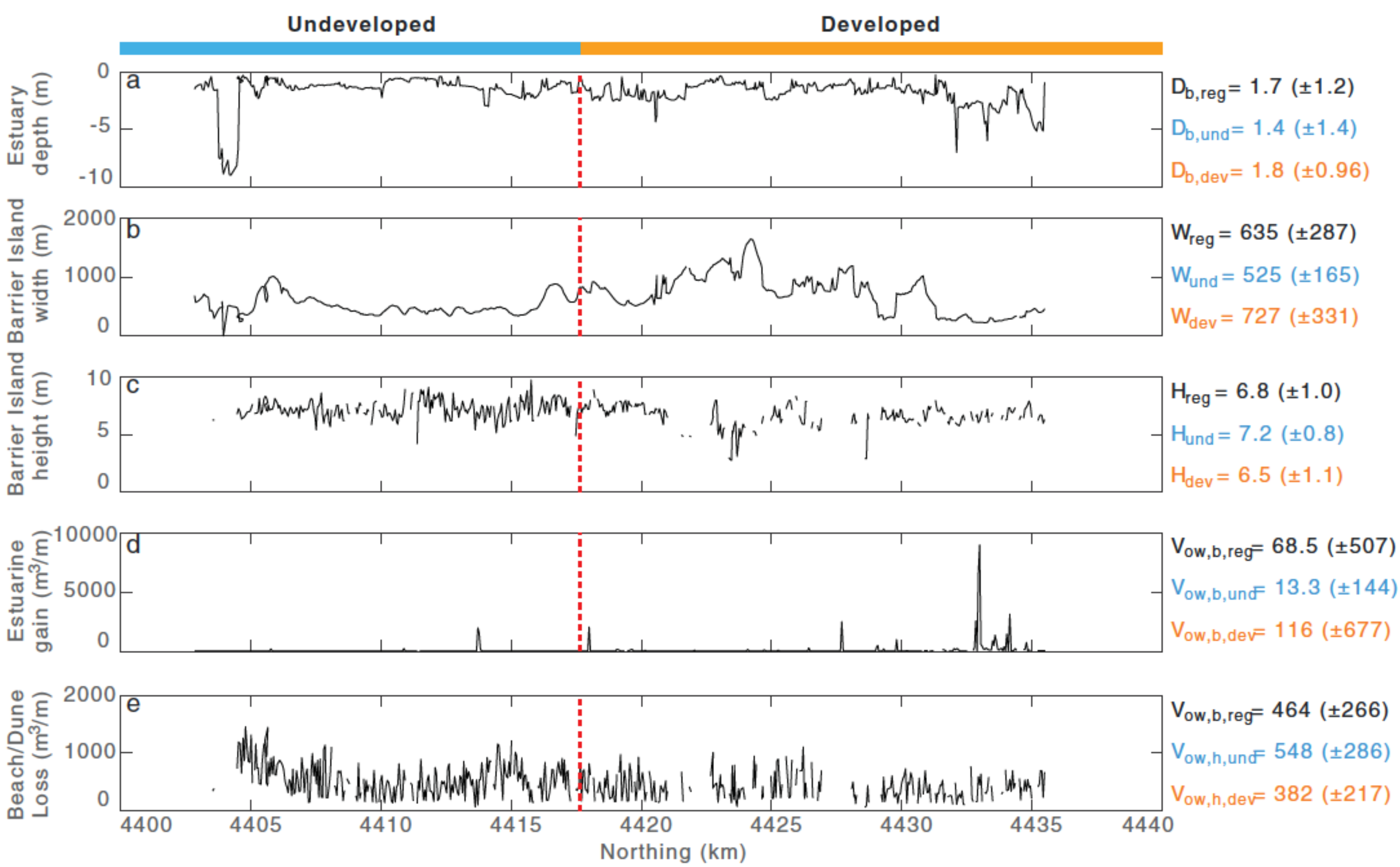


Figure 2. (a c) Geomorphologic and (d and e) storm response observations parameterized for this analysis. Regional, undeveloped, and developed averages are reported at the right.

a return interval of 50 years, which yields maximum overwash flux rates within the range used by LTA (2014). Additionally, we simulate an increase in the frequency and intensity of tropical storms (Emanuel, 2013) by assuming a return interval of 1 year, which we consider an upper limit.

3. Results

3.1. Modeled Responses to Sea Level Rise

Modeled barrier responses to three SLR rates (4, 7, and 10 mm/yr; bases for these rates are described in the supporting information) are shown in regime diagrams and are overlain with overwash flux and estuary depth observations from developed and undeveloped sites (Figures 3a–3c). For a modeled SLR rate of 4 mm/yr, all of the sites keep pace with SLR. As the SLR rate increases to 7 mm/yr, 13% of the sites experience width drowning and 15% of the sites experience height drowning. Due to a combination of deeper back-barrier depths and lower overwash fluxes for developed compared to undeveloped areas, width and height drowning outcomes were predominantly associated with developed locations; 87% of the width drowning predictions and 62% of the height drowning predictions were associated with developed sites. When the SLR rate is increased to 10 mm/yr, all sites are unable to keep up with sea level and experience either width (78%) or height (22%) drowning, though developed areas are more likely to experience height drowning. Since model input parameters correspond to specific locations, spatial variability in modeled barrier island response regime can be shown for the study site (Figures 4a and 4b). We interpret either height or width drowning as indicators of vulnerability to SLR, particularly when the same modeled behavior is consistent alongshore (e.g., spans several transects).

To explore how increases in storm-driven, cross-shore fluxes alter modeled response regimes, we increased overwash fluxes in the model (e.g., return interval = 1 year; Figures 3d–3f), leaving all other parameters the

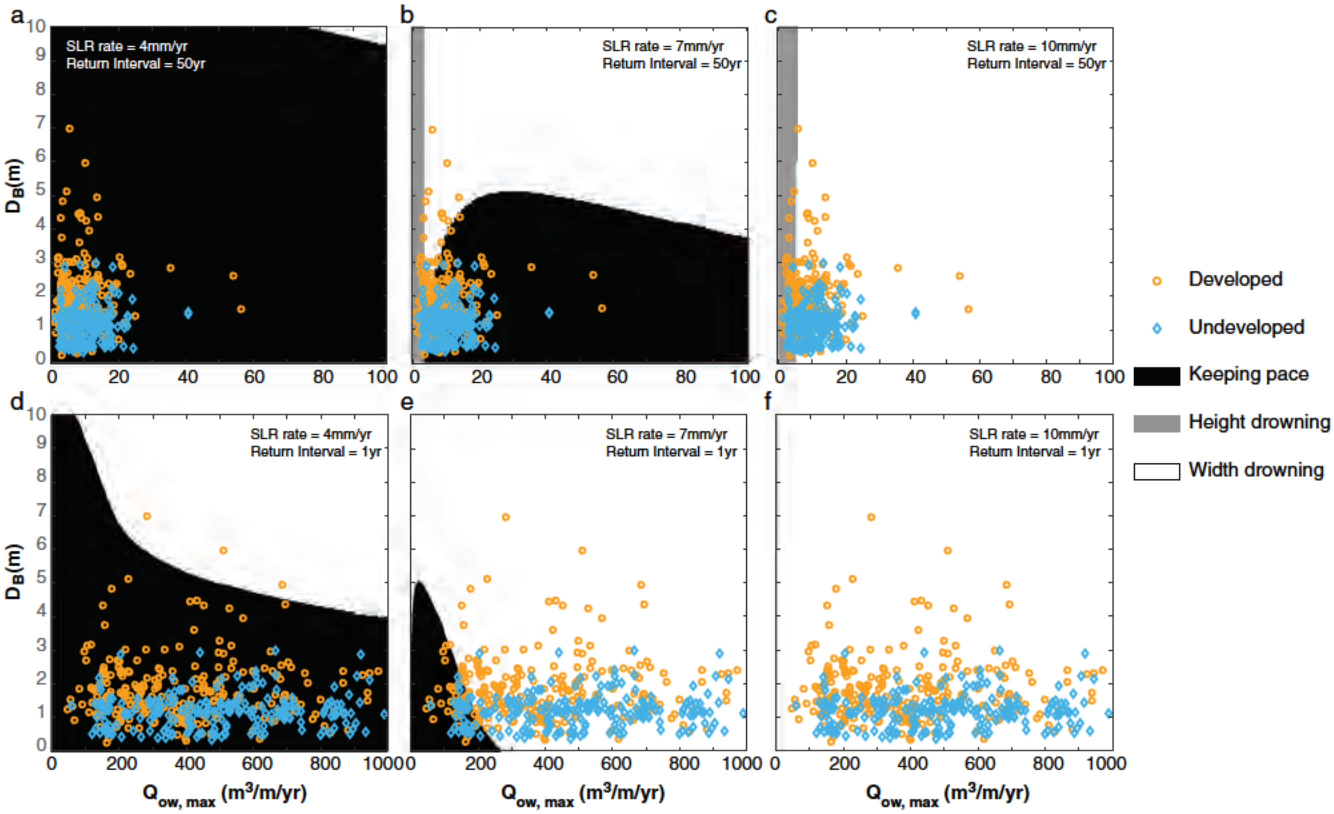


Figure 3. Modeled barrier island response to SLR given variations in maximum overwash flux, $Q_{ow,max}$ (x axis), and lagoon depth (D_B; y axis) for SLR rates of 4, 7, and 10 mm/yr for a storm return interval of (a c) 50 years and (d f) 1 year. The background colors indicate modeled barrier response modes: keeping pace = black; height drowning = gray; width drowning = white. Observations from undeveloped (blue diamonds) and developed (orange circles) locations are overlain on the modeled responses in order to determine barrier response for each observation pair.

same. Modeled outcomes included keeping pace and width drowning. For a SLR rate of 4 mm/yr, only extreme back-barrier depths (>regional average + 3 standard deviations or ~5 m) experience width drowning and all are developed sites. With a modeled SLR rate of 7 mm/yr, only the lowest fluxes and shallowest back-barrier depths result in the barrier keeping pace with SLR (15%), whereas the other sites undergo width drowning (85%). When the SLR rate is increased to 10 mm/yr, all sites succumb to width drowning regardless of magnitudes of overwash flux or back-barrier depth.

3.2. Human Impacts on Barrier Response to Sea Level Rise

Using regional averages for initial barrier geometry (Figure 2) and development-based input parameters (Table S3), we model long-term effects of human alterations on barrier island response to SLR. In one scenario, we assume that human modifications to the system stop at $t = 0$, and therefore, development-specific overwash rates are applied and barrier geometry evolves. Though average developed island width is greater than average undeveloped width (Figure 2), the developed barrier narrows and drowns faster than the undeveloped barrier (Figure 5a). In a second scenario, we assume that human alterations continue in the developed region for some time, T_A. During this time, the barrier is fixed in place (ocean and back-barrier shorelines are static) and the barrier does not aggrade vertically ($Q_{ow,max} = 0$). Here we assume the ocean shoreline is fixed by protection measures, such as beach nourishment and/or hard structures, and the barrier does not aggrade because whatever subaerial overwash that occurs is moved back to the beach, consistent with observations from the study area (Miselis et al., 2016; Rogers et al., 2015). We find that the longer coastal geometry is fixed (a higher T_A), the earlier width drowning occurs (Figure 5b). However, drowning is the end result of a variety of human interventions and island adjustments over ~2,000 years; the model forecasts developed ocean shoreline retreat by a distance equal to 6–45% of modern island width after ~275 years (Figures 5c and 5d; ~3–14% for undeveloped).

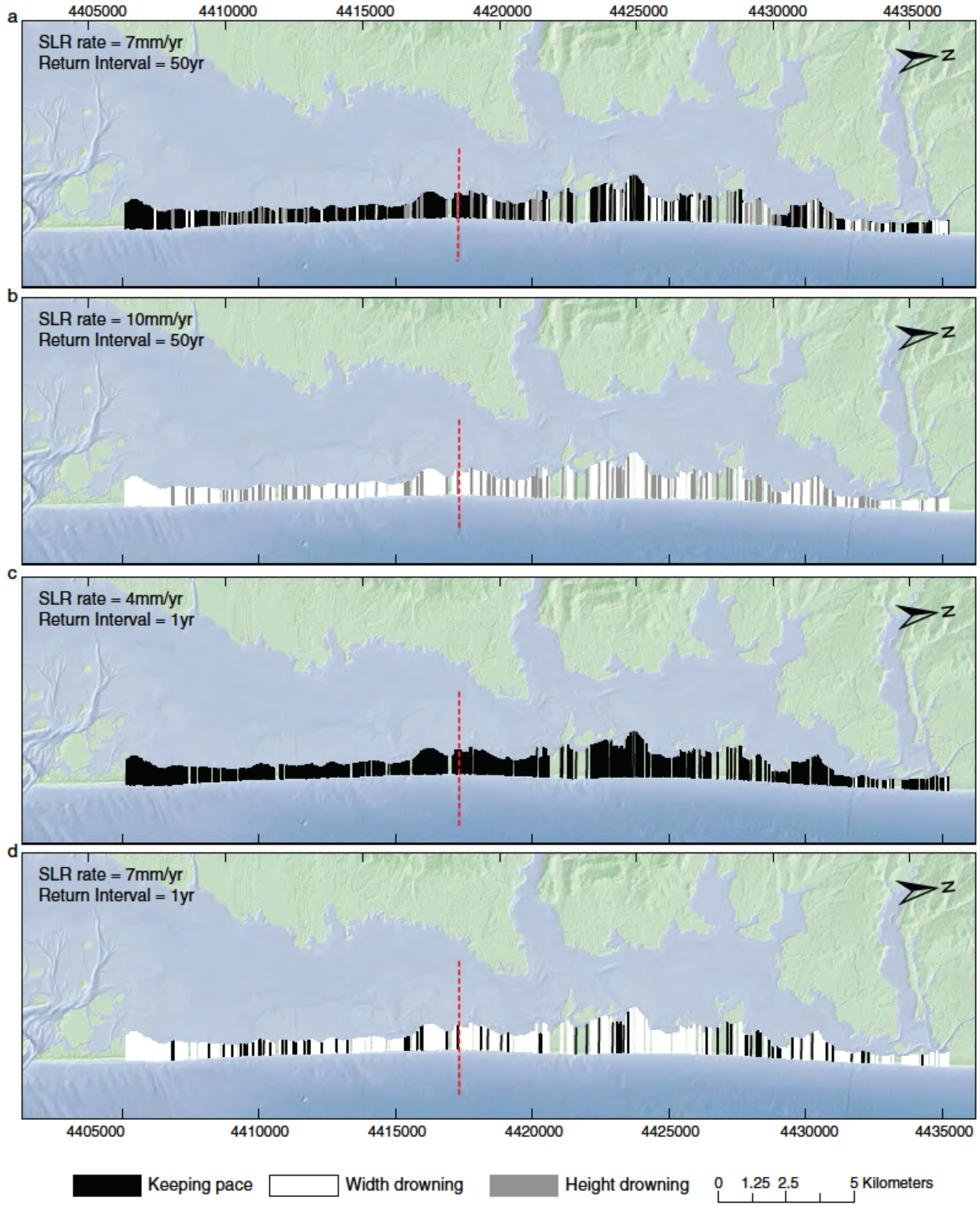


Figure 4. Alongshore varying forecasts of barrier island response to SLR for storm return intervals of (a and b) 50 years and (c and d) 1 year and for SLR rates of 4 (Figure 4c), 7 (Figures 4a and 4d), and 10 mm/yr (Figure 4b). The dashed red line indicates the (right) developed and (left) undeveloped transition. The lines spanning the barrier indicate location of cross shore transects; the colors indicate modeled barrier island response: keeping pace = black; height drowning = gray; width drowning = white. No color indicates no data.

4. Discussion

This study utilized geomorphic and storm-response observations as morphodynamic model inputs in order to model barrier island response to varying rates of SLR and explore the impact of human alterations to the island-estuary system on long-term barrier behavior. Though we believe the model results are more informative when constrained by observations, the intent of this effort is not to predict the location and timing of a specific response. Instead, we suggest that observation-based model output allows us to explore how

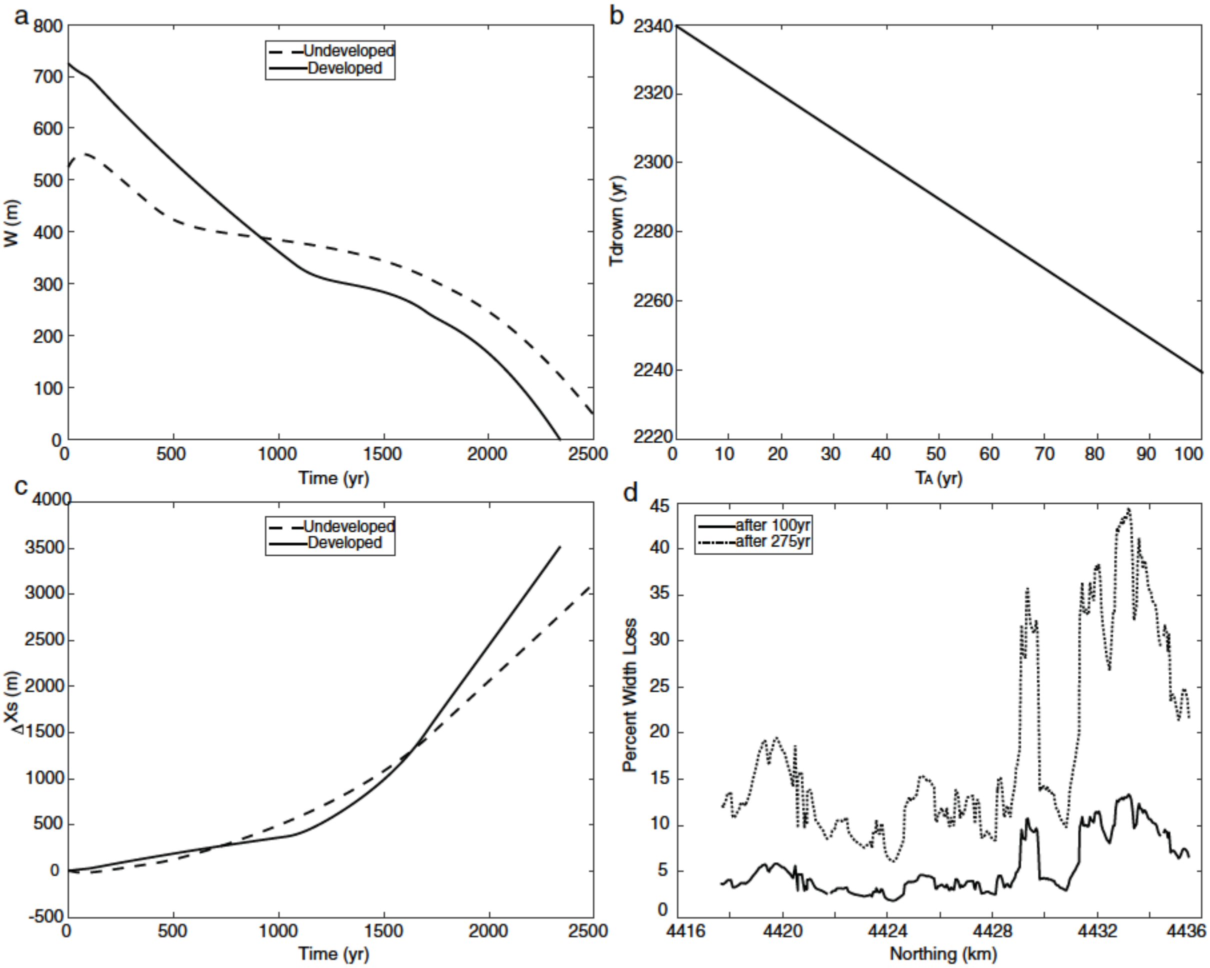


Figure 5. Modeled human impacts on (a) barrier island width and (b) time to drowning for an SLR rate of 7 mm/yr. Developed barrier drowns faster than the undeveloped barrier (Figure 5a). Drowning occurs faster if the time period of human alterations (T_A) is longer (Figure 5b). (c) The model forecasts that developed shoreline will retreat by 100 m after ~275 years. Over the same period, undeveloped barrier shoreline retreats by ~35 m (Δx_s on the y axis represents change in shoreline position). (d) For developed barriers, this retreat represents 6% 45% of modern barrier island width for the 275 year estimate.

reduced cross-shore sediment fluxes and variable island-estuary morphology may interact to increase barrier island vulnerability to SLR on this island and in general. By integrating storm-response fluxes with coastal geomorphology, this approach marries shorter and longer time scales to deliver a forecast for island vulnerability beyond storm time scales (Sallenger, 2000; Stockdon et al., 2007). Furthermore, this is an improvement over SLR vulnerability assessments that rely on inundation of existing coastal topography (Strauss et al., 2012), since the model allows the barrier island to dynamically adjust and, in this case, uses observations that accurately represent both natural and human-altered systems. This approach supports recent research that demonstrates that dynamic adjustment of coastal landscapes changes the likelihood of inundation (Lentz et al., 2016) by driving dynamic behavior with spatially varying cross-shore fluxes from both developed and undeveloped environments.

Despite these advantages, the model does not capture a range of processes and complexities known to influence barrier evolution. Alongshore sediment transport, for example, can diffuse the effects of cross-shore processes over time scales of months and years (Lazarus et al., 2011; List et al., 2006) to millennia (Ashton & Lorenzo-Trueba, 2015) and might reduce or eliminate localized vulnerabilities forecast by the model. However, this benefit may be diminished if alongshore sediment fluxes along engineered coastlines are restricted, such as by groins or jetties, resulting in barrier islands that are more vulnerable to cross-shore sediment flux imbalances simulated here. Furthermore, by assuming uniform sediment distribution, the model homogenizes barrier island geology, whereas natural barriers are composed of a mix of coarse and fine sediments. Any reduction in coarse sediment volume could significantly enhance barrier drowning (Brenner et al., 2015). Notwithstanding these simplifications, this initial step of bounding an exploratory model with empirical parameters is a critical one, because it allows us to explore in general ways how island-estuary geometry, overwash fluxes, and coastal development interact to drive spatial variations in barrier island vulnerability over long time scales.

Interpretation of model results shows that natural and human-induced variability in island-estuary geomorphology and cross-shore sediment fluxes result in spatially variable barrier vulnerability to SLR. At low, moderate, and high SLR rates, 0%, 28%, and 100% of the barrier is predicted to be vulnerable, respectively. Different modeled behaviors for similar island-estuary geometries underscore the importance of sediment fluxes in contributing to future barrier island evolution. Though dune/island height is a good predictor of coastal response to storms (Plant et al., 2010; Sallenger, 2000; Stockdon et al., 2007), this work demonstrates that island-estuary geomorphology alone is not sufficient for understanding future coastal response to SLR and that quantifying sediment budgets and associated fluxes is essential (Roelvink, 2015).

Increasing only overwash fluxes in the model to simulate increased storminess did not lead to fewer SLR vulnerabilities along the island as might be expected. Instead, the imbalance between overwash and shoreface fluxes (e.g., material loss from increased overwash was not replenished at the same rate by shoreface fluxes) leads to elevated barrier vulnerability to SLR. As above, this effect is likely to be more pronounced in sediment-limited coastal systems and/or where diffusive alongshore fluxes are restricted. Also, because modeled shoreface flux is highly theoretical, quantifying existing imbalances in cross-shore fluxes from detailed morphological (Brenner et al., 2017), geological (Locker et al., 2017; Miselis & McNinch, 2006), and physical (Limber et al., 2008) observations and deriving more representative shoreface flux values would result in more realistic forecasts of the influence of increased storminess on barrier vulnerability to SLR.

Human modification of the island-estuary system contributes to differences in modeled barrier island behavior. First, model results indicate that development makes barrier drowning more likely (consistent with the nonlocation-based modeling results of Rogers et al. (2015)); developed locations in the study area were ~6 times as vulnerable to SLR due to loss of island width and almost 2 times as vulnerable due to loss of island height compared to undeveloped sites. This disparity was driven by the coupling of deeper estuarine depths due to dredged navigation channels (Kennish, 2001; Miselis et al., 2016) and reduced overwash fluxes due to interactions with infrastructure (Rogers et al., 2015) common to developed locations. Second, in model results, developed barriers narrow and drown faster than undeveloped barriers, though modeled time-to-drowning could decrease with increasing sediment limitation (Brenner et al., 2015). Moreover, it is important to note that drowning is only an end result. Given that model results also show significant ocean shoreline retreat over <300 years, it is likely that decreases in island area available for infrastructure and habitat will occur long before the island is completely submerged. Finally, model simulations indicate that the longer humans intervene in the coastal system by fixing the barrier in place laterally and vertically, the faster drowning occurs, even if natural barrier island morphodynamics are restored after human intervention. This suggests that coastal management techniques that seek to maintain barrier position and redistribute overwash deposits may result in more resilient coastlines initially but that increased vulnerability resulting from existing human alterations may not be reversible over longer time scales.

5. Conclusions

Integration of observations extracted from remotely sensed data and a morphodynamic model could be a powerful tool for forecasting barrier island vulnerabilities to SLR over large spatial domains. Natural and human-induced spatial variability in island-estuary geometry and sediment fluxes tends to result in nonuniform barrier island response to SLR and an increase in vulnerable locations from 28% to 100% with an increase in SLR rates from moderate to high. For the same rate of SLR, percent vulnerability increases as overwash fluxes are increased in the model, suggesting that enhanced storminess will exacerbate SLR effects, particularly along sediment-limited coasts. Human influence is apparent in modeled response to SLR, and spatial associations between barrier island vulnerability and coastal development suggest that human modification of island-estuary geometry and cross-shore sediment fluxes will influence future barrier island retreat trajectories.

Acknowledgments
Observational data are published and available online as cited in the text. This work was funded by the New Jersey Department of Environmental Protection and the USGS Coastal and Marine Geology Program and a National Science Foundation grant CNH 1518503 to Lorenzo Trueba. Brian Andrews provided GIS support for spatial analysis. Noreen Buster assisted with drafting of figures. Thoughtful reviews by Eli Lazarus, A. Brad Murray, and an anonymous reviewer improved the manuscript. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

Andrews, B. D., Defne, Z., Miselis, J. L., & Ganju, N. K. (2015). Continuous terrain model for water circulation studies, Barnegat Bay, New Jersey. U.S. Geological Survey Data Release. https://doi.org/10.5066/F7PK0D6B

Andrews, B. D., Miselis, J. L., Danforth, W. W., Irwin, B. J., Worley, C. R., Bergeron, E. M., & Blackwood, D. S. (2016). Marine geophysical data collected in a shallow back barrier estuary, Barnegat Bay, New Jersey. U.S. Geological Survey Data Series 937 (15 p.). https://doi.org/10.3133/ds937

Ashton, A., & Lorenzo Trueba, J. (2015). Complex responses of barriers to sea level rise emerging from a model of alongshore coupled dynamic profile evolution. Coastal Sediments 2015, San Diego, CA, 11 15 May. https://doi.org/10.1142/9789814689977 0003

Brenner, O. T., Lentz, E. E., Hapke, C. J., Henderson, R. E., Wilson, K. E., & Nelson, T. R. (2017). Characterizing storm response and recovery using the beach change envelope: Fire Island, New York. *Geomorphology*, *300*, 189 202. https://doi.org/10.1016/j.geomorph.2017.08.004

Brenner, O. T., Moore, L. J., & Murray, A. B. (2015). The complex influences of back barrier deposition, substrate slope and underlying stratigraphy in barrier island response to sea level rise: Insights from the Virginia Barrier Islands, mid Atlantic Bight, U.S.A. *Geomorphology*, *246*, 334 350. https://doi.org/10.1016/j.geomorph.2015.06.014

Church, J. A., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., … Unnikrishnan, A. S. (2013). Sea level change. In T. F. Stocker, et al. (Eds.), *Climate change 2013: The physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1137 1216). Cambridge, United Kingdom and New York: Cambridge University Press.

Emanuel, K. (2013). Downscaling CMIP5 climate models shows increased tropical cyclone activity over the 21st century. *PNAS*, *110*(30), 12,219 12,224. https://doi.org/10.1073/pnas/1301293110

Fleming, K., Johnston, P., Zwartz, D., Yokoyama, Y., Lambeck, K., & Chappell, J. (1998). Refining the eustatic sea level curve since the Last Glacial Maximum using far and intermediate field sites. *Earth and Planetary Science Letters*, *163*(1 4), 327 342. https://doi.org/10.1016/S0012 821X(98)00198 8

Jevrejeva, S., Grinsted, A., & Moore, J. C. (2014). Upper limit for sea level projections by 2100. *Environmental Research Letters*, *9*(10), 104008. https://doi.org/10.1088/1748 9326/9/10/104008

Kemp, A. C., Horton, B. P., Donnelly, J. P., Mann, M. E., Vermeer, M., & Rahmstorf, S. (2011). Climate related sea level variations over the past two millennia. *Proceedings of the National Academy of Sciences*, *108*(27), 11,017 11,022. https://doi.org/10.1073/pnas.1015619108

Kennish, M. J. (2001). Physical description of the Barnegat Bay Little Egg Harbor estuarine system. *Journal of Coastal Research Special Issue*, *32*, 13 27.

Khan, N. S., Ashe, E., Shaw, T. S., Vacchi, M., Walker, J., Peltier, W. R., … Horton, B. P. (2015). Holocene relative sea level changes from near , intermediate , and far field locations. *Current Climate Change Reports*, *1*(4), 247 262. https://doi.org/10.1007/s40641 015 0029 z

Kopp, R. W., Horton, R. M., Little, C. M., Mitrovica, J. X., Oppenheimer, M., Rasmussen, D. J., … Tebaldi, C. (2014). Probabilistic 21st and 22nd century sea level projections at a global network of tide gauge sites. *Earth's Future*, *2*(8), 383 406. https://doi.org/10.1111/eft2.2014EF000239

Lazarus, E., Ashton, A., Murray, A. B., Tebbens, S., & Burroughs, S. (2011). Cumulative versus transient shoreline change: Dependencies on temporal and spatial scale. *Journal of Geophysical Research*, *116*, F02014. https://doi.org/10.1029/2010JF001835

Lazarus, E. D., Ellis, M. A., Murray, A. B., & Hall, D. M. (2016). An evolving research agenda for human coastal systems. *Geomorphology*, *256*, 81 90. https://doi.org/10.1016/j.geomorph.2015.07.043

Lentz, E. E., Thieler, E. R., Plant, N. G., Stippa, S. R., Horton, R. M., & Gesch, D. B. (2016). Evaluation of dynamic coastal response to sea level rise modifies inundation likelihood. *Nature Climate Change*, *6*(7), 696 700. https://doi.org/10.1038/nclimate2957

Limber, P. W., Patsch, K. B., & Griggs, G. B. (2008). Coastal sediment budgets and the littoral cutoff diameter: A grain size threshold for quantifying active sediment inputs. *Journal of Coastal Research*, *24*(2A), 122 133.

List, J. H., Farris, A. S., & Sullivan, C. (2006). Reversing storm hotspots on sandy beaches: Spatial and temporal characteristics. *Marine Geology*, *226*(3 4), 261 279. https://doi.org/10.1016/j.margeo.2005.10.003

Locker, S. D., Miselis, J. L., Buster, N. A., Hapke, C. J., Wadman, H. M., McNinch, J. E., … Stalk, C. A. (2017). Nearshore sediment thickness, Fire Island, New York. U.S. Geological Survey Open File Report 2017 1024 (21 pp.). https://doi.org/10.3133/ofr20171024.

Lorenzo Trueba, J., & Ashton, A. D. (2014). Rollover, drowning, and discontinuous retreat: Distinct modes of barrier response to sea level rise arising from a simple morphodynamic model. *Journal of Geophysical Research: Earth Surface*, *119*, 779 801. https://doi.org/10.1002/2013JF002941

McBride, R. A., Anderson, J. B., Buynevich, I. V., Cleary, W., Fenster, M. S., Fitzgerald, D. M., … Wang, P. (2013). Morphodynamics of barrier systems: A synthesis. In J. F. Shroder, & D. J. Sherman (Eds.), *Treatise on geomorphology, Coastal and Submarine Geomorphology* (Vol. 10, pp. 166 244). San Diego, California, USA: Academic Press. https://doi.org/10.1016/B978 0 12 374739 6.00279 7

McNamara, D. E., Murray, A. B., & Smith, M. D. (2011). Coastal sustainability depends on how economic and coastline responses to climate change affect each other. *Geophysical Research Letters*, *38*, L07401. https://doi.org/10.1029/2011GL047207

McNamara, D. E., & Werner, B. T. (2008a). Coupled barrier island resort model: 1. Emergent instabilities induced by strong human landscape interactions. *Journal of Geophysical Research*, *113*, F01016. https://doi.org/10.1029/2007JF000840

McNamara, D. E., & Werner, B. T. (2008b). Coupled barrier island resort model: 2. Tests and predictions along Ocean City and Assateague Island National Seashore, Maryland. *Journal of Geophysical Research*, *113*, F01017. https://doi.org/10.1029/2007JF000841

Miller, K. G., Kopp, R. E., Horton, B. P., Browning, J. V., & Kemp, A. C. (2013). A geological perspective on sea level rise and its impacts along the U.S. mid Atlantic coast. *Earth's Future*, *1*(1), 3 18. https://doi.org/10.1002/2013EF000135

Milne, G. A., Long, A. J., & Bassett, S. E. (2005). Modelling Holocene relative sea level observations from the Caribbean and South America. *Quaternary Science Reviews*, *24*(10 11), 11,183 11,202. https://doi.org/10.1016/j.quascirev.2004.10.005

Miselis, J. L., Andrews, B. A., Nicholson, R. S., Defne, Z., Ganju, N. K., & Navoy, A. (2016). Evolution of mid Atlantic coastal and back barrier estuary environments in response to a hurricane: Implications for barrier estuary connectivity. *Estuaries and Coasts*, *39*(4), 916 934. https://doi.org/10.1007/s12237 015 0057 x

Miselis, J. L., & McNinch, J. E. (2006). Calculating shoreline erosion potential using nearshore stratigraphy and sediment volume: Outer Banks, North Carolina. *Journal of Geophysical Research*, *111*, F02019. https://doi.org/10.1029/2005JF000389

Moore, L. J., List, J. H., Williams, S. J., & Stolper, D. (2010). Complexities in barrier island response to sea level rise: Insights from numerical model experiments, North Carolina Outer Banks. *Journal of Geophysical Research*, *115*, F03004. https://doi.org/10.1029/2009JF001299

Murray, A. B. (2003). Contrasting the goals, strategies, and predictions associated with simplified numerical models and detailed simulations. In R. M. Iverson, & P. R. Wilcock (Eds.), *Prediction in geomorphology, AGU geophysical monograph* (Vol. 135, pp. 151 165). Washington, DC: American Geophysical Union.

Nordstrom, K. F. (2000). *Beaches and dunes of developed coasts*, (p. 343). Cambridge, United Kingdom: Cambridge University Press. https://doi.org/10.1017/CBO9780511549519

Plant, N. G., & Stockdon, H. F. (2012). Probabilistic prediction of barrier island response to hurricanes. *Journal of Geophysical Research*, *117*, F03015. https://doi.org/10.1029/2011JF002326
Plant, N. G., Stockdon, H. F., Sallenger, A. H. Jr., Turco, M. J., East, J. W., Taylor, A. A., & Shaffer, W. A. (2010). Forecasting hurricane impact on coastal topography. *Eos, Transactions American Geophysical Union*, *91*(7), 65 66. https://doi.org/10.1029/2010EO070001
Roelvink, D. (2015). Addressing local and global sediment imbalances: Coastal sediments as rare minerals. Coastal Sediments 2015: Proceedings of the Coastal Sediments 2015.
Rogers, L. J., Moore, L. J., Goldstein, E. B., Hein, C. J., Lorenzo Trueba, J., & Ashton, A. D. (2015). Anthropogenic controls on overwash deposition: Evidence and consequences. *Journal of Geophysical Research: Earth Surface*, *120*, 2609 2624. https://doi.org/10.1002/2015JF003634
Sallenger, A. H. Jr. (2000). Storm impact scale for barrier islands. *Journal of Coastal Research*, *16*, 890 895.
Scileppi, E., & Donnelly, J. P. (2007). Sedimentary evidence of hurricane strikes in western Long Island, New York. *Geochemistry, Geophysics, Geosystems*, *8*, Q06011. https://doi.org/10.1029/2006GC001463
Sopkin, K. L., Stockdon, H. F., Doran, K. S., Plant, N. G., Morgan, K. L. M., Guy, K. K., & Smith, K. E. L. (2014). Hurricane Sandy: Observations and analysis of coastal change, U.S. Geological Survey Open File Report 2014 1088 (54 p.). https://doi.org/10.3133/ofr20141088
Stockdon, H. F., Sallenger, A. H. Jr., Holman, R. A., & Howd, P. A. (2007). A simple model for the spatially variable coastal response to hurricanes. *Marine Geology*, *238*(1 4), 1 20. https://doi.org/10.1016/j.margeo.2006.11.004
Strauss, B. H., Ziemlinski, R., Weiss, J. L., & Overpeck, J. T. (2012). Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous U.S. *Environmental Research Letters*, *7*(1), 014033. https://doi.org/10.1088/1748 9326/7/1/014033
Wolinsky, M. A., & Murray, A. B. (2009). A unifying framework for shoreline migration: 2. Application to wave dominated coasts. *Journal of Geophysical Research*, *114*, F01009. https://doi.org/10.1029/2007JF000856
Wright, C. W., Troche, R. J., Klipp, E. S., Kranenburg, C. J., Fredericks, X., & Nagle, D. B. (2014). EAARL B submerged topography Barnegat Bay, New Jersey, pre Hurricane Sandy, 2012: U.S. Geological Survey Data Series 885. https://doi.org/10.3133/ds885
Wright, C. W., Troche, R. J., Kranenburg, C. J., Klipp, E. S., Fredericks, X., & Nagle, D. B. (2014). EAARL B submerged topography Barnegat Bay, New Jersey, post Hurricane Sandy, 2012 2013. U.S. Geological Survey Data Series 887. https://doi.org/10.3133/ds887

STATUS OF THE SPECIES/CRITICAL HABITAT – piping plover (*Charadrius melodus*)

Legal Status – endangered and threatened

On January 10, 1986, the U.S. Fish and Wildlife Service (Service) listed the piping plover (*Charadrius melodus*) as endangered in the Great Lakes watershed and threatened elsewhere within its range, including migratory routes outside of the Great Lakes watershed and wintering grounds, under the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884; 16 U.S.C. 1531 *et seq*.) (Service 1985). Piping plovers were listed principally because of habitat destruction and degradation, predation, and human disturbance. Critical habitat was designated for the Great Lakes breeding population, wintering piping plovers, and the Northern Great Plains breeding population on May 7, 2001, July 10, 2001, and September 11, 2002, respectively (Service 2001a,b; Service 2002).

Species/critical habitat description

Appearance/Morphology

The piping plover is a small (7 inches [in] long) shorebird with a wingspan of 15 in (Palmer 1967). Throughout the year, adults have sand-colored upper body parts, white undersides, and orange legs. During the breeding season, adults acquire a black forehead, a single black breast band, and an orange bill with a black tip. In general, males have brighter bands than females, and inland birds have more complete bands than east coast birds. Fledglings have flesh-colored legs and black bills and immature plumage is similar to adult non-breeding plumage. Juveniles acquire adult plumage in spring following the hatching year. The piping plover is similar to other ringed plovers in size and body shape; however, the very pale color of its upper parts, its orange legs, and the complete white band across the upper tail coverts are diagnostic characteristics.

Breeding populations

Three separate breeding populations have been identified, each with its own recovery criteria: the Northern Great Plains (threatened), the Great Lakes (endangered), and the Atlantic coast (threatened). The piping plover winters in coastal areas of the United States (U.S.) from North Carolina to Texas, along the coast of eastern Mexico, on Caribbean islands from Barbados to Cuba, and in the Bahamas (Haig and Elliott-Smith 2004). Because birds breeding populations overlap on their wintering grounds, most piping plover studies in the nonbreeding range report results without regard to breeding origin. Therefore, information summarized herein pertains to the species as a whole (*i.e.,* all three breeding populations), except where a particular breeding population is specified.

Critical Habitat

The Service designated critical habitat for the piping plover on three occasions. Two of these designations protected different breeding populations. Critical habitat for the Great Lakes and

5. Agreements and funding mechanisms are in place for long-term protection and management activities in essential breeding and wintering habitat.

Atlantic Coast Population (Service 1996)

1. Increase and maintain for 5 years a total of 2,000 breeding pairs, distributed among 4 recovery units.

Recovery Unit	Minimum Subpopulation
Atlantic (eastern) Canada	400 pairs
New England	625 pairs
New York-New Jersey	575 pairs
Southern (DE-MD-VA-NC)	400 pairs

2. Verify the adequacy of a 2,000 pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term.
3. Achieve a 5-year average productivity of 1.5 fledged chicks per pair in each of the 4 recovery units described in criterion 1, based on data from sites that collectively support at least 90 percent of the recover unit's population.
4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.
5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

Threats to piping plovers/critical habitat

In the following sections, we provide an analysis of threats to piping plovers in their migration and wintering range. We have updated information obtained since the 1985 listing rule, the 1991 and 2009 status reviews, and the three breeding population recovery plans. Both previously identified and new threats are discussed. With minor exceptions, this analysis is focused on threats to piping plovers within the continental U.S. portion of their migration and wintering range. Threats in the Caribbean and Mexico remain largely unknown.

Climate change

Numerous studies have documented accelerating rise in sea levels worldwide (Douglas et al. 2001; Rahmstorf et al. 2007; Hopkinson et al. 2008; Pilkey and Young 2009; U.S. Climate Change Science Program [USCCSP] 2009; Vermeer and Rahmstorf 2009; Pilkey and Pilkey 2011). Predictions include a sea level rise of between 19.7 and 78.7 in above 1990 levels by the year 2100 (Rahmstorf et al. 2007; Pfeffer et al. 2008; Vermeer and Rahmstorf 2009; Grinsted et al. 2010; Jevrejeva et al. 2010) and potential conversion of as much as 33 percent of the world's coastal wetlands to open water by 2080 (Intergovernmental Panel on Climate Change [IPCC] 2007; USCCSP 2008). Potential effects of sea level rise on piping plover roosting and foraging habitats may vary regionally due to subsidence or uplift, the geological character of the coast and near-shore, and the influence of management measures such as beach nourishment, jetties, groins, and seawalls (Galbraith et al. 2002; USCCSP 2009; Gutierrez et al. 2011). Sea level rise along the U.S. Gulf coast exceeded the global average by 5.1-5.9 in because coastal lands there are subsiding (U.S. Environmental Protection Agency [EPA] 2009).

Low elevations and proximity to the coast make all non-breeding piping plover foraging and roosting habitats vulnerable to the effects of rising sea level. Areas with small tidal ranges are the most vulnerable to loss of intertidal wetlands and flats (EPA 2009). Sea level rise was cited as a contributing factor in the 68 percent decline in tidal flats and algal mats in the Corpus Christi, Texas region (*i.e.,* Lamar Peninsula to Encinal Peninsula) between the 1950s and 2004 (Tremblay et al. 2008). Mapping by Titus and Richman (2001) showed that more than 80 percent of the lowest land along the Atlantic and Gulf coasts was in Louisiana, Florida, Texas, and North Carolina. Gutierrez et al. (2011) found that along the Atlantic coast, the central and southern Florida coast is the most likely Atlantic portion of the wintering and migration range to experience moderate to severe erosion with sea level rise.

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat if natural coastal dynamics are impeded by numerous structures or roads, especially if those shorelines are also armored with hardened structures (Brown and McLachlan 2002, Dugan and Hubbard 2006, Fish et al. 2008, Defeo et al. 2009). Without development or armoring, low undeveloped islands can migrate toward the mainland, pushed by the over-washing of sand eroding from the seaward side and being re-deposited in the bay (Scavia et al. 2002). Over-wash and sand migration are impeded on developed portions of islands. Instead, as sea-level increases, the ocean-facing beach erodes and the resulting sand is deposited offshore. The buildings and the sand dunes then prevent sand from washing back toward the lagoons, and the lagoon side becomes increasingly submerged during extreme high tides (Scavia et al. 2002), diminishing both barrier beach shorebird habitat and protection for mainland developments.

Modeling by Galbraith et al. (2002) for three sea level rise scenarios at five important U.S. shorebird staging and wintering sites predicted aggregate loss of 20-70 percent of current intertidal foraging habitat. The most severe losses were projected at sites where the coastline is unable to move inland due to steep topography or seawalls. Of five study sites, the model predicted the lowest loss of intertidal shorebird foraging habitat at Bolivar Flats, Texas (a designated piping plover critical habitat unit) by 2050 because the habitat at that site will be able to migrate inland in response to rising sea level. The potential for such barrier island migration with rising sea level is most likely in the 42 percent of plover's U.S. non-breeding range that is currently preserved from development (Rice 2012a). Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith et al. (2002) noted that time lags between these losses and the creation of replacement habitat elsewhere may have serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or subsequent productivity.

In summary, the magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization that modify and degrade habitat. These threats will be perpetuated in places where damaged structures are repaired or replaced, exacerbated where the height and strength of structures are increased, and increased at locations where develo ment and coastal stabilization is ex anded. Sites that are able to ada t to sea level rise are likely to become more important to piping plovers as habitat at developed or stabilized sites degrades. Potential effects of storms, which could increase in frequency or intensity due to climate change, are discussed in a following section. If climate change increases the frequency or magnitude of extreme temperatures, piping plover survival rates may be affected. Other potential adverse and beneficial climate change-related effects (*e.g.,* changes in the composition or availability of prey, emergence of new diseases, fewer periods of severe cold weather) are poorly understood, but cannot be discounted.

Destruction, modification, or curtailment of its habitat or range (present or threatened)

The final rule stated that in addition to extensive breeding area problems, the loss and modification of winterin habitat was a si nificant threat to the i in lover Service 1985 . The three recover plans state that shoreline develo ment throu hout the winterin ran e oses a threat to all o ulations of i in lovers Service 1988 1994 1996 2003 . The plans further state that beach maintenance and nourishment inlet dred in and artificial structures such as etties and roins could eliminate winterin areas and alter sedimentation atterns leadin to the loss of nearby habitat. Priority 1 actions in the 1996 Atlantic Coast and 2003 Great Lakes Recover Plans identif tasks to rotect natural rocesses that maintain coastal ecos stems and ualit winterin i in lover habitat and to protect wintering habitat from shoreline stabilization and navigation projects. The 1988 Northern Great Plains Recovery Plan states that, as winter habitat is identified, current and potential threats to each site should be determined.

The threats to piping plover habitat used during winter and migration were identified by the Service during its designation of critical habitat. The threats affecting most winter and migration areas include unregulated use of motorized vehicles, unregulated pedestrian recreation, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution. Conservation efforts at some locations have likely resulted in the protection and/or enhancement of wintering habitat.

Im ortant com onents of ecolo icall sound barrier beach management include er etuation of natural d namic coastal formation rocesses. Structural develo ment alon the shoreline or mani ulation of natural inlets u sets the d namic rocesses and results in habitat loss or de radation Melvin et al. 1991 . Throu hout the ran e of mi ratin and winterin i in lovers inlet and shoreline stabilization inlet dred in beach maintenance and nourishment activities and seawall installations continue to constrain natural coastal rocesses. Dred in of inlets can affect s it formation ad acent to inlets and directl remove or affect ebb and flood tidal shoal formation. Jetties which stabilize an island cause island widenin and subse uent rowth of vegetation on inlet shores. Seawalls restrict natural island movement and exacerbate erosion. As discussed in more detail below all these efforts result in loss of i in lover habitat. Construction of these ro ects durin months when i in lovers are resent also causes disturbance that disru ts the birds' fora in efficienc and hinders their abilit to build fat reserves over the winter and in preparation for migration, as well as their recuperation from migratory flights.

Any assessment of threats to piping plovers from loss and degradation of habitat must recognize that up to 24 shorebird species migrate or winter along the Atlantic coast and almost 40 species of shorebirds are present during migration and wintering periods in the Gulf of Mexico region (Helmers 1992). Continual degradation and loss of habitats used by wintering and migrating shorebirds may cause an increase in intra-specific and inter-specific competition for remaining food supplies and roosting habitats. In Florida, for example, approximately 825 mi of coastline and parallel bayside flats (unspecified amount) were present prior to the advent of high human densities and beach stabilization projects. We estimate that only about 35 percent of the Florida coastline continues to support natural coastal formation processes, thereby concentrating foraging and roosting opportunities for all shorebird species and forcing some individuals into suboptimal habitats. Thus, intra- and inter-specific competition most likely exacerbates threats from habitat loss and degradation.

Development and construction

Development and associated construction threaten the piping plover in its migration and wintering range by degrading, fragmenting, and eliminating habitat. Constructing buildings and infrastructure adjacent to the beach can eliminate roosting and loafing habitat within the development's footprint and degrade adjacent habitat by replacing sparsely vegetated dunes or back-barrier beach areas with landscaping, pools, fences, etc. In addition, the development of bayside or estuarine shorelines (with finger canals and their associated bulkheads, docks, buildings, and landscaping) leads to direct loss and degradation of plover habitat. Finger canals can lead to water pollution, fish kills, loss of aquatic nurseries, saltwater intrusion of groundwater, disruption of surface flows, island breaching due to the funneling of storm surge, and a perpetual need for dredging and disposal of dredged material in order to keep the canals navigable for property owners (Morris et al. 1978, Bush et al. 1996). High-value plover habitat becomes fragmented as lots are developed or coastal roads are built between ocean-side and bayside habitats. Development activities can also include lowering or removing natural dunes to improve views or grade building lots, planting vegetation to stabilize dunes, and erecting sand fencing to establish or stabilize continuous dunes in developed areas. Such activities can further degrade, fragment, and eliminate sparsely vegetated and unvegetated habitats used by the piping plover and other wildlife. Development and construction of other infrastructure in close proximity to barrier beaches often creates economic and social incentives for subsequent shoreline stabilization projects, such as shoreline hardening and beach nourishment. Developed beaches are also highly vulnerable to further habitat loss because they cannot migrate in response to sea level rise.

Approximately 40 percent of the sandy beach shoreline in the migration and wintering range is already developed, and Rice (2012a) has identified over 900 mi (43 percent) of sandy beaches in the wintering range that are currently "preserved" through either public ownership, ownership by non-governmental conservation organizations, or conservation easements. These beaches may be subject to some erosion as they migrate in response to sea level rise or if sediment is removed from the coastal system, and they are vulnerable to recreational disturbance. However, the "preserved" shoreline areas are most likely to maintain the geomorphic characteristics of suitable piping plover habitat. The remaining 17 percent of shoreline habitat in the migration and wintering range (that which is currently undeveloped, but not preserved) is susceptible to future loss to development and the resultant threats from shoreline stabilization activities. Nonetheless, the entire coastline regardless of whether it is developed or not is susceptible to sea level rise.

Disease

No instances of disease have been documented in piping plovers outside the breeding range. In the southeastern U.S., the cause of death of one piping plover received from Texas was emaciation (Acker 2009). Newstead (2012b) reported circumstantial evidence that red tide weakened piping plovers in the vicinity of Laguna Madre and Padre Island, Texas during the fall of 2011. Samples collected in Florida from two live piping plovers in 2006 both tested negative for avian influenza (Hines 2009). Based on information available to date, West Nile virus and avian influenza are a minor threat to piping plovers (Service 2009a). Neither the final listing rule nor the recovery plans state that disease is an issue for the species, and no plan assigns recovery actions to this threat factor.

Energy development

Various oil and gas exploration and development activities occur along the Gulf coast. Examples of conservation measures prescribed to avoid adverse effects on piping plovers and their habitats include conditions on driving on beaches and tidal flats, restrictions on discharging fresh water across unvegetated tidal flats, timing exploration activities during times when the plovers are not present, and use of directional drilling from adjacent upland areas (Service 2008b; Firmin 2012). With the implementation of appropriate conditions, threats to non-breeding piping plovers from land-based oil and gas extraction are currently very low.

Wind turbines are a potential future threat to piping plovers in their coastal migration and wintering range. Relatively small single turbines have been constructed along the beachfront in a few locations (*e.g.,* South Carolina; Caldwell 2012). Current risk to piping plovers from several wind farms located on the mainland north and west of several bays in southern Texas is deemed low during months of winter residency because the birds are not thought to traverse these areas in their daily movements (Newstead 2012a). To date, no piping plovers have been reported from post-construction carcass detection surveys at these sites (Clements 2012). However, Newstead (2012a) raised questions about collision risk during migration departure, as large numbers of piping plovers have been observed in areas of Laguna Madre east of the wind farms during the late winter. Furthermore, there is concern that, as sea level rises, the intertidal zone (and potential piping plover activity) may move closer to these sites.

In addition to uncertainty regarding the location and design (*e.g.,* number and height of turbines) of future wind turbines, the magnitude of potential threats is difficult to assess without better information about piping plover movements and behaviors. For wind projects situated on barrier beaches, bay shorelines, or within bays, relevant information includes the flight routes of piping plovers moving among foraging and roosting sites, flight altitude, and avoidance rates under varying weather and light conditions. For off-shore wind projects, piping plover migration routes and altitude, as well as avoidance rates will be key determinants of threats.

Exotic/invasive vegetation

An identified threat to piping plover habitat, not described in the listing rule or older recovery plans, is the spread of coastal invasive plants into suitable piping plover habitat. Like most invasive species, coastal exotic plants reproduce and spread quickly and exhibit dense growth habits, often outcompeting native plant species. If left uncontrolled, invasive plants cause a habitat shift from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods. The propensity of these exotic species to spread, and their tenacity once established, make them a persistent threat, partially countered by increasing landowner awareness and willingness to undertake eradication activities.

Many invasive species are either currently affecting or have the potential to affect coastal beaches and thus plover habitat. Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant which has spread to coastal communities throughout the southeastern U.S. from Virginia to Florida, and west to Texas (Westbrooks and Madsen 2006). Unquantified amounts of crowfoot grass (*Dactyloctenium aegyptium*) grow invasively along portions of the Florida coastline. It forms thick bunches or mats that may change the vegetative structure of coastal plant communities and alter shorebird habitat. The Australian pine (*Casuarina equisetifolia*) also changes the vegetative structure of the coastal community in south Florida and islands within the Bahamas. Shorebirds prefer foraging in open areas where they are able to see potential predators, and tall trees provide good perches for avian predators. Australian pines potentially impact shorebirds, including the piping plover, by reducing attractiveness of foraging habitat and/or increasing avian predation. Japanese sedge *(Carex kobomugi)*, which aggressively encroaches into sandy beach habitats (USDA 2013), was documented in Currituck County, North Carolina, in the mid-1970s and as recently as 2003 on Currituck National Wildlife Refuge (Gramling 2011), at two sites where migrating piping plovers have also been documented. Early detection and rapid response are key to controlling this and other invasive plants (Westbrooks 2011).

Defeo et al. (2009) cite biological invasions of both plants and animals as global threats to sandy beaches, with the potential to alter the food web, nutrient cycling and invertebrate assemblages. Although the extent of the threat is uncertain, this may be due to poor survey coverage more than an absence of invasions.

Groins

Groins pose an ongoing threat to piping plover beach habitat within the continental wintering range. Groins (structures made of concrete, riprap, wood, or metal built perpendicular to the beach in order to trap sand) are typically found on developed beaches with severe erosion. Although groins can be individual structures, they are often clustered along the shoreline. Groins can act as barriers to long-shore sand transport and cause down-drift erosion (Hayes and Michel 2008), which prevents piping plover habitat creation by limiting sediment deposition and accretion. The resulting beach typically becomes scalloped in shape, thereby fragmenting plover habitat over time. Groins and groin fields are found throughout the southeastern Atlantic and Gulf coasts, and although most were in place prior to the piping plover's 1986 listing under the Act, installation of new groins continues to occur, perpetuating the threat to migrating and wintering piping plovers. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from groins and groin fields may increase as communities and beachfront property owners seek additional ways to protect infrastructure and property.

Human disturbance

Disturbance (*i.e.,* human and pet presence that alters bird behavior) disrupts piping plovers as well as other shorebird species. Intense human disturbance in shorebird winter habitat can be functionally equivalent to habitat loss if the disturbance prevents birds from using an area for a significant amount of time (Goss-Custard et al. 1996), which can lead to roost abandonment and local population declines (Burton et al. 1996). Pfister et al. (1992) implicated anthropogenic disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. Disturbance can also cause shorebirds to spend less time roosting or foraging and more time in alert postures or fleeing from the disturbances (Johnson and Baldassarre 1988; Burger 1991, 1994; Elliott and Teas 1996; Lafferty 2001a, 2001b; Thomas et al. 2002), which limits the local abundance of piping plovers (Zonick and Ryan 1995; Zonick 2000). Shorebirds that are repeatedly flushed in response to disturbance expend energy on costly short flights (Nudds and Bryant 2000) and may not feed enough to support migration and/or subsequent breeding efforts (Puttick 1979; Lafferty 2001b). Elliott and Teas (1996) found a significant difference in actions between piping plovers encountering pedestrians and those not encountering pedestrians. Piping plovers encountering pedestrians spend proportionately more time in non-foraging behavior. This study suggests that interactions with pedestrians on beaches cause birds to shift their activities from calorie acquisition to calorie expenditure. In wintering and migration sites, human disturbance continues to decrease the amount of undisturbed habitat and appears to limit local piping plover abundance (Zonick and Ryan 1995).

Shorebirds are more likely to flush from the presence of dogs than people, and birds react to dogs from farther distances than people (Lafferty 2001a, 2001b; Thomas et al. 2002). Dogs off leash are more likely to flush piping plovers from farther distances than are dogs on leash; nonetheless, dogs both on and off leashes disturb piping plovers (Hoopes 1993). Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds, which may increase the likelihood that dogs would chase birds. Although the timing, frequency, and duration of human and dog presence throughout the wintering range are unknown, studies in Alabama and South Carolina suggest that most disturbances to piping plovers occur during periods of warmer weather, which coincides with piping plover migration (Johnson and Baldassarre 1988; Lott et al. 2009; Maddock et al. 2009).

Off-road vehicles (ORVs) can also significantly degrade piping plover habitat (Wheeler 1979) or disrupt the birds' normal behavior patterns (Zonick 2000). The 1996 Atlantic Coast Recovery Plan cites tire ruts crushing wrack into the sand, making it unavailable as cover or as foraging substrate (Goldin 1993; Hoopes 1993). The plan also notes that the magnitude of the threat from ORVs is significant, because ORVs extend impacts to remote stretches of beach where human disturbance will otherwise be very slight. Godfrey et al. (1978, 1980) postulated that vehicular traffic along the beach may compact the substrate and kill marine invertebrates that are food for the piping plover. Zonick (2000) found that the density of ORVs negatively correlated with the abundance of roosting piping plovers on the ocean beach. Cohen et al. (2008a) found that piping plovers using ocean beach habitat were less likely to use the north side of the inlet where ORV use is allowed. Ninety-six percent of piping plover detections occurred on the south side of the inlet even though it was farther away from foraging sites (Cohen et al. 2008a). Although there is some variability among states, disturbance from human activities and pets poses a moderate to high and escalating threat to migrating and wintering piping plovers.

Based on surveys with land managers and biologists, knowledge of local site conditions, and other information, the Service has estimated the levels of eight types of disturbance at sites in the U.S. with wintering piping plovers (Service 2009b; Table 3). There are few areas used by wintering piping plovers that are devoid of human presence, and just under half have leashed and unleashed dog presence (Smith 2007; Lott et al. 2009). Data are not available on human disturbance at wintering sites in the Bahamas, other Caribbean countries, or Mexico.

Disturbance can be addressed by implementing recreational management techniques such as vehicle and pet restrictions and symbolic fencing (usually sign posts and string) of roosting and feeding habitats. In implementing conservation measures, managers need to consider a range of site-specific factors, including the extent and quality of roosting and feeding habitats and the types and intensity of recreational use patterns. In addition, educational materials such as informational signs or brochures can provide valuable information so that the public understands the need for conservation measures.

Inlet stabilization/relocation

Man navi able mainland or barrier island tidal inlets alon the Atlantic and Gulf of Mexico coasts are stabilized with etties roins seawalls, and/or adjacent industrial or residential develo ment. Jetties are structures built er endicular to the shoreline that extend throu h the entire near-shore zone and ast the breaker zone to revent or decrease sand de osition in the channel Ha es and Michel 2008 . Inlet stabilization with rock etties and associated channel dred in for navi ation alter the d namics of lon -shore sediment transport and affect the location and movement rate of barrier islands Camfield and Holmes 1995 t ically causing down-drift erosion. Sediment is then dredged and added back to the islands which are subse uentl widened. Once the island becomes stabilized ve etation encroaches on the ba side habitat thereb diminishin and eventuall destro in its value to i in lovers. Accelerated erosion ma com ound future habitat loss de endin on the de ree of sea-level rise. Unstabilized inlets naturall mi rate re-formin im ortant habitat com onents whereas jetties often tra sand and cause si nificant erosion of the down-drift shoreline. These combined actions affect the availabilit of i in lover habitat Cohen et al. 2008b . Rice (2012b) found that 40 ercent 89 out of 221 of the inlets o en in 2011 have been stabilized in some wa contributing to habitat loss and de radation throu hout the winterin ran e. Accelerated erosion ma com ound future habitat loss de endin on the de ree of sea level rise Titus et al. 2009 . Due to the complexity of impacts associated with projects such as jetties and groins, Harrington

2008 noted the need for a better understanding of potential effects of inlet-related projects, such as jetties, on bird habitats.

Althou_h the loss and/or de_radation of _i_in_ _lover habitat associated with the effects of tidal inlet relocation ma_ _ersist for _ears the effects are less _ermanent than the construction of hard structures. An inlet relocation _ro_ect on Kiawah Island South Carolina de_raded one of the most im_ortant _i_in_ _lover habitats in the State b_ reducin_ the size and _h_sical characteristics of an active fora_in_ site chan_in_ the com_osition of the benthic community, decreasin_ the tidal la_ in an ad_acent tidal la_oon and decreasin_ the ex_osure time of the associated sand flats (Service and Town of Kiawah Island 2006 . In 2006 _re-_ro_ect _i_in_ _lover numbers in the _ro_ect area recorded durin_ four surve_s conducted at low tide averaged 13.5 _i_in_ _lovers. This contrasts with a _ost-_ro_ect avera_e of 7.1 _lovers durin_ ei_ht surve_s four in 2007 and four in 2008 conducted durin_ the same months Service and Town of Kiawah Island 2006), indicating that reduced habitat quality was one possible cause of the lower usage by plovers.

Macroinvertebrate prey base loss due to shoreline stabilization

Winterin_ and mi_ratin_ _i_in_ _lovers de_end on the availabilit_ and abundance of macroinvertebrates as an im_ortant food item. Studies of invertebrate communities have found that communities are richer (greater total abundance and biomass) on protected (bay or lagoon) intertidal shorelines than on ex_osed ocean beach shorelines McLachlan 1990 Cohen et al. 2006 Defeo and McLachlan 2011 . Pol_chaete worms tend to have a more diverse communit_ and be more abundant in more _rotected shoreline environments and mollusks and crustaceans such as am_hi_ods thrive in more ex_osed shoreline environments McLachlan and Brown 2006 . Pol_chaete worms com_rise the ma_orit_ of the shorebird diet Kale_ta 1992 Mercier and McNeil 1994 Tsi_oura and Bur_er 1999 Verkuil et al. 2006 and of the piping plover diet in particular (Hoopes 1993; Nicholls 1989; Zonick and Ryan 1995).

The _ualit_ and _uantit_ of the macroinvertebrate _re_ base is threatened b_ shoreline stabilization activities includin_ beaches that have received sand placement of various t_pes. The addition of dred_ed sediment can tem_oraril_ affect the benthic fauna of intertidal s_stems. Invertebrates ma_ be crushed or buried durin_ _ro_ect construction. Some benthic s_ecies can burrow through a thin la_er 15-35 in for different s_ecies of additional sediment since the_ are ada_ted to the turbulent environment of the intertidal zone however thicker la_ers *i.e.,* >3.3 feet of sediment are likel_ to smother the benthic fauna Greene 2002). Numerous studies of such effects indicate that the recovery of benthic fauna after beach nourishment or sediment _lacement _ro_ects can take an_where from 6 months to 2 _ears and _ossibl_ lon_er in extreme cases (Thrush et al. 1996; Peterson et al. 2000; Zajac and Whitlatch 2003; Bishop et al. 2006; Peterson et al. 2006).

Invertebrate communities ma_ also be affected b_ chan_es in the ph_sical environment resultin_ from shoreline stabilization activities that alter the sediment com_osition or de_ree of ex_osure. Shoreline armoring with hard stabilization structures such as seawalls and revetments can alter the degree of exposure of the macroinvertebrate prey base by modifying the beach and intertidal _eomor_hology, or to_o_ra_h_. Seawalls typicall_ result in the narrowin_ and stee_enin_ of the beach and intertidal slo_e in front of the structure eventually leadin_ to com_lete loss of the dry and intertidal beach as sea level continues to rise Pilke_ and Wri_ht 1988 Hall and Pilke_ 1991 Dugan and Hubbard 2006 Defeo et al. 2009 Kim et al. 2011 . Sand _lacement _ro_ects bury the natural beach with new sediment and _rade the new beach and intertidal zone with heav_ e_ui_ment to conform to a _redetermined to_o_ra_hic _rofile which can lead to com_action of the sediment Nelson et al. 1987 Cor_s 2008 Defeo et al. 2009 . If the material used in a sand _lacement _ro_ect does not closel_ match the native material on the beach the sediment incom_atibilit_ ma_ result in modifications to the macroinvertebrate communit_ structure because several s_ecies are sensitive to _rain size and com_osition Rakocinski et al. 1996; Peterson et al. 2000, 2006; Peterson and Bishop 2005; Colosio et al. 2007; Defeo et al. 2009).

Dela_ed recover_ of the benthic _re_ base or chan_es in their communities due to _h_sical habitat chan_es ma_ affect the _ualit_ of _i_in_ _lover fora_in_ habitat. The duration of the im_act can adversel_ affect pi_in_ _lovers because of their hi_h site fidelit_. Althou_h recovery of invertebrate communities has been documented in man_ studies sam_lin_ desi_ns have t_ _icall_ been inade_uate and have onl_ been able to detect lar_e-ma_nitude chan_es Schoeman et al. 2000 Peterson and Bisho_ 2005 . Therefore uncertaint_ _ersists about the im_acts of various _ro_ects to invertebrate communities and how these im_acts affect shorebirds _articularly the _i_in_ _lover. Rice 2009 identified several conservation measures that can avoid and minimize some of the known impacts.

Military actions

Twelve coastal military bases are located in the Southeast. To date, five bases have consulted with the Service under section 7 of the Act, on military activities on beaches and baysides that may affect piping plovers or their habitat. Overall, project avoidance and minimization actions currently reduce threats from military activities to wintering and migrating piping plovers to a minimal threat level. However, prior to removal of the piping plover from protection under the Act, Integrated Resource Management Plans or other agreements should clarify if and how a change in legal status would affect plover protections.

Oil spills and other contaminants

Contaminants have the potential to cause direct toxicity to individual birds or negatively affect their invertebrate prey base (Rattner and Ackerson 2008). Depending on the type and degree of contact, contaminants can have lethal and sub-lethal effects on birds, including behavioral impairment, deformities, and impaired reproduction (Rand and Petrocelli 1985; Gilbertson et al. 1991; Hoffman et al. 1996). Petroleum products are the contaminants of primary concern, as opportunities exist for petroleum to pollute intertidal habitats that provide foraging substrate. Impacts to piping plovers from oil spills have been documented throughout their life cycle (Chapman 1984; Service 1996; Burger 1997; Massachusetts Audubon 2003-2009; Amirault-Langlais et al. 2007; Amos 2009). However, lightly oiled piping plovers have survived and successfully reproduced (Chapman 1984; Amirault-Langlais et al. 2007; Amos 2009). To date, no plover mortality has been attributed to oil contamination outside the breeding grounds, but latent effects would be difficult to prove. Chapman (1984) noted shifts in habitat use as piping plovers moved out of spill areas. This behavioral change was believed to be related to the demonstrated decline in benthic infauna (prey items) in the intertidal zone and may have decreased the direct impact to the species.

More subtle but cumulatively damaging sources of oil and other contaminants are leaking vessels located offshore or within the bays on the Atlantic and Gulf coasts, offshore oil rigs and undersea pipelines in the Gulf of Mexico, pipelines buried under the bay bottoms, and onshore facilities such as petroleum refineries and petrochemical plants. In Louisiana, about 2,500-3,000 oil spills are reported in the Gulf region each year, ranging in size from very small to thousands of barrels (Carver 2011). Chronic spills of oil from rigs and pipelines and natural seeps in the Gulf of Mexico generally involve small quantities of oil. The oil from these smaller leaks and seeps, if they occur far enough from land, will tend to wash ashore as tar balls. In cases such as this, the impact is limited to discrete areas of the beach, whereas oil slicks from larger spills coat longer stretches of the shoreline (Rice 2009). Federal and state land managers have protective provisions in place to secure and remove the oil, thus reducing the likelihood of contamination.

According to government estimates, the 2010 Deepwater Horizon Mississippi Canyon Well #252 (Deepwater Horizon) oil spill discharged more than 200 million gallons of oil into the Gulf of Mexico. Containment activities, recovery of oil-water mix, and controlled burning removed some oil, but additional impacts to natural resources may stem from the 1.84 million gallons of dispersant that were applied to the spill (U.S. Government 2010). Approximately 1,100 mi of shoreline was estimated to be oiled in the Gulf of Mexico. This included approximately 665 mi in Louisiana, 160 mi in Mississippi, 95 mi in Alabama, and 175 mi in Florida (Michel et al. 2013). These numbers do not address cumulative impacts or include shoreline that was cleaned earlier. The U.S. Coast Guard, the states, and responsible parties that form the Unified Command (with advice from federal and state natural resource agencies) initiated protective measures and clean-up efforts as provided in contingency plans for each state’s coastline. The contingency plans identified sensitive habitats, including all ESA-listed species’ habitats, which received a higher priority for response actions.

Efforts to prevent shoreline oiling and cleanup response activities can disturb piping plovers and their habitat. Although most piping plovers were on their breeding grounds in May, June, and early July when the Deepwater Horizon well was discharging oil, oil was still washing onto Gulf beaches when the plovers began arriving back on the Gulf in mid-July. Ninety percent of piping plovers detected during the prior 4 years of surveys in Louisiana were in the Deepwater Horizon oil spill impact zone, and Louisiana’s Department of Wildlife and Fisheries reported significant disturbance to birds and their habitat from response activities. Wrack lines were removed, and sand washing equipment “cleansed” beaches (Seymour 2011). Potential long-term adverse effects stem from the construction of sand berms and closing of at least 32 inlets (Rice 2012b). Implementation of prescribed best management practices reduced, but did not negate, disturbance to plovers (and to other beach-dependent wildlife) from cleanup personnel, all-terrain vehicles, helicopters, and other equipment. Service and state biologists present during cleanup operations provided information about breeding, migrating, and wintering birds and their habitat protection needs. However, high staff turnover during the extended spill response period necessitated continuous education and training of clean up personnel (Bimbi 2011). Limited clean-up operations were still ongoing throughout the spill area in November 2012 (Herod 2012). Results of a natural resources damage assessment study to assess injury to piping plovers are not yet available.

Pesticides and other contaminants

In 2000, mortality of large numbers of wading birds and shorebirds, including one piping plover, at Audubon's Rookery Bay Sanctuary on Marco Island, Florida, occurred following the county's aerial application of the organophosphate pesticide Fenthion for mosquito control purposes (Williams 2001). Fenthion, a known toxin to birds, was registered for use as an avicide by Bayer, a chemical manufacturer. Subsequent to a lawsuit being filed against the EPA in 2002, the manufacturer withdrew Fenthion from the market, and EPA declared all uses of the chemical were to end by November 30, 2004 (American Bird Conservancy 2007). All other counties in the U.S. now use less toxic chemicals for mosquito control. It is unknown whether pesticides are a threat for piping plovers wintering in the Bahamas, other Caribbean countries, or Mexico.

There has been limited opportunistic testing of piping plover eggs. Polychlorinated biphenol (PCB) concentrations in several composites of Great Lakes piping plover eggs tested in the 1990s had potential to cause reproductive harm. Analysis of prey available to piping plovers at representative Michigan breeding sites indicated that breeding areas along the upper Great Lakes region were not likely the major source of contaminants to this population (Service 2003). Relatively high levels of PCB, dichloro diphenyl dichloroethylene, and polybrominated diphenyl ether were detected in one of two clutches of Ontario piping plover eggs analyzed in 2009 (Cavalieri 2011). Results of opportunistic egg analyses to date from Atlantic coast piping plovers did not warrant follow-up investigation (Mierzykowski 2009, 2010, 2012). No recent testing has been conducted for contaminants in the Northern Great Plains piping plover population.

Predation

The impact of predation on migrating or wintering piping plovers remains essentially undocumented. Avian and mammalian predators are common throughout the species' wintering range. Predatory birds are relatively common during fall and spring migration, and it is possible that raptors occasionally take piping plovers (Drake et al. 2001). The 1996 Atlantic Coast Recovery Plan summarized evidence that human activities affect types, numbers, and activity patterns of some predators, thereby exacerbating natural predation on breeding piping plovers. It has been noted, however, that the behavioral response of crouching when in the presence of avian predators may minimize avian predation on piping plovers (Morrier and McNeil 1991; Drake 1999a; Drake et al. 2001).

Non-breeding piping plovers may reap some collateral benefits from predator management on their migration and wintering grounds conducted for the primary benefit of other species. Some predator control programs may provide limited protection to piping plovers, should the birds use the areas for roosting or foraging. The Service is not aware of any current predator control programs targeting protection of coastal species in Georgia, Alabama, Mississippi, or Louisiana, but some predator control programs in North Carolina, South Carolina, Florida, and Texas may provide indirect benefits to plovers in wintering and migration habitat in those states.

Although the extent of predation to non-breeding piping plovers remains unknown, it remains a potential threat. Focused research to confirm impacts as well as to ascertain effectiveness of predator control programs may be warranted, especially in areas frequented by Great Lakes birds during migration and wintering months. At this time, however, we consider predator control on their wintering and migration grounds to be a low priority.

Sand mining/dredging

The dred_in_ and minin_ of sediment from inlet com_lexes threatens the _i_in_ _lover on its winterin_ _rounds throu_h habitat loss and de_radation. The maintenance of navi_ation channels b_ dred_in_ _es_eciall_ dee_ shi_ _in_ channels_ can si_nificantl_ alter the natural coastal _rocesses on inlet shorelines of nearb_ barrier islands _Otvos 2006_ Morton 2008_ Otvos and Carter 2008_ Beck and Wan_ 2009_ Stockdon et al. 2010_. Fort_-four percent of the tidal inlets within the U.S. winterin_ ran_e of the _i_in_ plover have been or continue to be dred_ed, _rimaril_ for navi_ational _ur_oses _Service 2015a_. The dred_in_ of navi_ation channels or relocation of inlet channels for erosion-control _ur_oses contributes to the cumulative effects of inlet habitat modification b_ removin_ or redistributin_ the local and re_ional sediment supply; the maintenance dred_in_ of deep shi_ _in_ channels can convert a natural inlet that normally b_ _asses sediment from one shoreline to the other into a sediment sink, where sediment no lon_er b_ _asses the inlet. Additionall_ dred_in_ can occur on an annual basis or every 2 to 3 years and the volume of sediment removed can be major, resulting in continual perturbations and modifications to inlet and adjacent shoreline habitat.

As sand sources for beach nourishment _ro_ects have become more limited_ the minin_ of ebb tidal shoals for sediment has increased _Cialone and Stauble 1998_. Ex_osed shoals and sandbars are valuable to _i_in_ _lovers_ as the_ tend to receive less human recreational use _because the_ are onl_ accessible b_ boat_ and therefore provide relativel_ less disturbed habitats for birds. Removin_ these sand sources can alter de_th contours and change wave refraction as well as cause localized erosion _Ha_es and Michel 2008_. Ebb shoals are es_eciall_ im_ortant because the_ act as “sand brid_es” that connect beaches and islands b_ trans_ortin_ sediment via lon_shore trans_ort from one side _u_drift_ to the other _downdrift_ side of an inlet. The mining of sediment from these shoals u_sets the inlet s_stem e_uilibrium and can lead to increased erosion of the ad_acent inlet shorelines _Cialone and Stauble 1998_. Rice _2012b_ noted mining of material from inlet shoals for use as beach fill is not equivalent to the natural sediment b_ _assin_ that occurs at unmodified inlets for several reasons. Most notably for the massive volumes involved that are “trans_orted” virtuall_ instantaneousl_ instead of _raduall_ and continuousl_ and for the _lacement of the material outside of the immediate inlet vicinit_ where it would naturall_ b_ _ass. The minin_ of inlet shoals can also remove massive amounts of sediment. Cialone and Stauble _1998_ found that monitorin_ of the im_acts of ebb shoal minin_ has been insufficient, and in one case the mining pit was only 66 percent recovered after 5 years.

They concluded that the larger the volume of sediment mined from the shoals, the larger the perturbation to the system and the longer the recovery period.

Information is limited on the effects to _i_in_ _lover habitat due to the de_osition of dred_ed material, and the available information is inconsistent. Studies have found instances where birds will and will not use islands created from dred_ed material throu_hout the winterin_ ran_e. Research is needed to understand why piping plovers use some dredge material islands, but are not regularly found using others.

In summary, the removal of sediment from inlet com_lexes via dred_in_ and sand minin_ for beach fill has modified nearly half of the tidal inlets within the continental wintering ran_e of the _i_in_ _lover_ leadin_ to habitat loss and de_radation. Man_ of these inlet habitat modifications have become _ermanent_ existin_ for over 100 _ears. The ex_ansion of several harbors and _orts to accommodate dee_er draft shi_s _oses an increasin_ threat as more sediment is removed from the inlet s_stem_ causin_ lar_er _erturbations and lon_er recover_ times. Sand removal or sediment starvation of shoals_ sandbars and ad_acent shoreline habitat has resulted in habitat loss and de_radation_ which ma_ reduce the s_stem's abilit_ to maintain a full suite of inlet habitats as sea level continues to rise at an acceleratin_ rate. Rice _2012b_ noted that the adverse im_acts of this threat to _i_in_ _lovers ma_ be mitigated b_ eliminatin_ dred_in_ and minin_ activities in inlet com_lexes with hi_h habitat value_ extendin_ the interval between dred_in_ c_cles_ dischar_in_ dred_ed material in near-shore downdrift waters so that it can accrete more naturally than when placed on the subaerial beach, and designing dredged material islands to mimic natural shoals and flats.

Sand placement projects

In the wake of e_isodic storm events_ mana_ers of lands under _ublic_ _rivate_ and count_ ownershi_ often _rotect coastal structures usin_ emer_enc_ storm berms which are fre_uentl_ followed b_ beach nourishment or renourishment activities _nourishment _ro_ects are considered "soft" stabilization versus "hard" stabilization such as seawalls_. Berm _lacement and beach nourishment de_osit substantial amounts of sand alon_ Gulf of Mexico and Atlantic beaches to _rotect local _ro_ert_ in antici_ation of _reventin_ erosion and what otherwise would be considered natural processes of over-wash and island mi_ration _Schmitt and Haines 2003_. On un_o_ulated islands_ the addition of sand and creation of marsh are sometimes used to counteract the loss of roosting and nesting habitat for shorebirds and wading birds as a result of erosional storm events.

Past and on_oin_ stabilization _ro_ects ma_ fundamentall_ alter the naturall_ d_namic coastal processes that create and maintain beach strand and ba_side habitats_ includin_ those habitat com_onents that _i_in_ _lovers rel_ u_on. Althou_h im_acts ma_ var_ de_endin_ on a ran_e of factors_ stabilization _ro_ects ma_ directl_ de_rade or destro_ _i_in_ plover roostin_ and fora_ing habitat in several wa_s. Front beach habitat ma_ be used to construct an artificial berm that is densel_ _lanted in _rass_ which can directl_ reduce the availabilit_ of roostin_ habitat. Over time_ if the beach narrows due to erosion_ additional roostin_ habitat between the berm and the water can be lost. Berms can also prevent or reduce the natural over-wash that creates roosting habitat b convertin ve etated areas to o en sand areas. The ve etation rowth caused b im edin natural over-wash can also reduce the maintenance and creation of bayside intertidal feedin habitats. In addition stabilization ro ects ma indirectl encourage further development of coastal areas and increase the threat of disturbance.

The coastal ecosystem associated with coastal habitats along the Gulf of Mexico and Atlantic Ocean is threatened b the inabilit of the barrier islands to maintain eomor holo ic functionality Cor s 2011 . Conse uentl most of the lanned sediment lacement projects are conducted as environmental restoration ro ects b various federal and state agencies because without the sediment many areas would erode below sea level since many coastal systems are starved for sediment sources. A encies conductin coastal restoration ro ects aim to desi n ro ects that mimic the natural existin elevations of coastal habitats *e.g.,* beach dune and marsh in order to allow their ro ects to work within and be sustained b the natural ecos stem processes that maintain those coastal habitats. Due to the low elevation of barrier islands and coastal headlands lacement of additional sediment in those areas enerall does not reach an elevation that would prevent the formation of over-wash areas or impede natural coastal rocesses es eciall durin storm events. Such careful desi n of these restoration ro ects allows dail tidal rocesses or storm events to re-work the sediments to reform the Gulf/Atlantic beach interface and create over-wash areas, sand flats and mud flats on the ba -side of the islands, as well as sand spits on the ends of the islands; thus, the added sediment aids in sustaining the barrier island system.

Sediment lacement also tem oraril affects the benthic fauna found in intertidal s stems b coverin them with a la er of sediment. Some benthic s ecies can burrow throu h a thin la er varies from 15 to 35 in for different species of additional sediment since the are ada ted to the turbulent environment of the intertidal zone however thicker la ers *i.e.,* >3.3 feet) of sediment are likel to smother the benthic fauna (Greene 2002 . Various studies of such effects indicate that the recover of benthic fauna after beach renourishment or sediment lacement can take an where from 6 months to 2 ears Rakocinski et al. 1996 Peterson et al. 2000 Peterson et al. 2006 . Such dela ed recovery of benthic prey species temporarily affects the quality of piping plover foraging habitat.

Seawalls and revetments

Seawalls and revetments are vertical hard structures built parallel to the beach in front of buildin s roads and other facilities to rotect them from erosion. However these structures often accelerate erosion b causin scourin in front of and down-drift from the structure Ha es and Michel 2008), which can eliminate intertidal fora in habitat and ad acent roostin habitat. Ph sical characteristics that determine microhabitats and biolo ical communities can be altered after installation of a seawall or revetment thereb de letin or chan in the benthic community composition that serves as the re base for i in lovers. At four California stud sites, each com rised of an unarmored se ment and a se ment seaward of a seawall, Du an and Hubbard 2006 found that armored se ments had narrower intertidal zones smaller standin cro s of macrophyte wrack, and lower shorebird abundance and species richness. Geotubes (long c lindrical ba s made of hi h-stren th ermeable fabric and filled with sand) are softer alternatives, but act as barriers by preventing over-wash.

The repair of existing armoring structures and installation of new structures continues to degrade, destroy, and fragment beachfront plover habitat throughout its continental wintering range. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from hard erosion-control structures is likely to increase as communities and property owners seek to protect their beachfront development. As coastal roads become threatened by rising sea level and increasing storm damage, additional lengths of beachfront habitat may be modified by riprap, revetments, and seawalls.

Severe cold weather

Several sources suggest the potential for adverse effects of severe winter cold on survival of piping plovers. The 1996 Atlantic Coast Recovery Plan mentioned high mortality of coastal birds and a drop from approximately 30-40, to 15 piping plovers following an intense 1989 snowstorm along the North Carolina coast (Fussell 1990). A preliminary analysis of survival rates for Great Lakes piping plovers found that the highest variability in survival occurred in spring and correlated positively with minimum daily temperature during the preceding winter (Roche 2010, 2012). Catlin (2012) reported that the average mass of 10 piping plovers captured in Georgia during unusually cold weather in December 2010, was 0.2 ounces less than the average for 9 birds captured in October of the same year.

Storm events

Storms are a component of the natural processes that form coastal habitats used by migrating and wintering piping plovers, and positive effects of storm-induced over-wash and vegetation removal have been noted in portions of the wintering range. For example, Gulf Islands National Seashore habitats in the National Park Service's Florida district benefited from increased over-wash events that created optimal habitat conditions during the 2004 and 2005 hurricane seasons, with biologists reporting piping plover use of these habitats within 6 months of the storms (Nicholas 2005). Hurricane Katrina (2005) over-washed the mainland beaches of Mississippi, creating many tidal flats where piping plovers were subsequently observed (Winstead 2008). Hurricane Katrina also created a new inlet and improved habitat conditions on some areas of Dauphin Island, Alabama (LeBlanc 2009). Conversely, localized storms, since Katrina, have induced habitat losses on Dauphin Island (LeBlanc 2009). Noel et al. (2005) suspected that changes in habitat caused by multiple hurricanes along the Georgia coastline altered the spatial distribution of piping plovers and may have contributed to mortality of three Great Lakes piping plovers wintering along the Georgia coastline. Following Hurricane Ike in 2008, Arvin (2009) reported decreased numbers of piping plovers at some heavily eroded Texas beaches in the center of the storm impact area, and increases in plover numbers at sites about 100 mi to the southwest. However, piping plovers were observed later in the season using tidal lagoons and pools that Ike created behind the eroded beaches (Arvin 2009).

The adverse effects on piping plovers attributed to storms are sometimes due to a combination of storms and other environmental changes or human use patterns. For example, four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 IPPC tallied more than 350 piping plovers. Comparison of imagery taken 3 years before and several days after Hurricane Katrina found that the Chandeleur Islands lost 82 percent of their surface area (Sallenger et al. 2009), and a review of aerial photography prior to the 2006 IPPC suggested little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009) noted that habitat changes in the Chandeleur Islands stem not only from the effects of these storms, but rather from the combined effects of the storms, long-term (*i.e.*, greater than 1,000 years) diminishing sand supply, and sea-level rise relative to the land. Sallenger et al. (2009) went on to explain that although the marsh platform of the Chandeleur Islands continued to erode for 22 months post-Katrina, some sand was released from the marsh sediments which in turn created beaches, spits, and welded swash bars that advanced the shoreline seaward. Thus, although intense erosional forces have affected the Chandeleur Islands, they are still providing high quality shorebird habitat in the form of sand flats, spits, and beaches, until they are eroded below sea level. On January 18 and 19, 2011, piping plover surveys of the Chandeleur Islands were conducted by the piping plover NRDAR study team. Catlin et al. (2011) observed 194 piping plovers utilizing the Chandeleur Islands, and the birds were not distributed uniformly across the islands, but were clumped mostly in three locations. Because the survey was conducted within a two-day window, Catlin et al. (2011) believe that higher numbers of piping plovers are likely using the islands during spring and fall migration.

Other storm-induced adverse effects include post-storm acceleration of human activities such as beach nourishment, sand scraping, and berm and seawall construction. Such stabilization activities can result in the loss and degradation of feeding and resting habitats. Storms also can cause widespread deposition of debris along beaches. Removal of debris often requires large machinery, which can cause extensive disturbance and adversely affect habitat elements such as wrack.

Recent climate change studies indicate a trend toward increasing hurricane numbers and intensity (Emanuel 2005; Webster et al. 2005). When combined with predicted effects of sea-level rise, there may be increased cumulative impacts from future storms. Storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range. Available information suggests that some birds may have resiliency to storms and move to unaffected areas without harm, while other reports suggest birds may perish from storm events. Significant concerns include disturbance to piping plovers and habitats during cleanup of debris along shorelines and post-storm acceleration of shoreline stabilization activities, which can cause persistent habitat degradation and loss.

Wrack removal and beach cleaning

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999a; Smith 2007; Lott et al. 2009; Maddock et al. 2009) and many other shorebirds on their winter, breeding, and migration grounds. Because shorebird numbers are positively correlated with wrack cover and biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987; Dugan et al. 2003; Hubbard and Dugan 2003), beach grooming has been shown to decrease bird abundance (Defeo et al. 2009).

There is increasing popularity along developed beaches in the Southeast, especially in Florida, for beach communities to carry out "beach cleaning" and "beach raking" actions. Beach cleaning occurs on private beaches, where piping plover use is not well documented, and on some municipal or county beaches that are used by piping plovers. Most wrack removal on state and federal lands is limited to post-storm cleanup and does not occur regularly.

Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). These efforts remove accumulated wrack, topographic depressions, and sparse vegetation nodes used by roosting and foraging piping plovers. Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defeo et al. 2009).

We estimate that 240 of 825 mi (29 percent) of sandy beach shoreline in Florida are cleaned or raked on various schedules (*i.e.,* daily, weekly, monthly) (Florida Department of Environmental Protection 2008). Service biologists estimate that South Carolina mechanically cleans approximately 34 of its 187 shoreline mi (18 percent), and Texas mechanically cleans approximately 20 of its 367 shoreline mi (5.4 percent). In Louisiana, beach raking occurs on Grand Isle (the state's only inhabited island) along approximately 8 mi of shoreline, roughly 2 percent of the state's 397 sandy shoreline mi.

Tilling beaches to reduce soil compaction, as sometimes required by the Service for sea turtle protection after beach nourishment activities, also has similar impacts. Recently, the Service improved sea turtle protection provisions in Florida; these provisions now require tilling, when needed, to be above the primary wrack line, not within it.

Threats summary

A review of threats to _i_in_ _lovers and their habitat in their mi_ration and winterin_ range shows a continuin_ loss and de_radation of habitat due to sand _lacement _ro_ects_ inlet stabilization_ sand minin_, _roins_ seawalls and revetments_ dred_in_ of canal subdivisions_ invasive ve_etation_ and wrack removal. This cumulative habitat loss is b_ itself_ a ma_or threat to _i_in_ _lovers_ as well as the man_ other shorebird s_ecies com_etin_ with them for foraging resources and roosting habitats in their non-breedin_ ran_e. In addition, artificial shoreline stabilization im_edes the _rocesses b_ which coastal habitats ada_t to storms and acceleratin_ sea level rise, thus setting the stage for compounding future losses. Furthermore, inadequate management of increasing numbers of beach recreationists reduces the functional suitability of coastal mi_ration and winterin_ habitat and increases pressure on piping plovers and other shorebirds depending upon a shrinking habitat base. Experience during the Deepwater Horizon oil spill illustrates how, in addition to the direct threat of contamination, spill response activities can result in short- and long-term effects on habitat and disturb piping plovers and other shorebirds. If climate change increases the frequency and magnitude of severe weather events, this may pose an additional threat. The best available information indicates that other threats are currently low, but vigilance is warranted, especially in light of the potential to exacerbate or compound effects of very significant threats from habitat loss and degradation and from increasing human disturbance.

Ongoing Conservation Efforts

Continued partnerships and long term planning among state and federal agencies, landowners, towns and beachgoers are vital to the plover's future. Conservation measures underway to protect the piping plover include recognition, research, protective management, requirements for federal protection, and prohibitions against certain practices.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://www.fws.gov/northeast/njfieldoffice

In Reply Refer to:

2008-F-0785-R001

DEC 2 9 2008

Minas M. Arabatzis, Chief
Planning Division
Philadelphia District
U.S. Army Corps of Engineers
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390
Attn: Mary E. Brandreth

Dear Mr. Arabatzis:

This letter documents re-initiation of formal consultation with the U.S. Army Corps of Engineers, Philadelphia District (Corps) for beach nourishment activities within the City of North Wildwood and the City of Wildwood, Cape May County, New Jersey. This letter supercedes the previously issued Tier 2 (streamlined) Biological Opinion (File No. 2008-F-0785) dated December 8, 2008, and addresses changes to the applicant's project description and the Corps' modified conservations measures (permit conditions). The Corps' proposed issuance of a 10-year Department of the Army permit (File No. CENAP-OP-R-2007-1181-24) addresses beach nourishment/maintenance activities to be conducted by the applicant, the New Jersey Department of Environmental Protection (NJDEP), on beaches between 2nd and 26th Avenues in the City of North Wildwood, and between East Juniper and East Poplar Avenues in the City of Wildwood, Cape May County, New Jersey (project area). The proposed permitted activity constitutes a Tier 2 (streamlined) individual project under the U.S. Fish and Wildlife Service's (Service) December 2005 Tier 1 Programmatic Biological Opinion (PBO) on the effects of beach nourishment and maintenance activities on the federally listed (threatened) piping plover (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*).

AUTHORITY

This response is provided pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) (ESA) to ensure the protection of endangered and threatened species and does not address all Service concerns for fish and wildlife resources. These comments do not preclude separate review and comment by the Service directed to the Corps via the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661. *et seq.*) for any permits required pursuant to Section 404 of the Clean Water Act (33 U.S.C. 1344 *et seq.*); or comments on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 (83 Stat. 852, as amended; 42 U.S.C. 4321 *et seq*).

CONSULTATION HISTORY

February 25, 2008	Via electronic mail, the Service and the Corps discussed potential effects that needed to be addressed in the consultation, specifically the impacts of dredging in Hereford Inlet to threatened and endangered species habitat. In addition, impacts to red knot (*Calidris canutus rufa*) needed to be addressed since it became a Federal candidate species after the issuance of the December 2005 Tier 1 Programmatic Biological Opinion.
March 26, 2008	By letter, the Service sent the Corps recommended conservation measures to protect piping plover and seabeach amaranth to be included as permit conditions in the subject permit.
September 18, 2008	By letter, the NJDEP Bureau of Coastal Engineering (BCE) informed the Corps and the Service of changes to the project, specifically modifications to the dredging site, addressing the Service's concerns regarding the potential impacts to the inlet beaches of North Wildwood and the threatened, endangered, and candidate species that utilize those beaches.
November 26, 2008	The Service, Corps, and BCE continued to coordinate via electronic mail regarding permit conditions for the North Wildwood/Wildwood project area.
December 8, 2008	The Service issued its Tier 2 streamlined Biological Opinion.
December, 2008	Via electronic mail and telephone calls, clarifications were made by the BCE regarding the project description which caused the need for modifications to permit conditions by the Corps and re-initiation of formal consultation with the Service. The Service had several discussions with the NJDEP Endangered and Nongame Species Program and BCE regarding a reduced buffer at the southern end of the current nesting area based on the environmental features of the project area. These changes were incorporated into the Corps permit.

PROJECT DESCRIPTION

Beach nourishment will occur between 2nd and 26th Avenues in the City of North Wildwood, and between East Juniper and Poplar Avenues in the City of North Wildwood, Cape May County, New Jersey. The design includes a berm taper extending approximately 600 feet into the existing beach north of the 2nd Avenue terminal groin in the City of North Wildwood, as well as a berm and dune taper extending approximately 800 feet in the City of Wildwood. As a result of the increased elevation of the berm and the berm taper adjacent to the intersection of 2nd Avenue, approximately 2/3 of the terminal groin will be buried with sand. Approximately 7,900 linear feet (1.5 linear miles) of coastal shoreline will be affected.

The proposed borrow site for obtaining sand is an off-shore borrow area within Hereford Inlet, approximately one-half mile northeast of 2nd Avenue in North Wildwood. Approximately 1,438,055 cubic yards of sand will be pumped hydraulically via pipeline to the beach from the off-shore borrow site. The project will include restoration of eroded dunes to an elevation of 14.25 feet (NAVD 88), including dune stabilization with native vegetation and fencing; construction of a 400-foot (maximum) wide beach berm to an elevation of 6.75 feet (NAVD 88) and a foreshore slope of 25:1; reconstruction of handicap and vehicular accesses; and the extension of three deteriorated storm water outfall pipes at 2nd, 21st, and Poplar Avenues. Outside the beach nourishment area, to the northeast of Central and Walnut/Spruce Avenues, a fourth outfall pipe may be reconstructed. The reconstruction of the outfall pipe at Central and Spruce Avenues may include grouting and plugging the existing pipe at Central and Walnut Avenues and redirecting stormwater, via a new pipeline under Central Avenue, to the existing outfall pipe at Central and Spruce Avenues. The permit will be issued to include future reconstruction of the outfall pipe at Central and Spruce Avenues if lengthening of the pipe is needed to allow for proper discharge.

ADHERENCE TO MEASURES TO MINIMIZE IMPACTS TO FEDERALY LISTED SPECIES

Relevant conservation measures proposed by the Corps for protection of federally listed species and reasonable and prudent measures imposed by the Service to minimize take of federally listed species are specified within the Service's 2005 Tier 1 Programmatic Biological Opinion and are applicable to all Tier 2 projects carried out under the Corps' program. All applicable measures were incorporated as appropriate permit conditions into the Tier 2 North Wildwood/Wildwood 10-year beach nourishment/maintenance permit.

STATUS OF THE SPECIES

Relevant biological and ecological information for the piping plover and seabeach amaranth was previously provided to the Corps in the Service's December 2005 Tier 1 Programmatic Biological Opinion. That information remains pertinent and was considered by the Service in formulating this Tier 2 (streamlined) Biological Opinion.

ENVIRONMENTAL BASELINE

The environmental baseline for the Corps overall program for Federal beach nourishment, renourishment, stabilization, restoration, and permitted activities along the Atlantic Coast of New Jersey within the Philadelphia District was established and fully described within the Service's December 2005 Tier 1 Programmatic Biological Opinion.

New site-specific information regarding piping plover and seabeach amaranth occurrence within the project area since issuance of the 2005 Tier 1 Programmatic Biological Opinion has become available. Portions of the project area have not been used by nesting piping plovers since 1996 (between 2nd and 26th Avenues). The area between East Juniper and East Poplar Avenues has no recorded nesting use by piping plovers. These sites have become degraded by erosion and do not provide suitable habitat. Piping plovers currently nest in the project area between Surf and New York Avenues (Hereford Inlet) with a nesting buffer that overlaps the 2nd and 26th Avenues nourishment portion of the project area. The nesting area also supports State-listed (endangered) least tern (*Sterna antillarum*) and State species of concern (currently proposed) American oystercatcher (*Haematopus palliatus*). Red knot, a Federal candidate species and State-listed (endangered) species, and black skimmer (*Rynchops niger*) (also State-listed as endangered), have also been known to use the inlet area for feeding and roosting activities during the fall and spring migrations. No seabeach amaranth plants were found within the project area during Service surveys in 2008, and none have previously been documented in North Wildwood or Wildwood.

All other information described within the December 2005 Tier 1 Programmatic Biological Opinion remains pertinent and was considered by the Service in formulating this Tier 2 Biological Opinion.

EFFECTS OF THE ACTION

Following review of the information provided by the Corps and NJDEP regarding the North Wildwood/Wildwood project, the Service has determined that the potential effects of the project are consistent with those addressed in the December 2005 Tier 1 Programmatic Biological Opinion and are hereby incorporated by reference. Beach habitats historically occupied by piping plovers within the North Wildwood/Wildwood project area between 2nd and 26th Avenues have been degraded by beach erosion. No piping plovers have nested within that area since 1996. Currently piping plover nesting areas (with nesting buffers) do occur within a portion of the project area.

The Corps anticipates that work may extend into the 2009 or 2010 piping plover nesting season; however, no direct adverse impacts to the piping plover are anticipated. Based on the environmental conditions of the project area, the 1000 meter buffer has been reduced to approximately 375 meters at the southern end of the nesting area, ending at the 2nd Avenue terminal groin. This will allow work to be conducted from 2nd Avenue south towards 26th Avenue during the nesting season, if necessary. A series of mature dunes would provide a visual buffer (in addition to the 2nd Avenue terminal groin) from construction activities during the egg laying/incubation season for any work conducted south of the 2nd Avenue terminal groin. Movement of chicks outside the nesting area toward the 2nd Avenue terminal groin has not been observed and the likelihood of a change in this pattern is low. Ponds and ephemeral pools within the nesting area have been the primary foraging areas for chicks and adults. The low-wave inlet shoreline has also kept adults and chicks relatively close to the nesting area when foraging. The upper portion of the 2nd Avenue terminal groin will not be covered with sand for this project and will continue to act as a partial barrier for chick movement. Therefore, the protective buffer area around the nesting area has been reduced and shall include the entire Hereford Inlet shoreline from the 2nd Avenue terminal groin northwest to the terminus of the beach at New York Avenue. This buffer may be modified if other nesting areas are identified during the life of the Corps permit. Taper construction north of the 2nd Avenue terminal groin will be constructed outside the nesting season. In addition, no seabeach amaranth has been documented. Therefore, no direct adverse impacts to these species are anticipated.

Following beach nourishment in other portions of the Corps' program area, piping plovers have reestablished nesting in previously occupied areas, and seabeach amaranth has colonized suitable habitats created by the beach fill. However, piping plover productivity on such stabilized beaches (where no habitat enhancement occurs) is generally lower than on unstabilized beaches where over-wash zones and/or tidal pools are available. Therefore, it is likely that at least one pair of piping plovers may nest or attempt to nest within the project area following the fill, and productivity is anticipated to be lower than on unstabilized beaches. Impacts to the piping plover associated with nourishment activities such as increased human disturbance, increased recreational activities, incompatible beach management practices, and increased predation are likely to occur and were addressed in the December 2005 Tier 1 Programmatic Biological Opinion. Past shoreline stabilization within the North Wildwood/Wildwood project area has interfered with formation and maintenance of natural habitats for piping plover and seabeach amaranth. The project perpetuates shoreline stabilization that has essentially stopped the natural process of shoreline migration and, consequently, prevents the natural formation of optimal habitats for piping plovers and seabeach amaranth (*e.g.*, inlets and overwash areas). Further, the beach renourishment plan selected for the project area will result in creation of sub-optimal beach and dune habitats for piping plover and seabeach amaranth. Therefore, the North Wildwood/Wildwood project area will preclude formation of natural habitats and create sub-optimal beach and dune habitats for piping plover and seabeach amaranth along approximately 1.5 linear miles of Atlantic coastal shoreline.

CONCLUSION

Actions and effects associated with the North Wildwood/Wildwood beach nourishment and maintenance project are consistent with those identified and discussed within the Service's December 2005 Tier 1 Programmatic Biological Opinion. After reviewing the size and scope of the project, the environmental baseline, the status of federally listed species within the project area, and the effects of the action, it is the Service's Biological Opinion that the North Wildwood/Wildwood project is not likely to jeopardize the continued existence of the piping plover or seabeach amaranth. No Critical Habitat has been designated for these species within the project area; therefore, no Critical Habitat will be affected.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and the Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. *Take* is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. *Harm* is further defined by the Service to include significant habitat modification or degradation that results in the death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. *Harass* is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering. *Incidental take* is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to, and not intended as part of, the agency action is not considered a prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. Sections 7(b)(4) and 7(o)(2) of the ESA do not apply to the incidental take of federally listed plant species; therefore, no incidental take statement, and subsequently no reasonable and prudent measures nor terms and conditions, were provided for seabeach amaranth within the Service's December 2005 Tier 1 Programmatic Biological Opinion or are provided within this Tier 2 Biological Opinion.

The indirect effects of the North Wildwood/Wildwood project are anticipated to result in harm in the form of reduced habitat quality along approximately 1.5 linear miles of Atlantic coastal shoreline and harassment of one pair of piping plovers and their young from disturbance by beach management activities and beach recreation, resulting in reduced productivity. The type and amount of anticipated incidental take is consistent with that described in the Service's December 2005 Tier 1 Programmatic Biological Opinion and does not cause the total annual level of incidental take described in the Programmatic Biological Opinion to be exceeded.

REASONABLE AND PRUDENT MEASURES AND TERMS AND CONDITIONS

Reasonable and prudent measures (RPMs) are measures necessary or appropriate to minimize the amount or extent of anticipated incidental take of the species. To be exempt from the take prohibitions of Section 9 of the ESA, the Corps must implement all pertinent RPMs and associated terms and conditions, pursuant to the Service's December 2005 Tier 1 Programmatic Biological Opinion, to minimize the impact of anticipated incidental take of piping plovers. The Corps has included the relevant RPMs and terms and conditions as non-discretionary permit conditions within the subject North Wildwood/Wildwood permit. The Service has determined that no new reasonable and prudent measures, beyond those specified in the December 2005 Tier 1 Programmatic Biological Opinion, are needed to minimize the impact of incidental take anticipated for the North Wildwood/Wildwood project.

The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps: (1) fails to demonstrate clear compliance with the RPMs and their implementing terms and conditions in this Biological Opinion; or (2) fails to require Corps staff, contractors, cooperators, and/or permittees to adhere to the terms and conditions of the incidental take statement; and/or (3) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or Critical Habitat, to help implement recovery plans, or to develop information. The following conservation recommendation is directed to the Corps as the lead federal authority for this action.

1. To protect migratory shorebirds, particularly the Federal candidate red knot, the Corps should ensure that the NJDEP and/or the City of North Wildwood maintain protective fencing of sensitive habitats at the inlet year-round to minimize disturbance of red knot and other shorebird feeding and roosting activities, particularly during the fall and spring migrations.

REINITIATION - CLOSING STATEMENT

This concludes Tier 2 formal consultation on the effects of beach renourishment activities to be permitted by the Corps, Philadelphia District within the City of North Wildwood/Wildwood, Cape May County, New Jersey. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or Critical Habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or Critical Habitat that was not considered in this opinion; or, (4) a new species is listed or Critical Habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

Please contact Stephanie Egger at (609) 383-3938, extension 47, if you have any questions regarding these comments or require further assistance regarding threatened or endangered species.

Sincerely,

J. Eric Davis Jr.
Supervisor

y Corps
eers
a District

NEW JERSEY SHORE PROTECTION STUDY

TOWNSENDS INLET TO CAPE MAY INLET FEASIBILITY STUDY

VOLUME 1

FINAL FEASIBILITY REPORT
FINAL ENVIRONMENTAL IMPACT STATEMENT

March 1997

TOWNSENDS INLET TO CAPE MAY INLET
FEASIBILITY STUDY

Final Feasibility Report
March 1997

SYLLABUS

This report presents the results of a feasibility phase study to determine an implementable solution and the extent of Federal participation in a storm damage reduction project for the communities of Avalon, Stone Harbor and North Wildwood, New Jersey, and an ecosystem restoration project for Stone Harbor Point. This feasibility study is prepared based on the recommendations of the reconnaissance study completed in 1992, which identified possible solutions to the storm damage problems and habitat loss facing the study area. Those areas which did not warrant further study due to their wide beaches (the oceanfronts of North Wildwood, Wildwood, and Wildwood Crest) were not recommended for further plan formulation.

The feasibility study was cost shared between the Federal Government and State of New Jersey through the New Jersey Department of Environmental Protection (NJDEP), and was conducted under the provisions of the Feasibility Cost Sharing Agreement executed 19 November 1992. The feasibility study was initiated in December 1992.

The Townsends Inlet to Cape May Inlet study area stretches for approximately 15 miles along the Atlantic Ocean coast of New Jersey, and includes two barrier islands and two coastal inlets. The area has been subject to major flooding, erosion and wave attack during storms, causing damage to structures, and, since 1992, was declared a National Disaster Area by the President of the United States on three separate occasions. In recent years, continued erosion has resulted in a reduction of the height and width of the beachfront, which has increased the potential for storm damage. In addition, valuable fish and wildlife habitat along the southern end of Stone Harbor has been lost to erosion.

The feasibility study evaluated various alternative plans of improvement formulated on hurricane and storm damage reduction. The National Economic Development (NED) plan has been identified as a 150 foot wide berm at elevation + 8.5 ft NGVD with a dune at elevation + 16 ft NGVD with a crest width of 25 feet for the oceanfront of Avalon and Stone Harbor, and stone seawall sections for the Avalon and North Wildwood inlet frontages with top elevations of +14 ft NGVD and +13 ft NGVD respectively . The selected oceanfront plans include dune grass, dune fencing and suitable advance beachfill and periodic nourishment to ensure the integrity of the design. The plan requires 3,111,000 cubic yards of initial fill to be placed from designated offshore borrow sites, and subsequent periodic nourishment of 746,000 cubic yards every 3 years for 50 years.

The feasibility study also evaluated various alternative plans of improvement formulated on ecosystem restoration. The selected plan has been identified as the restoration and protection of 116 acres of coastal barrier habitat including wetland, beach, dune and bayberry (tertiary dune) habitats. The selected plan includes the planting of 3 acres of dune grass and 64 acres of bayberry and eastern red cedar. The plan requires 1,366,000 cubic yards of fill to be placed from designated offshore borrow sites. On the oceanfront of the restoration site, a 150 foot wide berm at elevation + 8.5 ft NGVD with a dune at elevation + 12 ft NGVD and crest width of 25 feet will be built, extending 1000 linear feet southwest of the terminal groin in Stone Harbor. Along the inlet frontage, the beach will transition to the west 350 linear feet with a berm width of 275 ft at elevation +6 ft. NGVD with a dune at elevation 10 ft. NGVD and crest width of 20 feet. The dune will continue to the northwest along the inlet an additional 250 linear feet. The dune includes sand fence and has a sand-filled, geotextile core extending 1,350 ft with scour protection.

The feasibility report is based on October 1996 price levels and the Federal discount rate of 7.375%. The economic analysis for the selected hurricane and storm damage reduction plan indicates that the proposed plan will provide annual benefits of $10,694,000 which when compared to the annual cost of $5,958,000, yields a benefit to cost ratio of 1.8 to 1 with $4,736,000 in net benefits.

The incremental analysis of the ecosystem restoration is based on October 1996 price levels and the Federal discount rate of 7.375%. The HEP analysis and incremental cost analysis indicate that the proposed plan will provide an initial total of 194 high value coastal habitat units by restoring and protecting 116 acres at Stone Harbor Point. The proposed plan is projected to provide 79 average annual acres over the project life of 50 years at an average annual cost of $741,000.

The total initial project cost of construction is currently estimated to be $53,700,000 (at October 1996 price levels). The Federal share of this first cost is $34,905,000, and the non-Federal share is $18,795,000. Periodic nourishment is estimated at $6,147,000 on a three year cycle and will be cost shared 65-35 for hurricane and storm damage reduction for the life of the project. The ultimate project cost which includes initial construction and fifty years of periodic nourishment is currently estimated to be $167,044,000 (at October 1996 price levels).

In accordance with the Administration's budgetary policy for shore protection, the Corps will not budget funds to undertake Preconstruction Engineering and Design (PED) at this time for the shore protection portions of the selected plan. The ecosystem restoration plan is in accord with current budgetary policies and is recommended for continuance.

DESCRIPTION OF THE SELECTED PLAN
FOR AVALON, STONE HARBOR AND NORTH WILDWOOD

Project Title: New Jersey Shore Protection Study, Townsends Inlet to Cape May Inlet Feasibility Study

Description: The proposed project provides a protective beach with a dune system to reduce the potential for storm damage in the communities of Avalon and Stone Harbor, NJ, seawalls along both Avalon's Townsends Inlet frontage and North Wildwood's Hereford Inlet frontage, and ecosystem restoration of Stone Harbor Point including beachfill and plantings.

Seven Mile Island Beach Fill:

Volume of Initial Fill	3,111,000 yd^3
Volume of Renourishment Fill	746,000 yd^3
Interval of Renourishment	3 yrs
Length of Fill	22,500 l.f.
Width of Beach Berm	150 ft.
Width of Dune Crest	25 ft.
Elevation of Beach Berm	+ 8.5 ft. NGVD
Elevation of Dune Crest	+16 ft. NGVD
Dune Slopes	1V:5H
Beach Berm to Existing Bottom	1V:30H
Dune Grass Planting	50 Acres
Sand Fencing	42,500 l.f.

Townsends Inlet and Hereford Inlet Seawalls:

Length of Seawall (Townsends Inlet)	2,970 l.f.
Length of Seawall (Hereford Inlet)	8,660 l.f.
Seawall Top Elevation (Townsends Inlet)	+14 ft. NGVD
Seawall Top Elevation (Hereford Inlet)	+13 ft. NGVD
Stone Slope	1V:2H

Stone Harbor Point Ecosystem Restoration:

Volume of Initial Fill	1,366,000 yd^3
Width of Beach Berm	150 - 275 ft.
Elevation of Beach Berm	+8.5 ft. NGVD
Elevation of Dune Crest	+12 to +10 ft. NGVD
Dune Slopes	1V:5H
Dune Grass Planting	2.7 Acres
Bayberry/Eastern Red Cedar Planting	64 Acres
Sand Fencing	1,500 l.f.

Project Costs	
Ultimate Project Cost (October, 1996)	$167,044,000
Initial Cost	$ 53,700,000
Annualized - Shore Protection (7.375%)	$ 5,958,000
Annualized - Ecosystem Restoration (7.375%)	$ 741,000
Average Annual Benefits	
Storm Damage Reduction	$ 6,845,000
Reduced Maintenance	$ 1,206,000
Benefits During Construction	$ 501,000
Recreation	$ 2,142,000
Total Average Annual Benefits	$10,694,000
Initial Habitat Units	194
Initial Acres	116
Average Annual Acres	79
Benefit/Cost Ratio (Shore Protection Plan only)	1.8 to 1
Net Benefits	$ 4,736,000
Cost Apportionment (First Cost)	
Federal	$34,905,000
Non-Federal	$18,795,000

NOTE: All elevations referenced to the National Geodetic Vertical Datum (NGVD), 1929. To covert to North American Vertical Datum (NAVD), 1988, subtract 1.25 ft (see conversion table at the end of the main report).

cultural resources were identified along the project shoreline. No prehistoric sites have been documented in the vicinity.

EROSION CONTROL STRUCTURE INVENTORY AND ASSESSMENT

138. Field inspections of the existing coastal structures at Avalon, Stone Harbor and North Wildwood were conducted in October 1993, April 1994 and June 1994. Several types of shore protection structures are present in these communities, in varied condition. An inventory of these structures is included in Appendix D.

139. GROINS AND JETTIES. There are a total of 23 beach groins within the project limits; four (4) are located in Avalon, eight (8) in Stone Harbor, and eleven (11) in North Wildwood. The groins in Avalon, located along the inlet at 1st Ave., 2nd (Dune) Ave., and 3rd Ave., were constructed of stone in 1966 by the State of New Jersey. They appear to be in fair to good condition. The 8th St. groin/jetty, originally a timber crib structure filled with stone, was completely reconstructed with stone in 1966, extended and raised in 1986 by the state and just recently (1994) repaired by the borough. It is currently in good condition.

140. Five of the eight beach groins in Stone Harbor are constructed of timber with stone at the seaward ends. They were built by the State of New Jersey in the 1950's at 84th St., 92nd St., 98th St., 106th St. and 111th St. and are in fair to good condition. Three stone beach groins, located at 114th St., 122nd St. and 127th St., are currently in good condition. The groin at 114th St. was built in the 1940's and extended in the 1950's by the state, and the groins at 122nd St. and 127th St. were also constructed by the state in 1966.

141. There are eleven groins in North Wildwood which are located along the inlet frontage and are constructed of stone. Eight of the groins, spaced approximately 300 feet apart, are located adjacent to Anglesea Dr. near Oak Ave. and westward. The remaining three, spaced approximately 600 feet apart, are located at 2nd Ave. at J. F. K. Blvd., 2nd Ave. at Ocean Ave., and 2nd Ave. at Surf Ave. All of them were built by the state in the early 1970's and appear to be in poor to fair condition. The Surf Avenue groin extends into the main channel and has been severely undermined by currents.

142. BULKHEADS, SEAWALLS AND REVETMENTS. Bulkheads are another type of shore protection structure located within the study limits. Generally the bulkheads throughout the study area are constructed of timber piles and sheeting, with the exception of a short stretch of steel sheetpile bulkhead in North Wildwood and a new aluminum bulkhead in Avalon.

143. The bulkhead system in Avalon is continuous and extends along the inlet frontage from the western end of Inlet Dr. to near 17th St. on the oceanfront. The majority of its length was constructed by the State of New Jersey in the mid to late 1960's, but the oceanfront section between 13th St. and 17th St. was constructed by the Borough of Avalon in the 1980's. Also, a section of the bulkhead between Dune Dr. and 3rd St. was rebuilt by the state in the mid 1980's.

The top elevation of the bulkhead system ranges from approximately 12.0 feet to 12.5 feet MLW. It appears to be in fair to good condition. The Borough of Avalon recently (November 1994) constructed several sections of aluminum bulkhead landward of and several feet higher than the existing timber bulkhead as a means to prevent wave overtopping and ponding into low elevation areas behind the primary bulkhead. The new aluminum bulkheads, however, do not provide any additional protection against storm induced erosion. A stone revetment, constructed primarily of approximately 1 to 3 ton stone at a top elevation between 10.5 ft. and 11.0 ft. MLW, fronts the bulkhead in order to provide toe protection. Sections of the oceanside revetment were reset in the 1980's by the borough. The revetment is generally in fair to poor condition; poorer specifically in the section along the inlet just west of the 8th St. groin.

144. A continuous timber bulkhead runs along the entire oceanfront of Stone Harbor from 80th St. to the terminal groin at 127th St. The section from 80th St. to 114th St. was reconstructed by the Borough of Stone Harbor in the early 1960's after the original bulkhead in place was damaged or destroyed by the 1962 storm. The portion of the bulkhead between 114th St. and 127th was constructed, also by the borough, in 1967. The top elevation of the bulkhead system is approximately 14.0 feet MLW. It currently is in fair to good condition. A stone revetment, constructed primarily of 1 to 3 ton stone at a top elevation of approximately 11.0 MLW, fronts the bulkhead in order to provide toe protection. At the southern end of the island adjacent to the 127th St. groin, the revetment wraps around the back (landward side) of the timber bulkhead to protect its end. Monitoring done by the borough indicates that the revetment structure at most locations is lower (up to 4 feet) compared to its original constructed elevation. As a result, it is considered to be in fair to poor condition.

145. The inlet and ocean frontage of North Wildwood is protected by several types of protective structures, however bulkhead with stone revetment is a prevalent feature. The majority of the bulkhead system is timber. One portion extends approximately 2500 feet from Anglesea Dr. at Virginia Ave. to a location west of Sea Breeze Ct. of the Beach Colony Apts. Another long section extends from the end of Anglesea Ave. to approximately 200 feet east of the end of New Jersey Ave., where a small section (160 feet) of steel sheetpile bulkhead is present. A small stretch then continues from the steel bulkhead to the Central-Spruce Ave. curve. The 2500 foot long section was constructed in the 1960's has a top elevation between approximately 9.5 feet and 10.5 feet MLW and is in extremely poor condition. A stone revetment, constructed by the state in the late 1960's/early 1970's of 2 to 5 ton stone, fronts this section of the bulkhead in order to provide toe protection. It is in generally good condition, however, the poor condition of the bulkhead allows loss of backfill material to be washed out from behind the structure. Subsequent failure of infrastructure and destruction of property results. The remaining inlet sections of timber bulkhead with stone revetment for toe protection were constructed and/or reconstructed in segments between the 1940's and the 1970's by the city, county or state. The bulkhead top elevations vary between 10.5 feet and 12 feet MLW, and the top of the revetment stone is at approximately 6.0 feet MLW. Both the bulkhead and revetment appear to be in fair to poor condition.

146. In North Wildwood, sections of steel sheetpile bulkhead are present between New Jersey Ave. and Walnut Ave. A section of steel bulkhead along the Central-Spruce Ave. curve, constructed in the 1940's by the county, was capped with a stone seawall by the state in 1963. The most recent construction, which was completed by the state in 1990, replaced 160 feet of timber bulkhead near Spruce Ave. with steel sheetpile to a top elevation of 12 feet MLW. It is currently in good condition.

147. The oceanfront of North Wildwood is also protected by a timber bulkhead, which begins at 2nd Ave. between Ocean Ave. and JFK Blvd. and ends at 13th Ave. It was constructed by the city in 1963 to a top elevation of 12 feet MLW and appears to be in good condition. It is also fronted by a stone revetment along the inlet side and extending to 3rd Ave. The revetment, constructed by the state to a top elevation of 12 feet MLW in 1973, is in good condition.

148. Seawalls are utilized as another type of shore protection structure within the limits of study, however none are located in Stone Harbor. In Avalon the seawall runs parallel to Ocean Dr., extending from the end of Inlet Dr. to the Ocean Dr. bridge abutment. Constructed in two sections by the State of New Jersey in 1978 and 1981 to a top elevation of 13 feet MLW, it is in good condition. The inlet frontage of North Wildwood is protected by a combination of bulkheads and revetments, with seawalls in the gaps where there are no bulkheads. Three free-standing seawalls were constructed in the following locations: along Anglesea Dr. from Virginia Ave. to Anglesea Ave., near 2nd Ave. from between Ocean Ave. and JFK Blvd. to Surf Ave. (built by the State of New Jersey in 1973), and from Surf Ave. near 2nd Ave. to the Central-Spruce Ave. curve (built by the state in 1990). All three were constructed to a top elevation of 12 feet MLW, and were provided with a stone splash apron to protect the backfill. Additionally, short lengths of bulkhead were capped with stone to create a seawall in two locations. The seawall forming the Central-Spruce Ave. curve was constructed with a top elevation of 13.5 feet MLW by the state in 1963 and reconstructed to 12 feet MLW in 1990. The other seawall, located at the end of New York Ave., was built by the state in 1973 with a top elevation of 14 feet MLW. All of the seawalls in North Wildwood generally appear to be in fair to good condition.

149. OUTFALLS. A total of twenty-nine (29) storm drain outfall pipes are located within the study limits. Four (4) are located in Avalon, twelve (12) in Stone Harbor, and thirteen (13) in North Wildwood. Three of the outfalls in Avalon, located at 11th, 22nd and 30th Sts., are iron pipes supported by timber piles and cribbing that extend the width of the existing beach. They range in size from 18 inches to 30 inches in diameter. The fourth outfall is an 8 inch diameter, minimally supported, plastic pipe which empties into the inlet adjacent to the 8th St. jetty.

150. Eleven of the outfalls in Stone Harbor are 12" diameter and one is 14" diameter. The outfalls in Stone Harbor are located at every one to five street blocks. All twelve pipes are supported by timber piles and cribbing that extends the beach width. Pipe material is cast iron, pvc or transite.

151. The storm drain outfall pipes in North Wildwood range in size from 8 inches to 20 inches in

United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. Box 12559
217 Fort Johnson Road
Charleston, South Carolina 29422-2559

April 8, 1998

Mr. Mathew M. Laws III, P.E.
Chief, Engineering and Planning Division
Charleston District
U.S. Army Corps of Engineers
P.O. Box 919
Charleston, SC 29402-0919

Dear Mr. Laws:

The U.S. Fish and Wildlife Service (Service) has received your April 2, 1998 letter regarding dredging in and adjacent to the Folly River navigation channel as a borrow area and placement of 55,000 cubic yards of sand on the County Park, Folly Beach. Sand would be removed by a hydraulic dredge and piped to the beach renourishment site. The County Park beach has experienced severe erosion over the past three months due to winter storms. Most of the proposed borrow area lies within the Bird Key Complex, MO7, of the Coastal Barrier Resources System (CBRS). Your letter states that you believe this project meets Coastal Barrier Resources Act (CBRA) exceptions found in 16 USC 3505(a)(6), subparagraphs (E), (F), and (G).

The Bird Key Complex is located at the mouth of the Stono River and Folly River in Charleston County, South Carolina. The unit lies from the southern end of Folly Beach to the eastern end of Kiawah Island. Habitats in the unit include intertidal sand shoals (estuarine intertidal unconsolidated shore wetlands), open water (estuarine subtidal unconsolidated bottom), marsh (estuarine intertidal emergent wetland), and uplands (dunes and maritime forest). Wetlands of the unit provide important spawning, nursery, and feeding habitat for commercially and recreationally important species of estuarine-dependent finfish and shellfish. The unit also provides nesting, feeding, and resting areas for brown pelicans, terns, gulls, shorebirds, and wading birds. In the past, the colonial nesting bird habitat on Bird Key was of extraordinary biological importance. Subsequent to the Corps' Folly Beach renourishment project, Bird Key experienced severe erosion and the nesting habitat was eliminated. As Bird Key eroded, the adjacent Skimmer Flats grew and colonial nesting birds began to utilize that habitat.

Subparagraph (E) of CBRA provides an exception for "Assistance for emergency actions essential to the saving of lives and the protection of property and the public health and safety, if such actions are performed pursuant to Sections 402, 403, and 502 of the disaster Relief and Emergency Assistance Act and section 1362 of the National Flood Insurance Act and are limited to actions that are necessary to alleviate the emergency." It does not appear that the proposed project is being performed pursuant to either of the applicable laws. According to guidance from the Department of Interior, Office of the Solicitor, an "emergency" must be "immediate" and must represent a "major disaster" or a presidentially proclaimed "emergency" to fall within this exception. Therefore, we do not believe that the exception in subparagraph (E) applies to this project.

Subparagraph (F) of CBRA provides an exception for the maintenance, replacement, reconstruction, or repair of publicly owned or publicly operated roads, structures and facilities. The planned project obviously does not include any maintenance, replacement, reconstruction or repair work. This exception was meant to cover activities such as repairing road pot holes, but only when certain conditions are met. Therefore, we do not believe that the exception in subparagraph (F) applies to this project.

Subparagraph (G) of CBRA provides an exception for nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system. The Department of Interior, Office of the Solicitor has determined that section 6(a)6(G) applies only to projects for stabilizing the shoreline of a unit of the CBRS; it does not apply to projects to stabilize shoreline outside the CBRS regardless of whether the project might be consistent with purposes of CBRA. The entire project must be within the unit, and cause no damage to the unit, for exception 6(a)6(G) to apply. Therefore, we do not believe that the exception in subparagraph (G) applies to this project.

You also state that you believe that the borrow site should be "grandfathered" under our earlier concurrence with the Folly beach renourishment project. In 1990 the Service concurred with the use of the proposed borrow area provided that our recommendations to avoid or minimize impacts to fish and wildlife resources were implemented. The Service concurrence letter recommended monitoring the project and stated that "if the above monitoring and/or increased erosion indicates that habitat loss is occurring on Bird Key the Service will recommend that alternate borrow sources be utilized for future renourishment." The Corps did not disagree with this statement or ask for further clarification.

In 1991 all required permits for the project were obtained and in 1992 and 1993 the project was completed. Subsequent to the Corps' Folly Beach renourishment project, Bird Key experienced severe erosion and the colonial nesting bird habitat at that site was eliminated. Therefore, the Service is being consistent in recommending that future renourishment of Folly Beach use a borrow area outside the CBRS.

In summary we cannot concur with a determination that the proposed project meets any of the exceptions in the Coastal Barrier Resources Act. Please contact Ed EuDaly of my staff if you have any questions regarding the proposed project.

Sincerely yours,

Roger L. Banks
Field Supervisor

RLB/EE/km

United States Department of the Interior

FISH AND WILDLIFE SERVICE
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

July 11, 2018

Lt. Colonel Jeffrey S. Palazzini
District Engineer
U.S. Army Corps of Engineers
69A Hagood Avenue
Charleston, SC 29403-5107

Attn: Bethney Ward

Re: Folly Beach Shore Protection Project
Charleston County, South Carolina
FWS Log No. 2017-F-0746/2018-F-0273/2018-F-0273-R001

Dear Colonel Palazzini:

This letter acknowledges the U.S. Fish and Wildlife Service's (Service) July 3, 2018, receipt of your request to reinitiate the consultation for the Folly Beach Shore Protection Project. We received all of the information necessary to reinitiate formal consultation for this project as outlined in the regulations governing interagency consultations (50 CFR 402.14). We will address the potential impacts this project may have on all federally threatened and endangered species present within the project area in our Biological Opinion (BO). We have assigned FWS Log Number 04ES1000-2018-F-0273-R001 to this consultation. Section 7 of the Endangered Species Act of 1973 allows us up to 90 days to conclude formal consultation with your agency and an additional 45 days to prepare our BO (unless we mutually agree to an extension). Therefore, attached is the revised BO.

If you have any questions or concerns about this consultation or the consultation process, please feel free to contact Ms. Melissa Chaplin of my staff at (843) 727-4707 ext. 217. In future correspondence concerning the project, please reference FWS Log No. 04ES1000-2018-F-0273-R001.

Sincerely,

Thomas D. McCoy
Field Supervisor

TDM/MKC

United States Department of the Interior

FISH AND WILDLIFE SERVICE
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

July 11, 2018

Lt. Colonel Jeffrey S. Palazzini
District Engineer
U.S. Army Corps of Engineers
69A Hagood Avenue
Charleston, SC 29403-5107

Attn: Bethney Ward

Re: Folly Beach Shore Protection Project
Charleston County, South Carolina
FWS Log No. 04ES1000-2017-0746-R001/04ES1000-2018-F-0273-R001

Dear Colonel Palazzini:

This letter transmits the enclosed revised biological opinion (BO) of the U.S. Fish and Wildlife Service (Service) for the Folly Beach Shore Protection Project (the Action). The applicant is proposing to place 1.08 million cubic yards (mcy) of beach quality sand along 18,250 linear feet of shoreline. The Service received your letter on July 3, 2018, requesting to reinitiate formal consultation for the Action described in the Folly Beach Shore Protection Project Biological Assessment of Threatened and Endangered Species. You determined that the Action is *may affect and is likely to adversely affect* the loggerhead sea turtle (*Caretta caretta*) and its critical habitat.

You determined that the Action is *may affect, but not likely to adversely affect* the green sea turtle (*Chelonia mydas*), the leatherback sea turtle (*Dermochelys coriacea*), the West Indian manatee (*Trichechus manatus*), and the American wood stork (*Mycteria americana*). The Service concurs with these determinations, for reasons we explain in section 3 table 1 of the BO. You also determined that the Action is *may affect, but not likely to adversely affect* the piping plover (*Charadrius melodus*) and its critical habitat and the red knot (*Calidris canutus rufa*). We did not concur with this determination in our January 19, 2018, BO due to the presence of the species. We have included them in this revised BO.

The enclosed revised BO answers your request for formal consultation, concludes that the Action is not likely to jeopardize the continued existence of the species listed above, and is not likely to destroy or adversely modify the designated critical habitats listed above. This finding fulfills the requirements applicable to the Action for completing consultation under §7(a)(2) of the Endangered Species Act of 1973, as amended (ESA).

The BO includes an Incidental Take Statement, which requires the U.S. Army Corps of Engineers – Charleston District (Corps) to implement reasonable and prudent measures that the Service considers necessary or appropriate to minimize the impacts of anticipated take on listed species. The Incidental take of listed species that is compliance with the terms and conditions of this statement is exempted from the prohibitions against taking under the ESA.

Reinitiating consultation is required if the Corps retains discretionary involvement or control over the Action (or is authorized by law) when:

a. The amount or extent of incidental take is exceeded;
b. New information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered in this BO;
c. The Action is modified in a manner that causes effects to listed species or designated critical habitat not considered in this BO; or
d. A new species is listed or critical habitat designated that the Action may affect.

A complete administrative record of this consultation is on file in our office at the letterhead address. If you have any questions about the BO, please contact Ms. Melissa Chaplin at 843-727-4707 extension 217.

Sincerely,

Thomas D. McCoy
Thomas D. McCoy
Field Supervisor

TDM/MKC

Enclosure

turtle eggs. Although sea turtle nesting beaches are protected along large expanses of the western North Atlantic coast, other areas along these coasts have limited or no protection.

Loggerhead turtles are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration and transportation; marine pollution; underwater explosions; hopper dredging, offshore artificial lighting; power plant entrainment and/or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; poaching, and fishery interactions. In the oceanic environment, loggerheads are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar *et al.* 1995; Bolten *et al.* 1994; Crouse 1999). There is particular concern about the extensive incidental take of juvenile loggerheads in the eastern Atlantic by longline fishing vessels. In the neritic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in Federal and State waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries (NMFS and USFWS 2007).

Coastal Development

Loss of nestin_ habitat related to coastal develo_ment has had the _reatest im_act on nestin_ sea turtles. Beachfront development not onl_ causes the loss of suitable nestin_ habitat but can result in the disru_tion of _owerful coastal _rocesses acceleratin_ erosion and interru_tin_ the natural shoreline mi_ration National Research Council 1990b . This ma_ in turn cause the need to _rotect u_land structures and infrastructure b_ armorin_, _roin _lacement beach emer_enc_ berm construction and re_air and beach nourishment all of which cause chan_es in, additional loss of or im_act to the remainin_ sea turtle habitat. Rice 2012a identified that a__roximatel_ 856 miles (40%) of sandy beaches from North Carolina to Texas have been developed (**Table 3**).

Table 3. The lengths and percentages of sandy oceanfront beach in each state in the Southeastern U.S. that are developed, undeveloped, and preserved (Rice 2012b).

State	Approximate Shoreline Beach Length (miles)	Approximate Miles of Beach Developed (percent of total shoreline length)	Approximate Miles of Beach Undeveloped (percent of total shoreline length)[a]	Approximate Miles of Beach Preserved (percent of total shoreline length)[b]
NC	326	159 (49%)	167 (51%)	178.7 (55%)

unsuitable by hampering or deterring nesting by adult females and trapping or impeding hatchlings during their nest to sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Sobel (2002) describes nesting turtles being deterred by wooden lounge chairs that prevented access to the upper beach.

Sand Placement

Sand placement projects may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987, Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999, Trindell 2005). Rice (2012a) identified that approximately 32% of sandy shorelines from North Carolina to Texas have been modified by sand placement projects (**Table 4**).

Table 4. Approximate shoreline miles of sandy beach that have been modified by sand placement activities for each state in the Southeastern U.S. These totals are minimum numbers, given missing data for some areas (Rice 2012b).

State	Known Approximate Miles of Beach Receiving Sand	Proportion of Modified Sandy Beach Shoreline
NC	91.3	28%
SC	67.6	37%
GA	5.5	6%
FL - *Atlantic coast*	189.7	51%
FL - *Gulf coast*	189.9	43%
AL	7.5	16%
MS - *barrier island coast*	1.1	4%
MS - *mainland coast*	43.5	85%
LA	60.4	28%
TX	28.3	8%
TOTAL	684.8+	32%

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Very fine sand or the use of heavy machinery can cause sand compaction on nourished beaches (Nelson *et al.* 1987, Nelson and Dickerson 1988a). Significant reductions in nesting success (*i.e.*, false crawls occurred more frequently) have been documented on severely compacted nourished beaches (Fletemeyer 1980, Raymond 1984, Nelson and Dickerson 1987, Nelson *et al.* 1987), and increased false crawls may result in increased physiological stress to nesting females. Sand

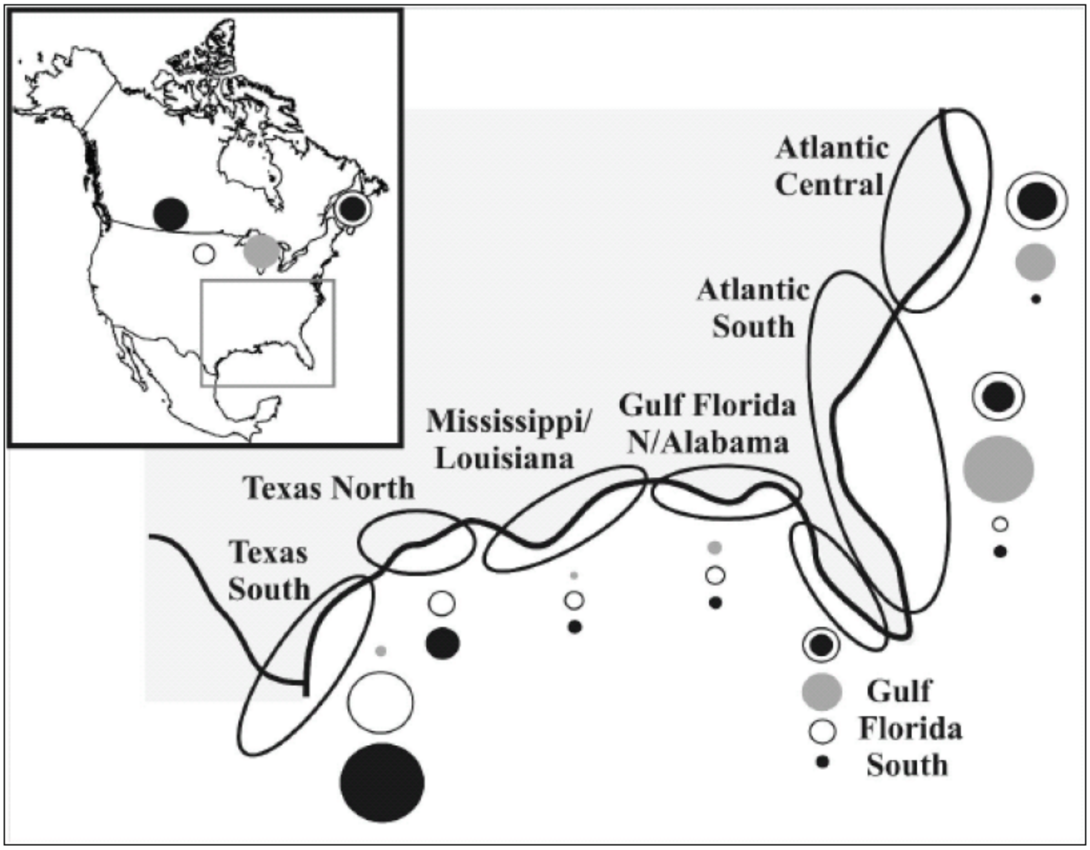


Figure 10. The winter distribution in the continental U.S. of piping plovers from four breeding locations (inset), including eastern Canada (white circle with central black dot), Great Lakes (gray circle), U.S. Northern Great Plains (white circle), and Prairie Canada (black circle). The wintering range is expanded to the right, divided into different wintering regions. The size of the adjacent circles relative to the others represents the percentage of individuals from a specific breeding area reported in that wintering region (from Gratto-Trevor *et al*. 2012; reproduced by permission).

6.1.4. Conservation Needs and Threats

Threats to Piping Plovers

The three recover   lans stated that shoreline develo ment throu hout the winterin ran e oses a threat to all o ulations of i in   lovers. The lans further stated that beach maintenance and nourishment inlet dred in   and artificial structures such as etties and roins could eliminate wintering areas and alter sedimentation patterns leading to the loss of nearby habitat.

Loss, Modification, and Degradation of Habitat

The wide flat s arsel ve etated barrier beaches s its sandbars and ba side flats referred b   i in   lovers in the U.S. are formed and maintained b natural forces and are thus susce tible to de radation caused b develo ment and shoreline stabilization efforts. As described below, barrier island and beachfront development, inlet and shoreline stabilization, inlet dredging, beach maintenance and nourishment activities, seawall installations, and mechanical beach grooming continue to alter natural coastal processes throughout the range of migrating and wintering piping plovers. Dredging of inlets can affect spit formation adjacent to inlets, as well as ebb and flood tidal shoal formation. Jetties stabilize inlets and cause island widening and subsequent vegetation growth on the updrift inlet shores; they also cause island narrowing and/or erosion on the downdrift inlet shores. Seawalls and revetments restrict natural island movement and exacerbate erosion. Although dredge and fill projects that place sand on beaches and dunes may restore lost or degraded habitat in some areas, in other areas these projects may degrade habitat quality by altering the natural sediment composition, depressing the invertebrate prey base, hindering habitat migration with sea level rise, and replacing the natural habitats of the dune-beach-nearshore system with artificial geomorphology. Construction of any of these projects during months when piping plovers are present also causes disturbance that disrupts the birds' foraging and roosting behaviors. These threats are exacerbated by accelerating sea level rise, which increases erosion and habitat loss where existing development and hardened stabilization structures prevent the natural migration of the beach and/or barrier island. Although threats from sea level rise are discussed on page 41, its specific synergistic effects on threats from coastal development and artificial coastal stabilization are also described in the pertinent subsections, below.

Development and Construction

Development and associated construction threaten the piping plover in its migration and wintering range by degrading, fragmenting, and eliminating habitat. Constructing buildings and infrastructure adjacent to the beach can eliminate roosting and loafing habitat within the development's footprint and degrade adjacent habitat by replacing sparsely vegetated dunes or back-barrier beach areas with landscaping, pools, fences, etc. In addition, bayside development can replace foraging habitat with finger canals, bulkheads, docks and lawns. High-value plover habitat becomes fragmented as lots are developed or coastal roads are built between oceanside and bayside habitats. Development activities can include lowering or removing natural dunes to improve views or grade building lots, planting vegetation to stabilize dunes, and erecting sand fencing to establish or stabilize continuous dunes in developed areas; these activities can further degrade, fragment, and eliminate sparsely vegetated and unvegetated habitats used by the piping plover and other wildlife. Development and construction of other infrastructure in close proximity to barrier beaches often creates economic and social incentives for subsequent shoreline stabilization projects, such as shoreline hardening and beach nourishment.

At present, there are approximately 2,119 miles of sandy beaches within the U.S. continental wintering range of the piping plover (**Table 3**). Approximately 40% (856 miles) of these sandy beaches are developed, with mainland Mississippi (80%), Florida (57%), Alabama (55%), South Carolina (51%), and North Carolina (49%) comprising the most developed coasts, and Mississippi barrier islands (0%), Louisiana (6%), Texas (14%) and Georgia (17%) the least developed (Rice 2012b). As discussed further below, developed beaches are highly vulnerable to further habitat loss because they cannot migrate in response to sea level rise.

Several studies highlight concerns about adverse effects of development and coastline stabilization on the quantity and quality of habitat for migrating and wintering piping plovers and other shorebirds. For example, Zdravkovic and Durkin (2011) observed fewer plovers on the developed portions of the Laguna and Gulf beach sides of South Padre Island than on undeveloped portions during both migratory and wintering surveys. Drake *et al.* (2001) observed that radio-tagged piping plovers overwintering along the southern Laguna Madre of Texas seldom used tidal flats adjacent to developed areas (five of 1,371 relocations of radio-marked individuals), suggesting that development and associated anthropogenic disturbances influence piping plover habitat use. Detections of piping plovers during repeated surveys of the upper Texas coast in 2008 were low in areas with significant beach development (Arvin 2008).

The development of bayside or estuarine shorelines with finger canals and their associated bulkheads, docks, buildings, and landscaping have led to direct loss and degradation of plover habitat. Finger canals are channels cut into a barrier island or peninsula from the soundside to increase the number of waterfront residential lots. Finger canals can lead to water pollution, fish kills, loss of aquatic nurseries, saltwater intrusion of groundwater, disruption of surface flows, island breaching due to the funneling of storm surge, and a perpetual need for dredging and disposal of dredged material in order to keep the canals navigable for property owners (Morris *et al.* 1978, Bush *et al.* 1996).

Rice 2012b has identified over 900 miles 43% of sand beaches in the winterin range that are currentl " reserved" throu h ublic ownershi ownershi b non-governmental conservation or anizations or conservation easements **Table 3** . These beaches ma be sub ect to some erosion as the mi rate in res onse to sea level rise or if sediment is removed from the coastal s stem and the are vulnerable to recreational disturbance. However these are the areas most likely to maintain the geomorphic characteristics of suitable piping plover habitat.

In summary, approximately 40% of the sandy beach shoreline in the migration and wintering ran_e is alread_ develo_ed while 43% are lar_el_ _reserved. This means however that the remaining 17% of shoreline habitat that which is currentl_ undevelo_ed but not _reserved is susceptible to future loss to development and the attendant threats from shoreline stabilization activities and sea level rise.

Dredging and Sand Mining

The dred_in_ and minin_ of sediment from inlet com_lexes threatens the _i_in_ _lover on its winterin_ _rounds throu_h habitat loss and de_radation. The maintenance of navi_ation channels b_ dred_in_ es_eciall_ dee_ shi_ _in_ channels such as those in Alabama and Mississippi, can si_nificantl_ alter the natural coastal _rocesses on inlet shorelines of nearb_ barrier islands as described b_ Otvos 2006 Morton 2008 Otvos and Carter 2008 Beck and Wan_ 2009 and Stockdon *et al.* 2010 . Cialone and Stauble 1998 describe the impacts of minin_ ebb shoals within inlets as a source of beach fill material at ei_ht locations and _rovide a recommended monitorin_ _rotocol for future minin_ events; Dabees and Kraus (2008) also describe the impacts of ebb shoal mining in southwest Florida.

Forty-four percent of the tidal inlets within the U.S. wintering range of the piping plover have been or continue to be dredged, primarily for navigational purposes (**Table 5**). States where more than two-thirds of inlets have been dredged include Alabama (three of four), Mississippi (four of six), North Carolina 16 of 20 and Texas 13 of 18 and 16 of 21 alon_ the Florida Atlantic coast. The dred_in_ of navi_ation channels or relocation of inlet channels for erosion-control _ur_oses contributes to the cumulative effects of inlet habitat modification by removing or redistributing the local and regional sediment suppl_ the maintenance dredging of deep shipping channels can convert a natural inlet that normally bypasses sediment from one shoreline to the other into a sediment sink, where sediment no longer bypasses the inlet.

Among the dredged inlets identified in Rice (2012a), dredging efforts began as early as the 1800s and continue to the present, generating long-term and even permanent effects on inlet habitat; at least 11 inlets were first dredged in the 19th century, with the Cape Fear River (North Carolina) being dredged as early as 1826 and Mobile Pass (Alabama) in 1857. Dredging can occur on an annual basis or every two to three years, resulting in continual perturbations and modifications to inlet and adjacent shoreline habitat. The volumes of sediment removed can be major, with 2.2 million cubic yards (mcy) of sediment removed on average every 1.9 years from the Galveston Bay Entrance (Texas) and 3.6 mcy of sediment removed from Sabine Pass (Texas) on average every 1.4 years (USACE 1992).

Among the dredged inlets identified in Rice (2012a), dredging efforts began as early as the 1800s and continue to the present, generating long-term and even permanent effects on inlet habitat; at least 11 inlets were first dredged in the 19th century, with the Cape Fear River (North Carolina) being dredged as early as 1826 and Mobile Pass (Alabama) in 1857. Dredging can occur on an annual basis or every two to three years, resulting in continual perturbations and modifications to inlet and adjacent shoreline habitat. The volumes of sediment removed can be major, with 2.2 million cubic yards (mcy) of sediment removed on average every 1.9 years from the Galveston

Bay Entrance (Texas) and 3.6 mcy of sediment removed from Sabine Pass (Texas) on average every 1.4 years (USACE 1992).

As sand sources for beach nourishment _ro_ects have become more limited the minin_ of ebb tidal shoals for sediment has increased Cialone and Stauble 1998 . This is a _roblem because ex_osed ebb and flood tidal shoals and sandbars are _rime roostin_ and fora_in_ habitats for _i_in_ _lovers. In _eneral such areas are onl_ accessible b_ boat and as a result the_ tend to receive less human recreational use than nearb_ mainland beaches. Rice 2012a found that the ebb shoal com_lexes of at least 20 inlets within the winterin_ ran_e of the _i_in_ _lover have been mined for beach fill. Ebb shoals are es_eciall_ im_ortant because they act as "sand brid_es" that connect beaches and islands b_ trans_ortin_ sediment via lon_shore trans_ort from one side u_drift to the other downdrift side of an inlet. The minin_ of sediment from these shoals u_sets the inlet s_stem e_uilibrium and can lead to increased erosion of the ad_acent inlet shorelines Cialone and Stauble 1998 . Rice 2012a noted that this minin_ of material from inlet shoals for use as beach fill is not e_uivalent to the natural sediment b_ _assin_ that occurs at unmodified inlets for several reasons most notabl_ for the massive volumes involved that are "trans_orted" virtuall_ instantaneousl_ instead of _raduall_ and continuousl_ and for the _lacement of the material outside of the immediate inlet vicinit_ where it would naturally b_ _ass. The minin_ of inlet shoals can remove massive amounts of sediment with 1.98 mc_ mined for beach fill from Lon_boat Pass Florida in 1998 1.7 mcy from Shallotte Inlet North Carolina in 2001 and 1.6 mc_ from Redfish Pass Florida in 1988 Cialone and Stauble 1998, USACE 2004 . Cialone and Stauble 1998 found that monitorin_ of the im_acts of ebb shoal minin_ has been insufficient and in one case the minin_ _it was onl_ 66% recovered after five _ears the_ conclude that the larger the volume of sediment mined from the shoals, the larger the perturbation to the system and the longer the recovery period.

Information is limited on the effects to piping plover habitat of the deposition of dredged material, and the available information is inconsistent. Drake *et al.* (2001) concluded that the conversion of bayshore tidal flats of southern Texas mainland to dredged material impoundments results in a net loss of habitat for wintering piping plovers because such impoundments eventually convert to upland habitat. Zonick *et al.* (1998) reported that dredged material placement areas along the Gulf Intracoastal Waterway in Texas were rarely used by piping plovers, and noted concern that dredge islands block the wind-driven water flows that are critical to maintaining important shorebird habitats. Although Zdravkovic and Durkin (2011) found 200 piping plovers on the Mansfield Channel dredge material islands during a survey in late 2009, none were counted there in early 2011. By contrast, most of the sound islands where Cohen *et al.* (2008) found foraging piping plovers at Oregon Inlet, North Carolina were created by the Corps from dredged material. Another example is Pelican Island, in Corpus Christi Bay, Texas, where dredged material is consistently used by piping plovers (R. Cobb, USFWS, pers. comm. 2012a). Research is needed to understand why piping plovers use some dredge material islands, but are not regularly found using many others.

In summary, the removal of sediment from inlet com_lexes via dred_in_ and sand minin_ for beach fill has modified nearly half of the tidal inlets within the continental winterin_ ran_e of the _i_in_ _lover leadin_ to habitat loss and de_radation. Many of these inlet habitat modifications have become permanent, existing for over 100 years. The expansion of several harbors and ports to accommodate deeper draft ships poses an increasing threat as more sediment is removed from the inlet system, causing larger perturbations and longer recovery times; maintenance dredging conducted annuall_ or every few years ma_ _revent full recover_ of the inlet s_stem. Sand removal or sediment starvation of shoals_ sandbars and adjacent shoreline habitat has resulted in habitat loss and de_radation_ which ma_ reduce the s_stem's ability to maintain a full suite of inlet habitats as sea level continues to rise at an acceleratin_ rate. Rice _2012a_ noted that the adverse im_acts of this threat to _i_in_ _lovers ma_ be miti_ated_ however_ b_ eliminatin_ dred_in_ and minin_ activities in inlet com_lexes with hi_h habitat value_ extendin_ the interval between dred_in_ c_cles_ dischar_in_ dred_ed material in nearshore downdrift waters so that it can accrete more naturall_ than when _laced on the subaerial beach, and designing dredged material islands to mimic natural shoals and flats.

Inlet Stabilization and Relocation

Many navigable tidal inlets along the Atlantic and Gulf coasts are stabilized with hard structures. A description of the different types of stabilization structures typically constructed at or adjacent to inlets – jetties, terminal groins, groins, seawalls, breakwaters and revetments – can be found in Rice (2009) as well in the *Manual for Coastal Hazard Mitigation* (Herrington 2003, available online) and in *Living by the Rules of the Sea* (Bush *et al.* 1996).

The adverse direct and indirect impacts of hard stabilization structures at inlets and inlet relocations can be significant. The impacts of jetties on inlet and adjacent shoreline habitat have been described by Cleary and Marden (1999), Bush *et al.* (1996, 2001, 2004), Wamsley and Kraus (2005), USFWS (2009a), Thomas *et al.* (2011), and many others. The relocation of inlets or the creation of new inlets often leads to immediate widening of the new inlet and loss of adjacent habitat, among other impacts, as described by Mason and Sorenson (1971), Masterson *et al.* (1973), USACE (1992), Cleary and Marden (1999), Cleary and Fitzgerald (2003), Erickson *et al.* (2003), Kraus *et al.* (2003), Wamsley and Kraus (2005) and Kraus (2007).

Rice _2012a_ found that_ as of 2011_ an estimated 54% of 221 mainland or barrier island tidal inlets in the U.S continental winterin_ ran_e of the _i_in_ plover had been modified b_ some form of hardened structure, dredging, relocation, mining, or artificial opening or closure (**Table 5**). On the Atlantic Coast, 43% of the inlets have been stabilized with hard structures, whereas 37% were stabilized on the Gulf Coast. The Atlantic coast of Florida has 17 stabilized inlets adjacent to each other, extending between the St. John's River in Duval County and Norris Cut in Miami-Dade County, a distance of 341 miles. A shorebird would have to fly nearly 344 miles between unstabilized inlets along this stretch of coast.

The state with the highest proportion of natural, unmodified inlets is Georgia (74%). The highest number of adjacent unmodified, natural inlets is 15, which is the number of inlets found in Georgia between Little Tybee Slough at Little Tybee Island Nature Preserve and the entrance to Altamaha Sound at the south end of Wolf Island National Wildlife Refuge, a distance of approximately 54 miles. Another relatively long stretch of adjacent unstabilized inlets is in Louisiana, where 17 inlets between a complex of breaches on the West Belle Pass barrier headland (in Lafourche Parish) and Beach Prong (near the western boundary of the state

Rockefeller Wildlife Refuge) have no stabilization structures; one of these inlets (the Freshwater Bayou Canal), however, is dredged (Rice 2012a).

Unstabilized inlets naturally migrate, reforming important habitat components over time, particularly during a period of rising sea level. Inlet stabilization with rock jetties and revetments alters the dynamics of longshore sediment transport and the natural movement and formation of inlet habitats such as shoals, unvegetated spits and flats. Once a barrier island becomes "stabilized" with hard structures at inlets, natural overwash and beach dynamics are restricted, allowing encroachment of new vegetation on the bayside that replaces the unvegetated (open) foraging and roosting habitats that plovers prefer. Rice (2012a) found that 40% (89 out of 221) of the inlets open in 2011 have been stabilized in some way, contributing to habitat loss and degradation throughout the wintering range.
Accelerated erosion may compound future habitat loss, depending on the degree of sea level rise (Titus *et al*. 2009). Due to the complexity of impacts associated with projects such as jetties and groins, Harrington (2008) noted the need for a better understanding of potential effects of inlet-related projects, such as jetties, on bird habitats.

Relocation of tidal inlets also can cause loss and/or degradation of piping plover habitat. Although less permanent than construction of hard structures, the effects of inlet relocation can persist for years. For example, December-January surveys documented a continuing decline in wintering plover numbers from 20 birds pre-project (2005-2006) to three birds during the 2009-2011 seasons (SCDNR 2011). Subsequent decline in the wintering population on Kiawah is strongly correlated with the decline in polychaete worm densities, suggesting that plovers emigrated to other sites as foraging opportunities in these habitats became less profitable (SCDNR 2011). At least eight inlets in the migration and wintering range have been relocated; a new inlet was cut and the old inlet was closed with fill. In other cases, inlets have been relocated without the old channels being artificially filled (**Table 5** and Rice 2012a).

The artificial opening and closing of inlets typically creates very different habitats from those found at inlets that open or close naturally (Rice 2012a). Rice (2012a) found that 30 inlets have been artificially created within the migration and wintering range of the piping plover, including 10 of the 21 inlets along the eastern Florida coast (**Table 5**). These artificially created inlets tend to need hard structures to remain open or stable, with 20 of the 30 (67%) of them having hard structures at present. An even higher number of inlets (64) have been artificially closed, the majority in Louisiana (**Table 5**). One inlet in Texas was closed as part of the Ixtoc oil spill response efforts in 1979 and 32 were closed as part of Deepwater Horizon oil spill response efforts in 2010-2011. Of the latter, 29 were in Louisiana, two in Alabama and one in Florida. To date only one of these inlets, West (Little Lagoon) Pass in Gulf Shores, Alabama, has been reopened, and the rest remain closed with no plans to reopen any of those identified by Rice (2012a). Most other artificial inlet closures in Louisiana are part of barrier island restoration projects, because much of that state's barrier islands are disintegrating (Otvos 2006, Morton 2008, Otvos and Carter 2008). Inlets closed during coastal restoration projects in Louisiana are purposefully designed to approximate low, wide naturally closed inlets and to allow overwash in the future. By contrast, most artificially closed inlets have higher elevations and tend to have a constructed berm and dune system. Overwash may occur periodically at a naturally closed inlet but is prevented at an artificially closed inlet by the constructed dune ridge, hard structures, or sandbags (Rice 2012a).

The construction of jetties, groins, seawalls and revetments at inlets leads to habitat loss and both direct and indirect impacts to adjacent shorelines. Rice (2012a) found that these structures result in long-term effects, with at least 13 inlets across six of the eight states having hard structures initially constructed in the 19th century. The cumulative effects are ongoing and increasing in intensity, with hard structures built as recently as 2011 and others proposed for 2012.

With sea level risin_ and _lobal climate chan_e alterin_ storm d_namics, _ressure to modif_ the remainin_ half of sand_ tidal inlets in the ran_e is likel_ to increase, notwithstandin_ that this would be counter_roductive to the climate chan_e ada_tation strate_ies recommended b_ the USFWS (2010d), CCSP (2009), Williams and Gutierrez (2009), Pilkey and Young (2009), and many others.

Groins

Groins pose an ongoing threat to piping plover beach habitat within the continental wintering range. Groins are hard structures built perpendicular to the shoreline (sometimes in a T-shape), designed to trap sediment traveling in the littoral drift and to slow erosion on a particular stretch of beach or near an inlet. "Leaky" groins, also known as permeable or porous groins, are low-crested structures built like typical groins but which allow some fraction of the littoral drift or longshore sediment transport to pass through the groin. They have been used as terminal groins near inlets or to hold beach fill in place for longer durations. Although groins can be individual structures, they are often clustered along the shoreline in "groin fields." Because they intentionally act as barriers to longshore sand transport, groins cause downdrift erosion, which degrades and fragments sandy beach habitat for the piping plover and other wildlife. The resulting beach typically becomes scalloped in shape, thereby fragmenting plover habitat over time.

Groins and groin fields are found throughout the southeastern Atlantic and Gulf Coasts and are present at 28 of 221 sandy tidal inlets (Rice 2012a). Leaky terminal groins have been installed at the south end of Amelia Island, Florida, the west end of Tybee Island, Georgia, and the north end of Hilton Head Island, South Carolina. Permeable or leaky groins have also been constructed on the beaches of Longboat Key and Naples, Florida, and terminal groins were approved in 2011 for use in up to four inlet locations in North Carolina (reversing a nearly 30-year prohibition on hard stabilization structures in that state).

Although most groins were in place before the piping plover's 1986 ESA listing, new groins continue to be installed, perpetuating the threat to migrating and wintering piping plovers. Two groins were built in South Carolina between 2006 and 2010, bringing the statewide total to 165 oceanfront groins (SC DHEC 2010). Eleven new groins were built in Florida between 2000 and 2009. The East Pass Navigation Project in Okaloosa County, Florida (USFWS 2009a) illustrates the negative impacts to plover habitat that can be associated with groins, which are often built as one component of a much larger shoreline or inlet stabilization project. The East Pass Navigation Project includes two converging jetties, one with a groin at the end, with dredged material placed on either side to stabilize the jetties; minimal piping plover foraging habitat remains due to changed inlet morphology. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from groins and groin fields may increase as communities and beachfront property owners seek additional ways to protect infrastructure and property.

Seawalls and Revetments

Seawalls and revetments are hard vertical structures built parallel to the beach in front of buildings, roads, and other facilities. Although they are intended to protect human infrastructure from erosion, these armoring structures often accelerate erosion by causing scouring both in front of and downdrift from the structure, which can eliminate intertidal plover foraging and adjacent roosting habitat. Physical characteristics that determine microhabitats and biological communities can be altered after installation of a seawall or revetment, thereby depleting or changing composition of benthic communities that serve as the prey base for piping plovers (see *Loss of Macroinvertebrate Prey Base due to Shoreline Stabilization*). Dugan and Hubbard (2006) found in a California study that intertidal zones were narrower and fewer in the presence of armoring, armored beaches had significantly less macrophyte wrack, and shorebirds responded with significantly lower abundance (more than three times lower) and species richness (2.3 times lower) than on adjacent unarmored beaches. As sea level rises, seawalls will prevent the coastline from moving inland, causing loss of intertidal foraging habitat (Galbraith *et al.* 2002, Defeo *et al.* 2009). Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) are less permanent alternatives, but they prevent overwash and thus the natural production of sparsely vegetated habitat.

Rice (2012b) found that at least 230 miles of beach habitat has been armored with hard erosion-control structures. Data were not available for all areas, so this number is a minimum estimate of the length of habitat that has been directly modified by armoring. Out of 221 inlets surveyed, 89 were stabilized with some form of hard structure, of which 24 had revetments or seawalls along their shorelines (Rice 2012b). The Texas coast is armored with nearly 37 miles of seawalls, bulkheads and revetments, the mainland Mississippi coast has over 45 miles of armoring, the Florida Atlantic coast has at least 58 miles, and the Florida Gulf coast over 59 miles (Rice 2012b). Shoreline armoring has modified plover beachfront habitat in all states, but Alabama (4.7 miles), Georgia (10.5 miles) and Louisiana (15.9 miles) have the fewest miles of armored beaches.

Although North Carolina has prohibited the use of hard erosion-control structures or armoring since 1985 the "temporary" installation of sandbag revetments is allowed. As a result the precise length of armored sandy beaches in North Carolina is unknown, but at least 350 sandbag revetments have been constructed (Rice 2012b). South Carolina also limits the installation of some types of new armoring but already has 24 miles (27% of the developed shoreline or 13% of the entire shoreline) armored with some form of shore-parallel erosion-control structure (SC DHEC 2010).

The repair of existing armoring structures and installation of new structures continues to degrade, destroy, and fragment beachfront plover habitat throughout its continental wintering range. As sea level rises at an accelerating rate, the threat of habitat loss, fragmentation and degradation from hard erosion-control structures is likely to increase as communities and property owners seek to protect their beachfront development. As coastal roads become threatened by rising sea level and increasing storm damage, additional lengths of beachfront habitat may be modified by riprap, revetments, and seawalls.

Sand Placement Projects

Sand placement projects threaten the piping plover and its habitat by altering the natural dynamic coastal processes that create and maintain beach strand and bayside habitats, including the habitat components that piping plovers rely upon. Although specific impacts vary depending on a range of factors, so-called "soft stabilization" projects may directly degrade or destroy roosting and foraging habitat in several ways. Beach habitat may be converted to an artificial berm that is densely planted in grass, which can in turn reduce the availability of roosting habitat. Over time, if the beach narrows due to erosion, additional roosting habitat between the berm and the water can be lost. Berms can also prevent or reduce the natural overwash that creates and maintains sparsely vegetated roosting habitats. The growth of vegetation resulting from impeding the natural overwash can also reduce the availability of bayside intertidal feeding habitats.

Overwash is an essential process, necessary to maintain the integrity of many barrier islands and to create new habitat (Donnelly *et al.* 2006). In a study on the Outer Banks of North Carolina, Smith *et al.* (2008) found that human "modifications to the barrier island, such as construction of barrier dune ridges, planting of stabilizing vegetation, and urban development, can curtail or even eliminate the natural, self-sustaining processes of overwash and inlet dynamics." They also found that such modifications led to island narrowing from both oceanside and bayside erosion. Lott (2009) found a strong negative correlation between ocean shoreline sand placement projects and the presence of piping and snowy plovers in the Panhandle and southwest Gulf Coast regions of Florida.

Sand placement projects threaten migration and wintering habitat of the piping plover in every state throughout the range (**Table 4**). At least 684.8 miles (32%) of sandy beach habitat in the continental wintering range of the piping plover have received artificial sand placement via dredge disposal activities, beach nourishment or restoration, dune restoration, emergency berms, inlet bypassing, inlet closure and relocation, and road reconstruction projects. In most areas, sand placement projects are in developed areas or adjacent to shoreline or inlet hard stabilization structures in order to address erosion, reduce storm damages, or ameliorate sediment deficits caused by inlet dredging and stabilization activities.

The beaches along the mainland coast of Mississippi are the most modified by sand placement activities with at least 85% affected (**Table 4**). Of the oceanfront beaches, the Atlantic coast of Florida has had the highest proportion (at least 51%) of beaches modified by sand placement activities. Approximately 47% of Florida's sandy beach coastline has received sand placement of some type, with many areas receiving fill multiple times from dredge disposal, emergency berms, beach nourishment, dune restoration and other modifications (Rice 2012b).

In Louisiana, the sustainability of the coastal ecosystem is threatened by the inability of the barrier islands to maintain geomorphologic functionality. The state's coastal systems are starved for sediment sources (USACE 2010). Consequently, most of the planned sediment placement projects in Louisiana are conducted as environmental restoration projects by various Federal and State agencies because without the sediment many areas would erode below sea level. Several Louisiana Coastal Wetland Planning, Protection, and Restoration Act projects have been constructed on portions of undeveloped islands within the Terrebonne Basin to restore and maintain the diverse functions of those barrier island habitats (USFWS 2010). Altogether over 60 miles of sandy beaches have been modified with sand placement projects in Louisiana, both through restoration projects and in response to the Deepwater Horizon oil spill (Rice 2012b).

Both the number and the size of sand projects along the Atlantic and Gulf coasts are increasing (Trembanis *et al.* 1998), and these projects are increasingly being chosen as a means to combat sea level rise and related beach erosion problems (Klein *et al.* 2001).

Loss of Macroinvertebrate Prey Base due to Shoreline Stabilization

Wintering and migrating piping plovers depend on the availability and abundance of macroinvertebrates as an important food item. Studies of invertebrate communities have found that communities are richer (greater total abundance and biomass) on protected (bay or lagoon) intertidal shorelines than on exposed ocean beach shorelines (McLachlan 1990, Cohen *et al.* 2006, Defeo and McLachlan 2011). Polychaete worms tend to have a more diverse community and be more abundant in more protected shoreline environments, and mollusks and crustaceans such as amphipods thrive in more exposed shoreline environments (McLachlan and Brown 2006). Polychaete worms comprise the majority of the shorebird diet (Kalejta 1992, Mercier and McNeil 1994, Tsipoura and Burger 1999, Verkuil *et al.* 2006); and of the piping plover diet in particular (Hoopes 1993, Nicholls 1989, Zonick and Ryan 1996).

The quality and quantity of the macroinvertebrate prey base is threatened by shoreline stabilization activities, including the approximately 685 miles of beaches that have received sand placement of various types. The addition of dredged sediment can temporarily affect the benthic fauna of intertidal systems. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment (38-89 cm for different species), thicker layers (i.e., >1 meter) are likely to smother these sensitive benthic organisms (Greene 2002). Numerous studies of such effects indicate that the recovery of benthic fauna after beach nourishment or sediment placement projects can take anywhere from six months to two years, and possibly longer in extreme cases (Thrush *et al.* 1996, Peterson *et al.* 2000, Zajac and Whitlatch 2003, Bishop *et al.* 2006, Peterson *et al.* 2006).

Invertebrate communities may also be affected by changes in the physical environment resulting from shoreline stabilization activities that alter the sediment composition or degree of exposure. For example, SCDNR (2011) found the decline in piping plovers to be strongly correlated with a decline in polychaete densities on the east end of Kiawah Island, South Carolina, following an inlet relocation project in 2006. Similar results were documented on Bird Key, South Carolina, in 2006 when rapid habitat changes occurred within the sheltered lagoon habitat following dredge disposal activities, and piping plovers shifted to more exposed areas. Their diet also appeared to have shifted to haustoriid amphipods, based on analysis of fecal samples containing pieces of *Neohaustorius schmitzi*, *Lepidactylus dytiscus*, and *Acanthohaustorius* sp., which were also found during the invertebrate sampling in both locations (SCDNR 2011).

Shoreline armoring with hard stabilization structures such as seawalls and revetments can also alter the degree of exposure of the macroinvertebrate prey base by modifying the beach and intertidal geomorphology, or topography. Seawalls typically result in the narrowing and steepening of the beach and intertidal slope in front of the structure, eventually leading to complete loss of the dry and intertidal beach as sea level continues to rise (Pilkey and Wright 1988, Hall and Pilkey 1991, Dugan and Hubbard 2006, Defeo *et al*. 2009, Kim *et al*. 2011).

Sand placement projects bury the natural beach with up to millions of cubic yards of new sediment, and grade the new beach and intertidal zone with heavy equipment to conform to a predetermined topographic profile. This can lead to compaction of the sediment (Nelson *et al*. 1987, USACE 2008, Defeo *et al*. 2009). If the material used in a sand placement project does not closely match the native material on the beach, the sediment incompatibility may result in modifications to the macroinvertebrate community structure, because several species are sensitive to grain size and composition (Rakocinski *et al*. 1996; Peterson *et al*. 2000, 2006; Peterson and Bishop 2005; Colosio *et al*. 2007; Defeo *et al*. 2009).

Delayed recovery of the benthic prey base or changes in their communities due to physical habitat changes may affect the quality of piping plover foraging habitat. The duration of the impact can adversely affect piping plovers because of their high site fidelity. Although recovery of invertebrate communities has been documented in many studies, sampling designs have typically been inadequate and have only been able to detect large-magnitude changes (Schoeman *et al*. 2000, Peterson and Bishop 2005). Therefore, uncertainty persists about the impacts of various projects to invertebrate communities and how these impacts affect shorebirds, particularly the piping plover. Rice (2009) has identified several conservation measures that can avoid and minimize some of the known impacts.

Invasive Vegetation

The spread of invasive plants into suitable wintering piping plover habitat is a relatively recently identified threat (USFWS 2012). Such plants tend to reproduce and spread quickly and to exhibit dense growth habits, often outcompeting native plants. Uncontrolled invasive plants can shift habitat from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods. The propensity of invasive species to spread, and their tenacity once established, make them a persistent threat that is only partially countered by increasing landowner awareness and willingness to undertake eradication activities.

Many invasive species are either currently affecting or have the potential to affect coastal beaches and thus plover habitat. Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant which has spread to coastal communities throughout the southeastern U.S. from Virginia to Florida, and west to Texas (Westbrooks and Madsen 2006). Hundreds of beach vitex occurrences and targeted eradication efforts in North and South Carolina and a small number of known locations in Georgia and Florida are discussed in the 5-Year Review (USFWS 2009b). Crowfootgrass (*Dactyloctenium aegyptium*), which grows invasively along portions of the Florida coastline, forms thick bunches or mats that can change the vegetative structure of coastal plant communities and thus alter shorebird habitat (USFWS 2009b, Florida Exotic Pest Plant Council 2009). Australian pine (*Casuarina equisetifolia*) affects piping plovers and other shorebirds by encroaching on foraging and roosting habitat (Stibolt 2011); it may also provide perches for avian predators. Japanese sedge (*Carex kobomugi*), which aggressively encroaches into sand beach habitats (USDA plant profile website), was documented in Currituck County, North Carolina, in the mid-1970s and as recently as 2003 on Currituck National Wildlife Refuge (J. Gramling, Department of Biology, The Citadel, pers. comm. 2011), at two sites where migrating piping plovers have also been documented. Early detection and rapid response are the keys to controlling this and other invasive plants (R. Westbrooks, U.S. Geological Survey, pers. comm. 2011).

Defeo *et al*. (2009) cite biological invasions of both plants and animals as global threats to sandy beaches, with the potential to alter the food web, nutrient cycling and invertebrate assemblages. Although the extent of the threat is uncertain, this may be due to poor survey coverage more than an absence of invasions.

Wrack Removal and Beach Cleaning

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999, Smith 2007, Maddock *et al*. 2009, Lott *et al*. 2009b; see also discussion of piping plover use of wrack substrates in *Habitat Use*) and for many other shorebirds. Because shorebird numbers are positively correlated both with wrack cover and the biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987, Hubbard and Dugan 2003, Dugan *et al*. 2003), beach grooming has been shown to decrease bird numbers (Defeo *et al*. 2009).
It is increasingly common for beach-front communities to carry out “beach cleaning” and “beach raking” activities. Beach cleaning is conducted on private beaches, where piping plover use is not well documented, and on some municipal or county beaches used by piping plovers. Most wrack removal on state and Federal lands is limited to post-storm cleanup and does not occur regularly. Wrack removal and beach raking both occur on the Gulf beach side of the developed portion of South Padre Island in the Lower Laguna Madre in Texas, where plovers have been documented during both the migratory and wintering periods (Zdravkovic and Durkin 2011). Wrack removal and other forms of beach cleaning have been the subject of formal consultations between the U.S. Army Corps of Engineers, municipalities, and Service in Neuces County, Texas (USFWS 2008b, 2009c).

Although beach cleaning and raking machines effectively remove human-made debris, these efforts also remove accumulated wrack, topographic depressions, emergent foredunes and hummocks, and sparse vegetation nodes used by roosting and foraging piping plovers (Nordstrom 2000, Dugan and Hubbard 2010). Removal of wrack also reduces or eliminates natural sand-trapping, further destabilizing the beach. Cathcart and Melby (2009) found that beach grooming and raking beaches “fluffs the sand” whereas heavy equipment compacts the sand below the top layer; the fluffed sand is then more vulnerable to erosion by storm water runoff and wind. These authors found that beach raking and grooming practices on mainland

Mississippi beaches "exacerbate the erosion process and shorten the time interval between renourishment projects" (Cathcart and Melby 2009). Furthermore, the sand adhering to seaweed and trapped in the cracks and crevices of wrack also is lost to the beach when the wrack is removed. Although the amount of sand lost during a single sweeping activity may be small, over a period of years this loss could be significant (Neal *et al*. 2007).

Tilling beaches to reduce soil compaction, which is sometimes required by the Service for sea turtle protection after beach nourishment activities, has similar impacts to those described above. In northwest Florida, tilling on public lands is currently conducted only if the land manager determines that it is necessary. Where tilling is needed, adverse effects are reduced by Florida USFWS sea turtle protection provisions that require tilling to be above the primary wrack line, rather than within it.

As of 2009, the Florida Department of Environmental Protection's Beaches and Coastal Management Systems section had issued 117 permits allowing multiple entities to conduct beach raking or cleaning operations. The Florida Department of Environmental Protection estimated that 240 of 825 miles (29%) of sandy beach shoreline in Florida are cleaned or raked on varied schedules, i.e., daily, weekly, monthly (L. Teich, Florida DEP, pers. comm. 2009). Beach cleaning along 45 miles of coastline in Nueces, Kleberg, and Cameron Counties in Texas was addressed in five USFWS biological opinions completed between 2008 and 2012 (Cobb pers. comm. 2012c).

Dugan and Hubbard (2010), studying beach grooming activities on the beaches and dunes of southern California, concluded that "beach grooming has contributed to widespread conversion of coastal strand ecosystems to unvegetated sand" by removing wrack cover, increasing the transport of windblown sediment, lowering the seed bank and the survival and reproduction of native plants, and decreasing native plant abundance and richness. They argue that conserving beach ecosystems by reducing beach grooming and raking activities "could help retain sediment, promote the formation of dunes, and maintain biodiversity, wildlife, and human use in the face of rising sea level (Dugan and Hubbard 2010)."

Accelerating Sea Level Rise and other Climate Change Impacts

Accelerating sea level rise poses a threat to piping plovers during the migration and wintering portions of their life cycle. As noted in the previous section, threats from sea level rise are tightly intertwined with artificial coastal stabilization activities that modify and degrade habitat. Potential effects of storms, which could increase in frequency or intensity due to climate change, are discussed in the Storm Events section. If climate change increases the frequency or magnitude of extreme temperatures (see discussion in Severe Cold Weather), piping plover survival rates may be affected. Other potential adverse and beneficial climate change-related effects (e.g., changes in the composition or availability of prey, emergence of new diseases, fewer periods of severe cold weather) are poorly understood, but cannot be discounted.

Numerous studies have documented accelerating rise in sea levels worldwide (Rahmstorf *et al*. 2007, Douglas *et al*. 2001 as cited in Hopkinson *et al*. 2008, CCSP 2009, Pilkey and Young 2009, Vermeer and Rahmstorf 2009, Pilkey and Pilkey 2011). Predictions include a sea level rise of between 50 and 200 cm above 1990 levels by the year 2100 (Rahmstorf 2007, Pfeffer *et al.* 2008, Vermeer and Rahmstorf 2009, Grinsted *et al.* 2010, Jevrejeva *et al.* 2010) and potential conversion of as much as 33% of the world's coastal wetlands to open water by 2080 (IPCC 2007a, CCSP 2008). Potential effects of sea level rise on piping plover roosting and foraging habitats may vary regionally due to subsidence or uplift, the geological character of the coast and nearshore, and the influence of management measures such as beach nourishment, jetties, groins, and seawalls (CCSP 2009, Galbraith *et al.* 2002, Gutierrez *et al.* 2011). Sea level rise along the U.S. Gulf Coast exceeded the global average by 13-15 cm because coastal lands there are subsiding (EPA 2009). The rate of sea level rise in Louisiana is particularly high (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). Sediment compaction and oil and gas extraction compound tectonic subsidence along the Gulf of Mexico coastline (Penland and Ramsey 1990, Morton *et al.* 2003, Hopkinson *et al.* 2008).

Low elevations and proximity to the coast make all nonbreeding piping plover foraging and roosting habitats vulnerable to the effects of rising sea level. Areas with small tidal ranges are the most vulnerable to loss of intertidal wetlands and flats (EPA 2009). Sea level rise was cited as a contributing factor in the 68% decline in tidal flats and algal mats in the Corpus Christi, Texas region (i.e., Lamar Peninsula to Encinal Peninsula) between the 1950s and 2004 (Tremblay *et al.* 2008). Mapping by Titus and Richman (2001) showed that more than 80% of the lowest land along the Atlantic and Gulf coasts was in Louisiana, Florida, Texas, and North Carolina. Gutierrez *et al.* (2011) found that along the Atlantic coast, the central and southern Florida coast is the most likely Atlantic portion of the wintering and migration range to experience moderate to severe erosion with sea level rise.

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat, especially if those shorelines are armored with hardened structures (Brown and McLachlan 2002, Dugan and Hubbard 2006, Fish *et al.* 2008, Defeo *et al.* 2009). Overwash and sand migration are impeded on the developed portions of sandy ocean beaches (Smith *et al.* 2008) that comprise 40% of the U.S. nonbreeding range (Rice 2012b). As the sea level rises, the ocean-facing beaches erode and attempt to migrate inland. Buildings and artificial sand dunes then prevent sand from washing back toward the lagoons (i.e., bayside), and the lagoon side becomes increasingly submerged during extreme high tides (Scavia *et al.* 2002). Barrier beach shorebird habitat and natural features that protect mainland developments are both diminished as a result.

Modeling by Galbraith *et al.* (2002) for three sea level rise scenarios at five important U.S. shorebird staging and wintering sites predicted aggregate loss of 20-70% of current intertidal foraging habitat. The most severe losses were projected at sites where the coastline is unable to move inland due to steep topography or seawalls. Of five study sites, the model predicted the lowest loss of intertidal shorebird foraging habitat at Bolivar Flats, Texas (a designated piping plover critical habitat unit) by 2050 because the habitat at that site will be able to migrate inland in response to rising sea level. The potential for such barrier island migration with rising sea level is most likely in the 42% of plover's U.S. nonbreeding range that is currently preserved from development (Rice 2012b). Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith *et al.* (2002) noted that time lags between these losses and the creation of replacement habitat elsewhere may have serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or subsequent productivity.

In summary, the magnitude of threats from sea level rise is closely linked to threats from shoreline development and artificial stabilization. These threats will be perpetuated in places where damaged structures are repaired or replaced, exacerbated where the height and strength of structures are increased, and increased at locations where development and coastal stabilization is expanded. Sites that are able to adapt to sea level rise are likely to become more important to piping plovers as habitat at developed or stabilized sites degrades.

Weather events

Storm Events

Storms are an integral part of the natural processes that form coastal habitats used by migrating and wintering piping plovers, and positive effects of storm-induced overwash and vegetation removal have been noted in portions of the wintering range. For example, biologists reported piping plover use of newly created habitats at Gulf Islands National Seashore in Florida within six months of overwash events that occurred during the 2004 and 2005 hurricane seasons (M. Nicholas, Gulf Islands National Seashore, pers. comm. 2005). Hurricane Katrina created a new inlet and improved habitat conditions on some areas of Dauphin Island, Alabama, but subsequent localized storms contributed to habitat loss there (D. LeBlanc, USFWS, pers. comm. 2009) and the inlet was subsequently closed with a rock dike as part of Deepwater Horizon oil spill response efforts (Rice 2012a). Following Hurricane Ike in 2008, Arvin (2009) reported decreased numbers of piping plovers at some heavily eroded Texas beaches in the center of the storm impact area and increases in plover numbers at sites about 100 miles to the southwest. Piping plovers were observed later in the season using tidal lagoons and pools that Hurricane Ike created behind the eroded beaches (Arvin 2009).

Adverse effects attributed to storms alone are sometimes actually due to a combination of storms and other environmental changes or human use patterns. For example, four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Winter Census (Haig and Plissner 1992) tallied more than 350 birds. Comparison of imagery taken three years before and again several days after Hurricane Katrina found that the Chandeleur Islands had lost 82% of their combined surface area (Sallenger 2010). A review of aerial photographs taken before the 2006 Census suggested that little piping plover habitat remained (Elliott-Smith *et al.* 2009). However, Sallenger *et al.* (2009) noted that habitat changes in the Chandeleur Islands stem not only from the effects of these storms, but rather from the combined effects of the storms, and more than a thousand years of diminishing sand supply and sea level rise. Although the Chandeleur Islands marsh platform continued to erode for 22 months post-Katrina, some sand was released from the marsh sediments which in turn created beaches, spits, and welded swash bars that advanced the shoreline seaward. Despite the effects of intense erosion, the Chandeleur Islands are still providing high quality shorebird habitat in the form of sand flats, spits, and beaches used by substantial numbers of piping plovers (Catlin *et al.* 2011), a scenario that could continue if restoration efforts are sustainable and successful from a shorebird perspective (USACE 2010).

Storm-induced adverse effects include post-storm acceleration of human activities such as beach nourishment, sand scraping, closure of new inlets, and berm and seawall construction. As discussed previously, such stabilization activities can result in the loss and degradation of feeding and resting habitats. Land managers sometimes face public pressure after big storm events to plant vegetation, install sandfences, and bulldoze artificial "dunes." For example, national wildlife refuge managers sometimes receive pressure from local communities to "restore" the beach and dunes following blowouts from storm surges that create the overwash foraging habitat preferred by plovers (C. Hunter, USFWS, pers. comm. 2011). At least 64 inlets have been artificially closed, the vast majority of them shortly after opening in storm events (**Table 5**). Storms also can cause widespread deposition of debris along beaches. Subsequent removal of this debris often requires large machinery that in turn can cause extensive disturbance and adversely affect habitat elements such as wrack. Challenges associated with management of public use can grow when storms increase access (e.g., merger of Pelican Island with Dauphin Island in Alabama following a 2007 storm (Gibson et. al. 2009, D. LeBlanc pers. comm. 2009)).

Some available information indicates that birds may be resilient, even during major storms, and move to unaffected areas without harm. Other reports suggest that birds may perish in or following storm events. Noel and Chandler (2005) suspected that changes in habitat caused by multiple hurricanes along the Georgia coastline altered the spatial distribution of piping plovers and may have contributed to the winter mortality of three individuals. Wilkinson and Spinks (1994) suggested that low plover numbers in South Carolina in January 1990 could have been partially influenced by effects on habitat from Hurricane Hugo the previous fall, while Johnson and Baldassarre (1988) found a redistribution of piping plovers in Alabama following Hurricane Elena in 1985.

Climate change studies indicate a trend toward increasing numbers and intensity of hurricane events (Emanuel 2005, Webster *et al.* 2005). Combined with the predicted effects of sea level rise, this trend indicates potential for increased cumulative impact of future storms on habitat. Major storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range.

Severe Cold Weather

Several sources suggest the potential for adverse effects of severe winter cold on survival of piping plovers. The Atlantic Coast piping plover recovery plan mentioned high mortality of coastal birds and a drop from approximately 30-40 to 15 piping plovers following an intense 1989 snowstorm along the North Carolina coast (Fussell 1990). A preliminary analysis of survival rates for Great Lakes piping plovers found that the highest variability in survival occurred in spring and correlated positively with minimum daily temperature (weighted mean based on proportion of the population wintering near five weather stations) during the preceding winter (E. Roche, Univ. of Tulsa, pers. comm. 2010 and 2012). Catlin (pers. comm. 2012b) reported that the average mass of ten piping plovers captured in Georgia during unusually cold

If project construction occurs during the piping plover nonbreeding season, plovers may avoid the construction area on Bird Key Stono and use other areas on Bird Key Stono and/or the west end of Folly Beach. Therefore, Folly Beach and Bird Key Stono are considered to be part of the action area for piping plovers.

6.2.2. Action Area Conservation Needs and Threats

Recreational Disturbance

Intense human disturbance in winter habitat can be functionally equivalent to habitat loss. If the disturbance prevents birds from using an area (Goss-Custard *et al.* 1996), this can lead to roost abandonment and population declines (Burton *et al.* 1996). Disturbance from human and pet presence alters plover behavior and often negatively influences distribution.

West End of Folly Beach

The west end of Folly Beach provides public access and a portion of the beach is within the Folly Beach County Park. Dogs are allowed on the beach, but must be on leash at all times unless the dog owner is a member of the Folly Island Dog Owner (FIDO) club, which allows special privileges for "responsible dog owners and their dogs."

Bird Key

This undeveloped island is a SCDNR Heritage Preserve. It is managed for seabird and shorebird nesting and is within designated critical habitat for wintering piping plovers (see **Section 7**). No dogs are allowed on the island and pedestrian access is seasonally restricted.

6.3. Effects of the Action

This section analyzes the direct and indirect effects of the Action on the piping plover, which includes the direct and indirect effects of interrelated and interdependent actions. Direct effects are caused by the Action and occur at the same time and place. Indirect effects are caused by the Action, but are later in time and reasonably certain to occur. Our analyses are organized according to the description of the Action in section 2 of this BO.

6.3.1. Effects of beach renourishment on piping plovers

Beneficial Effects

The renourishment project may temporarily increase roosting habitat on the northeast end of Bird Key Stono due to the sand placement covering existing dune vegetation.

Adverse Effects

Shoreline stabilization projects have been documented to have adverse effects on nonbreeding piping plover habitat and piping plover abundance and distribution. Results of monitoring piping plovers and their habitat provide additional information on how piping plovers respond to these projects, minimization measures, and other factors that influence piping plover abundance, distribution, and site selection.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window overlaps with one nonbreeding season for piping plovers. Heavy machinery and equipment (e.g., trucks and bulldozers operating on project area beaches), sand excavation, and berm construction, may adversely affect migrating and wintering piping plovers in the project area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during each nourishment and renourishment cycle. Impacts will affect the 40,000 feet of shoreline. Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years (Thrush *et al.* 1996, Peterson *et al.* 2000, Zajac and Whitlatch 2003, Bishop *et al.* 2006, Peterson *et al.* 2006). Depending on actual recovery rates, impacts may occur even if nourishment activities occur outside the migration and wintering seasons. The sand is being placed above the high tide line on a small section of the island, which will limit impacts to intertidal foraging habitat.

Indirect effects: Indirect effects are effects caused by or result from the proposed action, are later in time, and are reasonably certain to occur. The proposed project may facilitate increased access to currently occupied roosting and foraging habitat. Recreational activities that potentially adversely affect plovers include disturbance by unleashed pets and increased pedestrian use.

6.3.2. Effects of Groin Rehabilitation

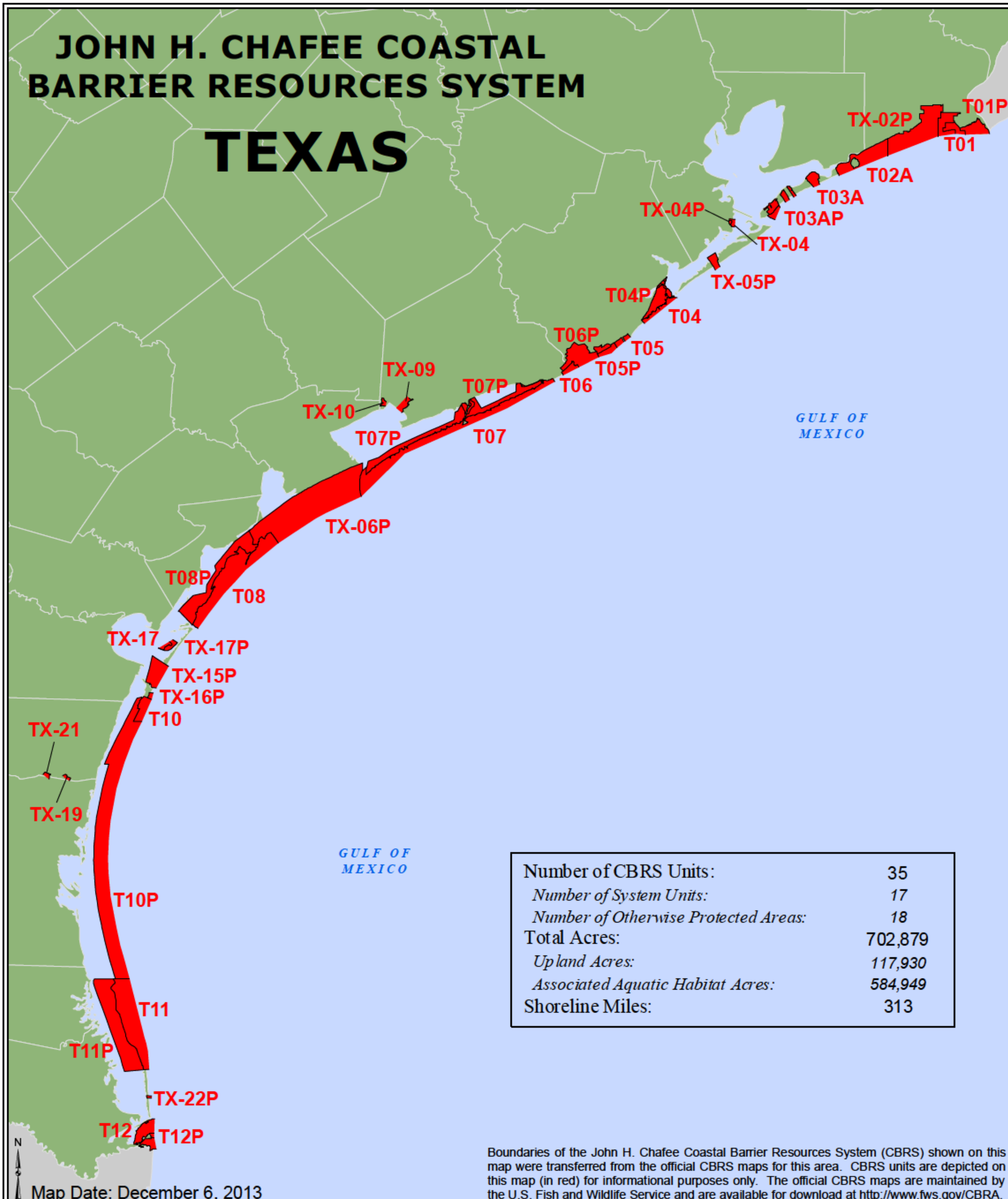
No additional effects due to groin rehabilitation are anticipated based on the location of the groins. Piping plovers tend to use the ends of the islands, which is outside of the area of groin rehabilitation. Folly Beach will continue to be renourished on a regular interval, which will allow sediment transport to continue to the west end of the island.

6.4. Cumulative Effects

For purposes of consultation under ESA §7, cumulative effects are those caused by future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future Federal actions that are unrelated to the proposed action are not considered, because they require separate consultation under §7 of the ESA. The Service is not aware of any cumulative effects in the Action Area at this time; therefore, cumulative effects are not relevant to formulating our opinion for the Action.

JOHN H. CHAFEE COASTAL BARRIER RESOURCES SYSTEM

TEXAS



Number of CBRS Units:	35
Number of System Units:	*17*
Number of Otherwise Protected Areas:	*18*
Total Acres:	702,879
Upland Acres:	*117,930*
Associated Aquatic Habitat Acres:	*584,949*
Shoreline Miles:	313

Map Date: December 6, 2013

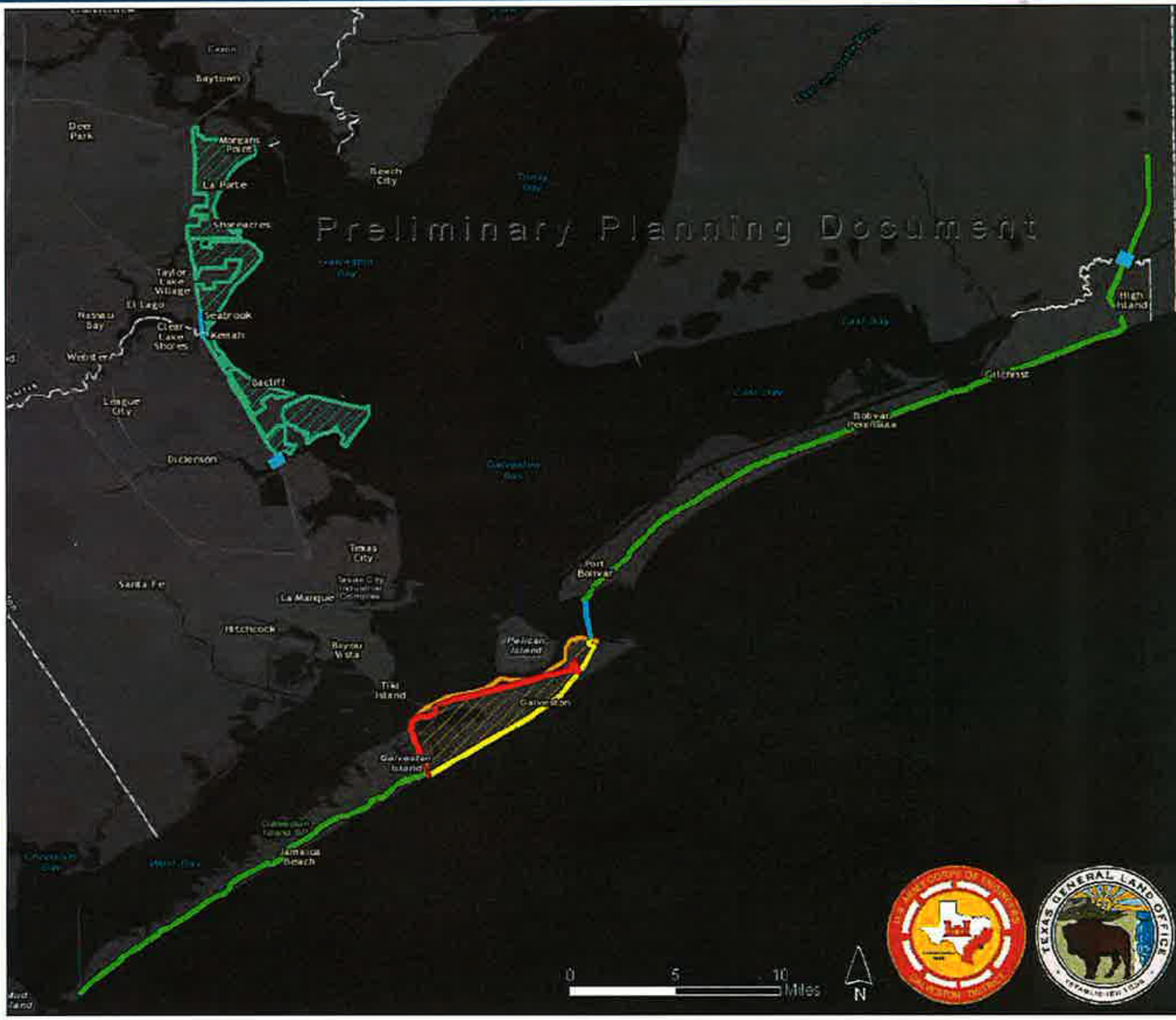
Boundaries of the John H. Chafee Coastal Barrier Resources System (CBRS) shown on this map were transferred from the official CBRS maps for this area. CBRS units are depicted on this map (in red) for informational purposes only. The official CBRS maps are maintained by the U.S. Fish and Wildlife Service and are available for download at http://www.fws.gov/CBRA.

Coastal Texas Protection and Restoration Study

Alternative A

- Navigation and Environmental Gates
- Levee/Floodwall
- Galveston Levee/Floodwall *
- Galveston Seawall Improvements
- Galveston Island Nonstructural Improvements *
- Nonstructural Improvements

* Galveston Back Bay Risk Reduction will select one of these measures.



Alternative A

Coastal Barrier Navigation and Environmental Gate

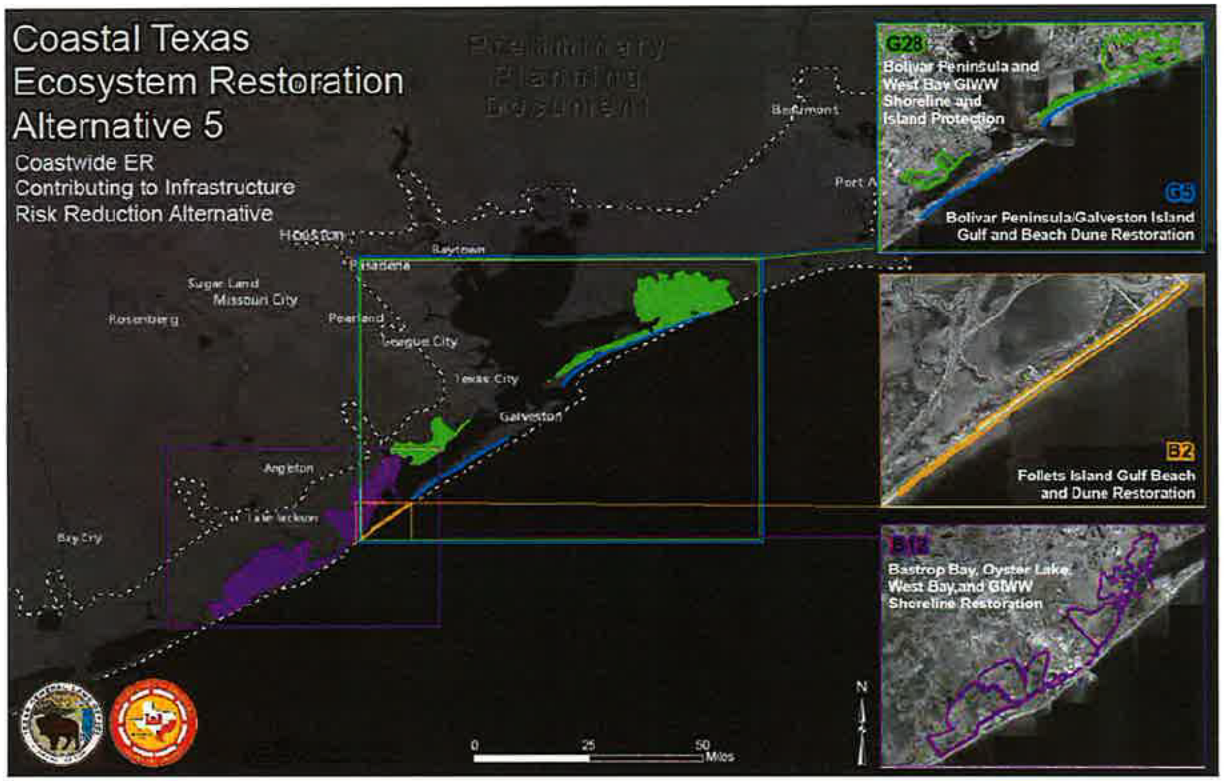
- Navigation and Environmental Gate plus Tie-Ins
- Navigation and Environmental Gates
- Levee/Floodwall
- Galveston Levee/Floodwall *
- Galveston Seawall Improvements
- Galveston Island Nonstructural Improvements *
- Nonstructural Improvements

* Galveston Back Bay Risk Reduction will select one of these measures.


Alt A and Alt A Modified
Cobra Zones Shown
35
146
6
45
87
Google earth
© 2017 Google
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
10 mi
N

Two Ecosystem Restoration Measures Affect CBRA Units

- See top-right inset map and center rectangle
- Measure G-5 – restores the Gulf shoreface, beach and dune system on Bolivar Peninsula and West Galveston Island; provides for periodic renourishment to maintain the beach; passes through 5 CBRA units on Bolivar and 1 unit on Galveston Island; meets CBRA exception Sec 6(G)
- Measure G-28 – minimizes erosion of the barrier peninsula from the inside (along the Gulf Intracoastal Waterway); passes through 5 CBRA units on Bolivar; restores marsh and stabilizes fish and wildlife habitat; meets CBRA exception Sec 6(A)



From:	Wright, Dana K
To:	Niemi, Katie
Subject:	Re: CBRA Website Update
Date:	Wednesday, November 13, 2019 8:52:50 AM
Attachments:	iconfinder_youtube-square-shadow-social-media_765073.png

I'm good with it. Let me know when it's ready to go to Andrew.

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Wed, Nov 13, 2019 at 8:49 AM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Dana,
> How about this (my edits in red):
>
> b5-DPP
> [redacted]
>
> ---------- Forwarded message ---------
> From: **Frazer, Gary** <gary_frazer@fws.gov>
> Date: Tue, Nov 12, 2019 at 10:11 PM
> Subject: Fwd: CBRA Website Update
> To: Katie Niemi <katie_niemi@fws.gov>
> Cc: Dana Wright <dana_wright@fws.gov>, Shaughnessy, Michelle <michelle_shaughnessy@fws.gov>
>
> Katie -- Department Comms is insisting that the Service post something related to the recent sand mining memo on our CBRA page. I edited their proposed language down to this:
>
> b5-DPP
> [redacted]

b5-DPP
[redacted]

Do you have any concerns with this language? If not, I'll run it through SOL and then someone (probably either me or Marty Kodis) will get back to you about posting it. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Frazer, Gary** <gary_frazer@fws.gov>
Date: Mon, Nov 11, 2019 at 9:26 PM
Subject: Fwd: CBRA Website Update
To: Gary Frazer <Gary_Frazer@fws.gov>

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Martin Kodis** <martin_kodis@fws.gov>
Date: Fri, Nov 8, 2019 at 4:42 PM
Subject: Fwd: CBRA Website Update
To: <gary_frazer@fws.gov>

Any ideas on what to do?

Sent from my iPhone

Begin forwarded message:

> **From:** Melissa Beaumont <melissa_beaumont@fws.gov>
> **Date:** November 8, 2019 at 4:29:31 PM EST
> **To:** Martin Kodis <martin_kodis@fws.gov>, Gavin Shire

<gavin_shire@fws.gov>
Cc: Charisa Morris <charisa_morris@fws.gov>
Subject: Fwd: CBRA Website Update

Did you see this earlier?

Sent from my iPhone

Begin forwarded message:

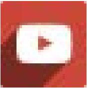
> **From:** "Goodwin, Nicholas" <nicholas_goodwin@ios.doi.gov>
> **Date:** November 8, 2019 at 3:55:00 PM EST
> **To:** Margaret Everson <margaret_e_everson@fws.gov>, John Tanner <john_tanner@ios.doi.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>
> **Cc:** "Budd-Falen, Karen" <karen.budd-falen@sol.doi.gov>, OCO-Theresa Eisenman <theresa_eisenman@ios.doi.gov>, "Schroeder, Darin" <Darin_Schroeder@ios.doi.gov>, Melissa Brown <melissa_brown@ios.doi.gov>
> **Subject: CBRA Website Update**
>
> Margaret/John/Melissa,
>
> Please update the CBRA website -
> - https://www.fws.gov/CBRA/ - Hot Topics section to include the blurb below. This was requested of FWS comms and CBRA staff earlier today to be completed, yet has not been done. The language below has been cleared for SOL. Please let me know when it is posted online today before COB.
>
> Any questions, please let me know.
>
> Thank you,
>
> –
>
> b5-DPP
> [redacted]

b5-DPP [redacted]

b5-DPP [redacted]

[redacted]

Nick Goodwin
Communications Director
Office of the Secretary
U.S. Department of the Interior
#: (202) 412-2249



From: Wright, Dana K
To: BalisLarsen, Martha
Cc: Shire, Gavin G; Hires, Brian K; Niemi, Katie; Phinney, Jonathan T; Bohn, Cynthia; Guy, Chris; Eisenhauer, David
Subject: Re: CBRA - media call
Date: Wednesday, November 13, 2019 11:40:03 AM
Attachments: Email 5.11.18 - [EXTERNAL] Re Delaware Beneficial Use of Dredged Material and CBRA Coordination.pdf

---

Hello all,

We are not aware of any Delaware projects that will be affected by the new SOL interpretation on CBRA and beach nourishment projects, however we would have to refer you to the Chesapeake Bay Field Office to confirm that (Chris Guy from that office is copied). The October 2019 SOL memo affects projects where a sand borrow site is located within a System Unit of the CBRS and the beach renourishment activities occur partially or completely outside of the CBRS. I am not aware of any borrow sites in Delaware that are within a System Unit. Chris, can you please confirm that the Corps has not contacted your office seeking to mine sand from within a System Unit in Delaware?

The Corps and the Service completed a CBRA consultation for a Delaware Bay Coastal Storm Risk Management Project in 2017 (see attached FYI only, not to share). That project was found to be allowable under CBRA's exceptions. My understanding is that in that case, the sand was coming from navigation channel maintenance outside of the CBRS, not from a borrow site in a System Unit.

It may be a good idea to also refer the reporter to the Corps to confirm that they are not seeking to mine sand from within System Units in Delaware. Chris, is there a contact at the Corps' Philadelphia District that could be provided? Is it Barb Conlin?

Thanks,

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Wed, Nov 13, 2019 at 10:34 AM BalisLarsen, Martha <martha_balislarsen@fws.gov> wrote:

> Gavin, as discussed, please call Sophie Schmidt, Reporter with Delaware Public Media. Interested in change in federal spending prohibitions under CBRA, re: NY Times article, and impact on beaches, especially those in Delaware. She looked online but could not find any documentation related to the change. 302-690-1616.
>
> Martha

Hi Barb and Scott,

This email message is in response to your February 10, 2017 letter regarding the Delaware Beneficial Use of Dredged Material for the Delaware River Project.

The CBRA seeks to save taxpayers' money, keep people out of harm's way, and remove Federal incentives to develop coastal barriers by restricting most new Federal expenditures and financial assistance (e.g., beach nourishment, disaster assistance, flood insurance, loans, and grants) that can encourage the development and redevelopment of coastal barriers.

The exception to the CBRA for nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system (16 U.S.C. 3503(a)(6)(G) also requires that the project be consistent with each of the three purposes of the CBRA, which are to minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers. The objective of this proposed project is to beneficially use high quality sand material dredged from the Delaware River main navigation channel in the lower bay to reduce flooding, erosion, and storm damage risks in coastal areas affected by Hurricane Sandy. This project is consistent with the purposes of the CBRA when conducted in front of the small communities that pre-date the CBRS units and are excluded from the CBRS. In these areas, only the beachfront and not the upland coastal barrier areas are within the CBRS. However, this project would not be consistent with the purposes of CBRA if it is conducted in front of developed coastal barrier upland areas that are designated within the CBRS. The very existence of a beach nourishment project can encourage more development in coastal areas (Dean 1999).

The last sentence in the first paragraph on page 5 of the Corps' February 10, 2017, letter states "The Corps anticipates that the design plans may be modified slightly during the optimization process; and the Corps will evaluate practicable opportunities to minimize those sections of the berm/dune footprint that enter into System Units, while maintaining the integrity of the shoreline stabilization and protection objective." The Service advises that the Corps avoid constructing the berm/dune footprint within the CBRS System Units at the following Delaware bayshore community project sites: the southern end of Pickering Beach, DE, the northern end of Kitts Hummock, DE; the southern end of Slaughter Beach, DE and Prime Hook Beach, DE. The attached maps of the project area have been annotated to note areas where beach nourishment would be inconsistent with the purposes of the CBRA. The CBRS System Units at these four project sites need to be avoided in order to meet the exception.

Please contact us if you have any questions. Thanks

--

Trevor Clark
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Chesapeake Bay Ecological Services Field Office
Endangered and Threatened Species Branch
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
Telephone: (410) 573-4527 Fax: (410) 269-0832
Email: trevor_clark@fws.gov <mailto:trevor_clark@fws.gov> <mailto:trevor_clark@fws.gov> <mailto:trevor_clark@fws.gov <mailto:trevor_clark@fws.gov> >

-

Trevor Clark
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Chesapeake Bay Ecological Services Field Office
Endangered and Threatened Species Branch
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
Telephone: (410) 573-4527 Fax: (410) 269-0832
Email: trevor_clark@fws.gov <mailto:trevor_clark@fws.gov> <mailto:trevor_clark@fws.gov>

--
Trevor Clark
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Chesapeake Bay Ecological Services Field Office
Endangered and Threatened Species Branch
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
Telephone: (410) 573-4527 Fax: (410) 269-0832
Email: trevor_clark@fws.gov

From:	Frazer, Gary D
To:	Niemi, Katie
Cc:	Wright, Dana K; Shaughnessy, Michelle
Subject:	Re: CBRA Website Update
Date:	Wednesday, November 13, 2019 1:30:01 PM
Attachments:	iconfinder_youtube-square-shadow-social-media_765073.png
Importance:	High

OK, now I understand. Good addition. I'm just going to change it to read, "The Service will assist federal agencies in evaluating such projects through the interagency consultation process." Thanks. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

On Wed, Nov 13, 2019 at 11:33 AM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Gary,
> It's up to you whether we add that sentence. Our thinking is that the local media (about a dozen articles about this issue now) and other interested parties (Congressional offices and stakeholder groups) are making the assumption that the new interpretation means that certain large-scale storm damage reduction projects are now consistent with CBRA. We thought it might be good to have a reminder that there is a consultation process (so at least the Corps produces documentation demonstrating how the project meets the exception and is consistent with the Act). However, if you want to delete that sentence, that's fine as well.
> Thanks.
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071
>
> On Wed, Nov 13, 2019 at 10:47 AM Frazer, Gary <gary_frazer@fws.gov> wrote:
>
> > Katie -- I'm not sure we want to add that last sentence. Are you wedded to that addition? Why did you want to add it? -- GDF
> >
> > *Gary Frazer*
> > *Assistant Director -- Ecological Services*
> > *U.S. Fish and Wildlife Service*
> > *(202) 208-4646*
> >
> > On Wed, Nov 13, 2019 at 9:19 AM Niemi, Katie <katie_niemi@fws.gov> wrote:
> >
> > > Gary,

Your version looks good. I have minor recommended edits in red below. Please let me know once it's cleared and we will get it posted to the hot topics section of the CBRA website. Thanks.
Katie

b5-DPP [redacted]

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

On Tue, Nov 12, 2019 at 10:11 PM Frazer, Gary <gary_frazer@fws.gov> wrote:

> Katie -- Department Comms is insisting that the Service post something related to the recent sand mining memo on our CBRA page. I edited their proposed language down to this:
>
> b5-DPP [redacted]
>
> Do you have any concerns with this language? If not, I'll run it through SOL and then someone (probably either me or Marty Kodis) will get back to you about posting it. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Frazer, Gary** <gary_frazer@fws.gov>
Date: Mon, Nov 11, 2019 at 9:26 PM
Subject: Fwd: CBRA Website Update
To: Gary Frazer <Gary_Frazer@fws.gov>

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Martin Kodis** <martin_kodis@fws.gov>
Date: Fri, Nov 8, 2019 at 4:42 PM
Subject: Fwd: CBRA Website Update
To: <gary_frazer@fws.gov>

Any ideas on what to do?

Sent from my iPhone

Begin forwarded message:

> **From:** Melissa Beaumont <melissa_beaumont@fws.gov>
> **Date:** November 8, 2019 at 4:29:31 PM EST
> **To:** Martin Kodis <martin_kodis@fws.gov>, Gavin Shire <gavin_shire@fws.gov>
> **Cc:** Charisa Morris <charisa_morris@fws.gov>
> **Subject: Fwd: CBRA Website Update**
>
> Did you see this earlier?
>
> Sent from my iPhone
>
> Begin forwarded message:
>
>> **From:** "Goodwin, Nicholas"

<nicholas_goodwin@ios.doi.gov>
Date: November 8, 2019 at 3:55:00 PM EST
To: Margaret Everson <margaret_e_everson@fws.gov>, John Tanner <john_tanner@ios.doi.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>
Cc: "Budd-Falen, Karen" <karen.budd-falen@sol.doi.gov>, OCO-Theresa Eisenman <theresa_eisenman@ios.doi.gov>, "Schroeder, Darin" <Darin_Schroeder@ios.doi.gov>, Melissa Brown <melissa_brown@ios.doi.gov>
Subject: CBRA Website Update

Margaret/John/Melissa,

Please update the CBRA website - - https://www.fws.gov/CBRA/ - Hot Topics section to include the blurb below. This was requested of FWS comms and CBRA staff earlier today to be completed, yet has not been done. The language below has been cleared for SOL. Please let me know when it is posted online today before COB.

Any questions, please let me know.

Thank you,

–

b5-DPP
[redacted]

b5-DPP

[redacted]

[redacted]

[redacted]

Nick Goodwin
Communications Director
Office of the Secretary
U.S. Department of the Interior
#: (202) 412-2249

From: Wright, Dana K
To: Cruz, Andrew
Cc: Niemi, Katie
Subject: Fwd: CBRA Website Update
Date: Thursday, November 14, 2019 7:28:34 AM
Attachments: iconfinder_youtube-square-shadow-social-media_765073.png
Importance: High

Hi Andrew,

Here is the revised language. Changes are underlined/bold. Please send me the mockup so I can double check before you publish.

U.S. Fish and Wildlife Service Provides Updated Interpretation for Beach Nourishment Projects

The U.S. Fish and Wildlife Service (FWS) will advise federal agencies that the Coastal Barrier Resources Act allows for sand removal from Coastal Barrier Resources System (CBRS) units to be used to replenish beaches located both within and outside the CBRS, so long as the proposed project is consistent with the purposes of the Act and meets the statutory exception for **"**nonstructural projects **for shoreline stabilization that are** designed to mimic, enhance, or restore ~~a~~ natural stabilization system**s**". **FWS** will assist federal agencies in evaluating such projects through the interagency consultation process.

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Frazer, Gary** <gary_frazer@fws.gov>
Date: Wed, Nov 13, 2019 at 4:49 PM
Subject: Re: CBRA Website Update
To: Romanik, Peg <peg.romanik@sol.doi.gov>, Katie Niemi <katie_niemi@fws.gov>
Cc: Kodis, Martin <martin_kodis@fws.gov>, Dana Wright <dana_wright@fws.gov>, Shaughnessy, Michelle <michelle_shaughnessy@fws.gov>

Thanks, Peg. Good catch.

Katie, pls change "Service" to "FWS" in the last sentence and get this posted first thing tomorrow.

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

On Wed, Nov 13, 2019 at 4:31 PM Romanik, Peg <peg.romanik@sol.doi.gov> wrote:

> Just two edits. B5-ACP-DPP [redacted]
>
> Peg Romanik
> Associate Solicitor
> Division of Parks and Wildlife
> Office of the Solicitor
> U.S. Department of the Interior
> **Office: (202)208-5578**
> **Cell: (202)515-1000**
>
> On Wed, Nov 13, 2019 at 4:13 PM Kodis, Martin <martin_kodis@fws.gov> wrote:
>
>> FWS won't be able to post to the web till tomorrow, so anytime tonight is fine if you can manage it!
>>
>> Thank you Peg, I hope the crisis is satisfactorily abated.
>>
>> Marty
>>
>> On Wed, Nov 13, 2019 at 3:30 PM Romanik, Peg <peg.romanik@sol.doi.gov> wrote:
>>
>>> Within the hour I'll respond - working the crisis of the hour right now. Peg
>>>
>>> Peg Romanik
>>> Associate Solicitor
>>> Division of Parks and Wildlife
>>> Office of the Solicitor
>>> U.S. Department of the Interior
>>> **Office: (202)208-5578**
>>> **Cell: (202)515-1000**

On Wed, Nov 13, 2019 at 3:28 PM Kodis, Martin <martin_kodis@fws.gov> wrote:

Thanks Gary and Peg.

Peg, a quick note to emphasize that DOI/OCO has been keen on FWS getting this on the web, and I imagine they'll be barking at us any moment for a progress report. It would be great to hear back from you today if possible.

Thank you.

Marty

On Wed, Nov 13, 2019 at 1:39 PM Frazer, Gary <gary_frazer@fws.gov> wrote:

Peg -- OCO is pushing to have us post something to our CBRA website reflecting the revised legal interpretation. Can you confirm that the attached is consistent with your memo? Thanks. -- GDF

B5-ACP-DPP

[redacted]

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Niemi, Katie** <katie_niemi@fws.gov>
Date: Wed, Nov 13, 2019 at 9:19 AM
Subject: Re: CBRA Website Update
To: Frazer, Gary <gary_frazer@fws.gov>
Cc: Dana Wright <dana_wright@fws.gov>, Shaughnessy, Michelle <michelle_shaughnessy@fws.gov>

Gary,
Your version looks good. I have minor recommended edits in red below. Please let me know once it's cleared and we will get it posted to the hot topics section of the CBRA website. Thanks.

Katie

b5-DPP
[redacted]

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

On Tue, Nov 12, 2019 at 10:11 PM Frazer, Gary <gary_frazer@fws.gov> wrote:

> Katie -- Department Comms is insisting that the Service post something related to the recent sand mining memo on our CBRA page. I edited their proposed language down to this:
>
> b5-DPP
> [redacted]
>
> Do you have any concerns with this language? If not, I'll run it through SOL and then someone (probably either me or Marty Kodis) will get back to you about posting it. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Frazer, Gary** <gary_frazer@fws.gov>
Date: Mon, Nov 11, 2019 at 9:26 PM
Subject: Fwd: CBRA Website Update
To: Gary Frazer <Gary_Frazer@fws.gov>

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

---------- Forwarded message ---------
From: **Martin Kodis** <martin_kodis@fws.gov>
Date: Fri, Nov 8, 2019 at 4:42 PM
Subject: Fwd: CBRA Website Update
To: <gary_frazer@fws.gov>

Any ideas on what to do?

Sent from my iPhone

Begin forwarded message:

> **From:** Melissa Beaumont <melissa_beaumont@fws.gov>
> **Date:** November 8, 2019 at 4:29:31 PM EST
> **To:** Martin Kodis <martin_kodis@fws.gov>, Gavin Shire <gavin_shire@fws.gov>
> **Cc:** Charisa Morris <charisa_morris@fws.gov>
> **Subject: Fwd: CBRA Website Update**
>
> Did you see this earlier?
>
> Sent from my iPhone
>
> Begin forwarded message:
>
>> **From:** "Goodwin, Nicholas"

<nicholas_goodwin@ios.doi.gov>
Date: November 8, 2019 at 3:55:00 PM EST
To: Margaret Everson <margaret_e_everson@fws.gov>, John Tanner <john_tanner@ios.doi.gov>, Melissa Beaumont <melissa_beaumont@fws.gov>
Cc: "Budd-Falen, Karen" <karen.budd-falen@sol.doi.gov>, OCO-Theresa Eisenman <theresa_eisenman@ios.doi.gov>, "Schroeder, Darin" <Darin_Schroeder@ios.doi.gov>, Melissa Brown <melissa_brown@ios.doi.gov>
Subject: CBRA Website Update

Margaret/John/Melissa,

Please update the CBRA website -- https://www.fws.gov/CBRA/ - Hot Topics section to include the blurb below. This was requested of FWS comms and CBRA staff earlier today to be completed, yet has not been done. The language below has been cleared for SOL. Please let me know when it is posted online today before COB.

Any questions, please let me know.

Thank you,

–

b5-DPP
[redacted]

b5-DPP

[redacted]

[redacted]

[redacted]

Nick Goodwin
Communications Director
Office of the Secretary
U.S. Department of the Interior
#: (202) 412-2249

--
Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

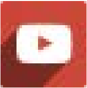
703-358-2241 ph
703-358-2245 fax

--

Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax



From:	Bohn, Cynthia
To:	Niemi, Katie; Wright, Dana K
Subject:	Fwd: Scanned CBRA doc2
Date:	Thursday, November 14, 2019 12:18:22 PM
Attachments:	CBRA docs2.pdf
Importance:	High

Ladies, I have coordinated with the ARDs and would like to send the following email to the Field Office's. I still need to contact the folks in Texas but they will need a different memo if we do one. Please send to Martha for review as requested. We would like to send to the Field as soon as possible to get input. thanks, c

MEMO to all FO Supervisors and CBRA Staff:

(It you do not work on the Coastal Barrier Resources Act please disregard and excuse this interruption.)

Hello CBRA folks and field supervisors,

Per my discussion with Acting ARD Pam Tochik and Deputy Spencer Simon or Michelle Everson and Deputy Jack Arnold, I wanted to reach out to you to provide an update and ask for your coordination on the Solicitor's opinion on sand mining in a CBRS Unit. (Please see the memo attached and the message from the Director below for background information) The Solicitor's memo reads in its conclusion, "Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act."

In a nutshell, here are the things you may need to know:

- b5-DPP [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Thank you all for your attention and patience as we work to provide the best possible guidance for furthering the purposes of CBRA to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers,". As always, please feel free to contact me at any time.

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 14, 2019 at 9:46 AM
Subject: Fwd: Scanned CBRA doc2
To: Cynthia Bohn <cynthia_bohn@fws.gov>

Hi Cindy,
Here's what we sent to our FOs.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 7, 2019 at 12:27 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5 ES Field Office Supervisors <fw5_es_field_office_supervisors@fws.gov>
Cc: Spencer Simon <spencer_simon@fws.gov>, Jahn, Kathryn <kathryn_jahn@fws.gov>, Martin Miller <martin_miller@fws.gov>, Diane Lynch <diane_opper@fws.gov>

Hi team,
Please see below and attached, and note we are anticipating additional guidance from HQ. If you have a CBRA action come up before we receive guidance, please coordinate with the RO and HQ.

Best wishes,
Pam

---------- Forwarded message ---------
From: **Wendi Weber** <wendi_weber@fws.gov>
Date: Tue, Nov 5, 2019 at 6:45 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5_Regional_Directorate@fws.gov <FW5_Regional_Directorate@fws.gov>

Please share with your staff as appropriate. Thank you

Sent from my iPhone

Begin forwarded message:

> **From:** "Everson, Margaret" <margaret_e_everson@fws.gov>
> **Date:** November 5, 2019 at 6:42:59 PM EST
> **To:** FWS Directorate & Deputies <fwsdirectanddep@fws.gov>
> **Cc:** Melissa Beaumont <melissa_beaumont@fws.gov>, "Morris, Charisa" <charisa_morris@fws.gov>, "Kodis, Martin" <Martin_Kodis@fws.gov>
> **Subject: Fwd: Scanned CBRA doc2**
>
> FWS Team.
> Plese find attached Correspondence regarding the Coastal Barrier Resources Act along with an opinion from the SOL concluding that the exemption within Section 6(a)(6)(G) of the Act is not limited to shoreline stabilization projects occuring within the Coastal Barrier Resources System. And sand from within a System unit may be used to renourish a beach that is located outside the System, provided the project furthers the purposes of the Act.
>
> I am working with Gary Frazer and his team to identify our existing Service guidence that needs to be updated to align with the SOL guidence. Please take the opportunity to understand the Oct 30th memo from SOL and let me know if you have any questions. We will make sure to communicate the updates that we have made to our existing gudience on this issue as they are made. Please make sure to communicate this information to any of your staff members who are working on this issue so our recomendations and opinions are consistent with the SOL memo.
>
> Best
> Margaret

--
Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services

North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

--

Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

Memorandum

To: Rob Wallace, Assistant Secretary for Fish and Wildlife and Parks
Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Secretary

Subject: Coastal Barrier Resources Act

Attached is correspondence regarding the above-referenced statute. Please notify your staffs of our position on this matter going forward, and modify any communications to bring them in compliance with the Department of the Interior's understanding of the language.

Attachment

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

Congress of the United States
Washington, DC 20515

October 25, 2019

The Honorable David Bernhardt
Secretary, U.S. Department of Interior
1849 C St., NW
Washington, DC 20240

Dear Secretary Bernhardt:

We write to you about an interpretation of the Coastal Barrier Resources Act (CBRA) that could jeopardize public and private infrastructure, small businesses and regional economies. The interpretation unnecessarily results in increased ecological impacts as well as increased Federal expenditures. In 2016, the U.S. Fish and Wildlife Service ("Service") issued an interpretation of a 1994 Solicitor's Opinion that has caused several ongoing coastal storm damage reduction (CSDR) projects from moving forward, even though these projects meet all the appropriate requirements of the CBRA and National Environmental Policy Act (NEPA). We believe that correcting the 2016 interpretation and the underlying 1994 Solicitor's Opinion is consistent with our infrastructure focus and small business support while retaining CBRA and NEPA regulatory compliance.

In 1982, the CBRA was enacted into law and established the John H. Chafee Coastal Barrier Resources System (System) to "minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers" in coastal areas along the Atlantic Ocean, Gulf of Mexico, Great Lakes, Puerto Rico, and the Virgin Islands. One objective was to ensure the proper balance of ecological, community and economic considerations on undeveloped coastal barriers. As such, CBRA prohibits new federal financial assistance in System "units" with exceptions outlined in Section 6 of the statute (16 U.S.C. 3505). While the original intent of the law is laudable, the current interpretation has unintended consequences, particularly as they relate to CSDR projects that are partially federally funded, resource management and economic impacts.

In our congressional districts, coastal storm damage reduction projects carried out by the U.S. Army Corps of Engineers (USACE) in partnership with our respective states have been stalled, and their costs have ballooned, because of a 2016 interpretation of a 1994 Department of Interior Solicitor's Opinion (FWS.CW.0380) by the Service that essentially states that sand from a System unit cannot be placed on a non-CBRA shoreline. This decision suddenly prohibited sand recycling from certain System units - despite the Service in 1996 having previously allowed sand recycling from these same System units per CBRA's exceptions.

For example, the congressionally authorized *New Jersey Shore Protection, Townsends Inlet to Cape May Inlet* project had previously accessed System unit NJ-09 as a borrow site multiple times with the consent of the Service. Yet the 2016 Service interpretation suddenly prevented access to the borrow site, despite the environmental benefits of the project, and increased project costs by at least $6.5 million, stalling the required periodic nourishment. As a result of the determination by the Service that sand cannot be beneficially used from CBRA units, specifically NJ-09, to benefit land immediately adjacent to but not located within the CBRA unit, Stone Harbor and North Wildwood are directly impacted to such an extent that they are facing loss of their economic ability to meet the USACE's Project Cooperation Agreement requirements. Moreover, the significant environmental benefits of CSDR projects such as improved wildlife habitat conditions that have occurred over the past several years are being jeopardized directly as a result of the Service's 2016 decision. Likewise, similar challenges exist with the CSDR projects at Carolina Beach and Wrightsville Beach, NC. These projects have used passive-infill inlet borrow sites in CBRA zones for decades. If forced to use offshore borrow sites instead because of the Service's interpretation, these projects would incur greater environmental impacts and costs to the federal government.

CSDR projects not only protect public and private infrastructure, but often have the added benefit of enhancing the environmental condition e.g. turtle and shorebird usage. These projects meet both NEPA and CBRA's goals to "minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers." A CSDR project typically dredges sand from an approved borrow site and deposits that sand within a defined and approved shoreline template imitating a nature based infrastructure system therefore, meeting the exception definition under 16 USC 3505(a)(6)(G) of "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Beaches represent a natural stabilization system and a CSDR is simply a restoration of that natural stabilization system. Furthermore, evidence shows that CSDRs have contributed and benefited "the study, management, protection, and enhancement of fish and wildlife resources and habitats, including acquisition of fish and wildlife habitats and related lands, stabilization projects for fish and wildlife habitats, and recreational projects" as defined in 16 U.S.C. 3505(a)(6)(A).

In our reading the statute, we feel that the current NEPA compliant inlet borrow sites meet the spirit and intent of CBRA. Therefore, we ask for your favorable consideration to allow continued use of these inlet borrow sites as allowed exceptions under CBRA. In light of our reading of the statute, we have a question for the Department of Interior to consider.

1. Does the Department take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

We thank you for your leadership and attention to this matter that is of grave importance to our communities.

Sincerely,

Jeff Van Drew
Member of Congress

David Rouzer
Member of Congress

Garret Graves
Member of Congress

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Richard Burr
United States Senate
Washington, DC 20510

Dear Senator Burr:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Thom Tillis
United States Senate
Washington, DC 20510

Dear Senator Tillis:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Doug Lamborn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Lamborn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Neal Dunn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Dunn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Randy Weber
U.S. House of Representatives
Washington, DC 20515

Dear Representative Weber:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Frank Pallone
U.S. House of Representatives
Washington, DC 20515

Dear Representative Pallone:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

United States Department of the Interior

OFFICE OF THE SOLICITOR
Washington, D.C. 20240

IN REPLY REFER TO:

OCT 30 2019

Memorandum

To: Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Peg Romanik, Associate Solicitor, Division of Parks and Wildlife

Subject: Coastal Barrier Resources Act

Introduction

You have requested our opinion as to whether Section 6(a)(6)(G) of the Coastal Barrier Resources Act ("CBRA" or "Act"), 16 U.S.C. § 3505(a)(6)(G), permits Federal funding for utilizing sand removed from a Coastal Barrier Resources System ("System") unit to renourish beaches located outside the System.

After considering the plain language of the Act, we conclude that the exemption in Section 6(a)(6)(G) is not limited to shoreline stabilization projects occurring within the System. Thus, sand from within a System unit may be used to renourish a beach that is located outside of the System. However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects.

Background

When it enacted the CBRA, Congress found that coastal barriers contain significant cultural and natural resources, including wildlife habitat and spawning areas, and function as natural storm protective buffers. *See* 16 U.S.C. § 3501(a). Congress further found that coastal barriers are generally unsuitable for development. *Id.* § 3501(a)(3). It enacted the CBRA to restrict Federal expenditures that encourage development of coastal barriers, thus minimizing the loss of human life and damage to natural resources within those areas. *Id.* § 3501(b). Section 5(a) of the Act prohibits most new Federal expenditures and financial assistance for activities occurring within the System. *Id.* § 3504(a). Section 6 of the Act sets forth exceptions to the prohibition, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems," if such projects are consistent with the purposes of the Act. *Id.* § 3505(a)(6)(G).

A 1994 legal memorandum from then Assistant Solicitor - Branch of Fish and Wildlife interpreting Section 6(a)(6)(G) concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit, and not to projects to renourish beaches outside the System. The 1994 opinion "interpret[s] section 6(a)(6) to refer to projects designed to renourish solely a beach within the [System unit]." We understand that local communities and members of Congress have recently raised concerns about their inability to receive Federal funds for beach nourishment and have asked the Department to revisit this issue

Discussion

Section 6 of the Act sets forth certain exceptions to the limitations on Federal expenditures within the System. The introductory paragraph of the Section provides that a Federal agency, after consultation with the Secretary, "may make Federal expenditures or financial assistance available within the [System]" for certain enumerated activities. 16 U.S.C. § 3505(a). The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g.*, *Hays v. Sebelius*, 589 F.3d. 1279, 1281 (D.C. Cir. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.") (citation omitted). Thus, the phrase applies solely to where the Federal expenditures or financial assistance may be applied. In this case, that means Federal funds associated with removing sand from a unit within the System.

By contrast, Section 3505(a)(6) does not contain language specifying that excepted actions must occur "within the [System]." That section permits certain "actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act." *Id.* § 3505(a)(6). Among those actions are "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G). The phrase "within the [System]" does not appear either in the introductory language to subsection 6 or in the subpart addressing shoreline stabilization projects. In sum, there is no express limitation on removing sediment from within the System and applying it to areas outside of the System for the purpose of shoreline stabilization.

The statutory language reflects that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Other provisions in Section 3505(a) indicate that Congress envisioned that the excepted activities might occur outside of the System. For example, Section 3505(a)(2) allows for the dredging of existing Federal navigation channels within the System, and the disposal of the dredge materials does not have to occur within the System. The House and Senate Reports specify that the "disposal site need not ... be consistent with the purposes of the Act" as the dredge materials may contain contaminants, and returning the contaminants to the system would not further the purposes of the CBRA.[1] Within Section 3505(a)(6), subparts (A) and (D) are similar in providing an exception for research for barrier resources, including fish and wildlife, which may require the study site to extend beyond the System to be most effective.

Alternatively, to the extent the statutory language could be viewed as ambiguous, our interpretation is reasonable and it furthers the purposes of the Act. There is no indication that Congress intended to conserve coastal barrier resources only within the System. Indeed, in calling for "coordinated action by Federal, State, and local governments," Congress appears to

[1] CBRA Senate Report (May 26, 1982) at 7, and CBRA House Report (September 21, 1982) at 16.

have envisioned the protection of broad swaths of coastal land. *Id.* § 3501(a)(1)(5). Our interpretation of Section 6(a)(6)(G) gives Federal agencies more flexibility to permit or undertake shoreline stabilization projects that will protect coastal resources, even if those resources are located outside of the System. These resources, identified in the CBRA's purpose, are "of significant value to society,"[2] providing over $1 billion in 1980 dollars for commercial fisheries, and high recreational value for people participating in sport fishing and waterfowl and duck hunting.[3]

Our interpretation also allows for projects that indirectly benefit coastal barrier resources within the System. For example, the U.S. Army Corps of Engineers ("Corps"), could use sand from a unit within the System to renourish a beach that is adjacent to that unit, but outside of the System. Stabilizing the adjacent beach could have positive effects on habitat located within the unit. The interpretation of Section 6(a)(6)(G) in the 1994 memorandum would preclude this project despite its beneficial effect on coastal barriers within the System.

Our interpretation does not alter the Service's (nor the action agency's) responsibility to consider on a case-by-case basis whether the proposed project is consistent with the purposes of the Act. *See id.* § 3505(a)(6). For example, the removal of the sand from within the System may not frustrate the "long-term conservation of these fish, wildlife, and other natural resources" associated with coastal barriers. *Id.* §3501(b). Thus, the Service should consider whether the sand could be removed without damage[4] to the natural resources within the System. Likewise, the project should not encourage development of coastal barriers in a manner that could result in "threats to human life, health, and property." *Id.* § 3501(a)(4). In addition, the Service should review whether the proposed project meets the limitations of the exception. That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to "mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G).

Conclusion

We recognize that our interpretation is a change from the conclusion presented in the 1994 legal memorandum. As noted above, however, that memorandum contained no analysis. After reviewing the legislative history and reading the plain language of the Act, we conclude a more reasoned interpretation is that the exception for shoreline stabilization projects is not expressly limited to projects occurring wholly within the System. And, to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act.

---

[2] CBRA House Report (September 21, 1982) at 8.

[3] CBRA Senate Report (May 26, 1982) at 2, CBRA House Report (September 21, 1982) at 8.

[4] We note that "damage" here would have to cause more than insignificant impact to the natural resources. That is, it would have to be damage that would frustrate the purposes of the Act in some meaningful manner.

From: Bohn, Cynthia
To: Niemi, Katie
Cc: BalisLarsen, Martha; Wright, Dana K
Subject: Re: Scanned CBRA doc2
Date: Thursday, November 14, 2019 3:27:53 PM
Importance: High

Thanks, will do, I'll wait to hear from Martha before I send.
c
Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Thu, Nov 14, 2019 at 3:05 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Hi Cindy,
> Dana and I have reviewed your draft email and have the following recommended edits:
>
> - Change "SOL opinion" to "SOL memo"
> - Second bullet, change "The Director has asked that we not release..." to "The SOL has advised that we not release ..."
> - Replace third bullet with "Until we have further guidance from HQ, please do not respond to any CBRA consultations without coordinating with me."
>
> Martha, do you have any further changes?
>
> Thanks Cindy for coordinating with the field.
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071

On Thu, Nov 14, 2019 at 12:18 PM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

> Ladies, I have coordinated with the ARDs and would like to send the following email to the Field Office's. I still need to contact the folks in Texas but they will need a different memo if we do one. Please send to Martha for review as requested. We would like to send to the Field as soon as possible to get input. thanks, c
>
> MEMO to all FO Supervisors and CBRA Staff:
>
> (It you do not work on the Coastal Barrier Resources Act please disregard and excuse this interruption.)
>
> Hello CBRA folks and field supervisors,
>
> Per my discussion with Acting ARD Pam Tochik and Deputy Spencer Simon or Michelle Everson and Deputy Jack Arnold, I wanted to reach out to you to provide an update and ask for your coordination on the Solicitor's opinion on sand mining in a CBRS Unit. (Please see the memo attached and the message from the Director below for background information) The Solicitor's memo reads in its conclusion, "Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act."
>
> In a nutshell, here are the things you may need to know:
>
> - (b) (5) [redacted]
> - [redacted]
> - [redacted]
> - [redacted]
> - [redacted]
> - [redacted]
>
> Thank you all for your attention and patience as we work to provide the best possible guidance for furthering the purposes of CBRA to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other

natural resources associated with coastal barriers,". As always, please feel free to contact me at any time.

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 14, 2019 at 9:46 AM
Subject: Fwd: Scanned CBRA doc2
To: Cynthia Bohn <cynthia_bohn@fws.gov>

Hi Cindy,
Here's what we sent to our FOs.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 7, 2019 at 12:27 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5 ES Field Office Supervisors <fw5_es_field_office_supervisors@fws.gov>
Cc: Spencer Simon <spencer_simon@fws.gov>, Jahn, Kathryn <kathryn_jahn@fws.gov>, Martin Miller <martin_miller@fws.gov>, Diane Lynch <diane_opper@fws.gov>

Hi team,
Please see below and attached, and note we are anticipating additional guidance from HQ. If you have a CBRA action come up before we receive guidance, please coordinate with the RO and HQ.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Wendi Weber** <wendi_weber@fws.gov>
Date: Tue, Nov 5, 2019 at 6:45 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5_Regional_Directorate@fws.gov <FW5_Regional_Directorate@fws.gov>

Please share with your staff as appropriate. Thank you

Sent from my iPhone

Begin forwarded message:

From: "Everson, Margaret" <margaret_e_everson@fws.gov>
Date: November 5, 2019 at 6:42:59 PM EST
To: FWS Directorate & Deputies <fwsdirectanddep@fws.gov>
Cc: Melissa Beaumont <melissa_beaumont@fws.gov>, "Morris, Charisa" <charisa_morris@fws.gov>, "Kodis, Martin" <Martin_Kodis@fws.gov>
Subject: Fwd: Scanned CBRA doc2

FWS Team.
Plese find attached Correspondence regarding the Coastal Barrier Resources Act along with an opinion from the SOL concluding that the exemption within Section 6(a)(6)(G) of the Act is not limited to shoreline stabilization projects occuring within the Coastal Barrier Resources System. And sand from within a System unit may be used to renourish a beach that is located outside the System, provided the project furthers the purposes of the Act.

I am working with Gary Frazer and his team to identify our existing Service guidence that needs to be updated to align with the SOL guidence. Please take the opportunity to understand the Oct 30th memo from SOL and let me know if you have any questions. We will make sure to communicate the updates that we have made to our existing gudience on this issue as they are made. Please make sure to communicate this information to any of your staff members who are working on this issue so our recomendations and opinions are consistent with the SOL memo.

Best
Margaret

--
Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior

U.S. Fish & Wildlife Service
Phone: (413) 253-8610

--

Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

From:	BalisLarsen, Martha
To:	Niemi, Katie
Cc:	Bohn, Cynthia; Wright, Dana K
Subject:	Re: Scanned CBRA doc2
Date:	Thursday, November 14, 2019 4:17:30 PM
Importance:	High

No further changes. Thanks for the opportunity to review.

Martha

Martha Balis-Larsen
Chief, Division of Budget & Technical Support
Ecological Services Program
U.S. Fish and Wildlife Service Headquarters
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
703-358-2171 (general)
703-358-2314 (direct)

On Thu, Nov 14, 2019 at 3:05 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Hi Cindy,
> Dana and I have reviewed your draft email and have the following recommended edits:
>
> - Change "SOL opinion" to "SOL memo"
> - Second bullet, change "The Director has asked that we not release..." to "The SOL has advised that we not release ..."
> - Replace third bullet with "Until we have further guidance from HQ, please do not respond to any CBRA consultations without coordinating with me."
>
> Martha, do you have any further changes?
>
> Thanks Cindy for coordinating with the field.
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071
>
> On Thu, Nov 14, 2019 at 12:18 PM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:
>
>> Ladies, I have coordinated with the ARDs and would like to send the following email to the Field Office's. I still need to contact the folks in Texas but they will need a different memo if we do one. Please send to Martha for review as requested. We would like to send

to the Field as soon as possible to get input.   thanks, c

MEMO to all FO Supervisors and CBRA Staff:

(It you do not work on the Coastal Barrier Resources Act please disregard and excuse this interruption.)

Hello CBRA folks and field supervisors,

Per my discussion with Acting ARD Pam Tochik and Deputy Spencer Simon or Michelle Everson and Deputy Jack Arnold, I wanted to reach out to you to provide an update and ask for your coordination on the Solicitor's opinion on sand mining in a CBRS Unit. (Please see the memo attached and the message from the Director below for background information) The Solicitor's memo reads in its conclusion, "Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act."

In a nutshell, here are the things you may need to know:

- (b) (5) [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Thank you all for your attention and patience as we work to provide the best possible guidance for furthering the purposes of CBRA to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers,". As always, please feel free to contact me at any time.

Cynthia Bohn

Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 14, 2019 at 9:46 AM
Subject: Fwd: Scanned CBRA doc2
To: Cynthia Bohn <cynthia_bohn@fws.gov>

Hi Cindy,
Here's what we sent to our FOs.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 7, 2019 at 12:27 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5 ES Field Office Supervisors <fw5_es_field_office_supervisors@fws.gov>
Cc: Spencer Simon <spencer_simon@fws.gov>, Jahn, Kathryn <kathryn_jahn@fws.gov>, Martin Miller <martin_miller@fws.gov>, Diane Lynch <diane_opper@fws.gov>

Hi team,
Please see below and attached, and note we are anticipating additional guidance from HQ. If you have a CBRA action come up before we receive guidance, please coordinate with the RO and HQ.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Wendi Weber** <wendi_weber@fws.gov>
Date: Tue, Nov 5, 2019 at 6:45 PM

Subject: Fwd: Scanned CBRA doc2
To: FW5_Regional_Directorate@fws.gov <FW5_Regional_Directorate@fws.gov>

Please share with your staff as appropriate. Thank you

Sent from my iPhone

Begin forwarded message:

From: "Everson, Margaret" <margaret_e_everson@fws.gov>
Date: November 5, 2019 at 6:42:59 PM EST
To: FWS Directorate & Deputies <fwsdirectanddep@fws.gov>
Cc: Melissa Beaumont <melissa_beaumont@fws.gov>, "Morris, Charisa" <charisa_morris@fws.gov>, "Kodis, Martin" <Martin_Kodis@fws.gov>
Subject: Fwd: Scanned CBRA doc2

FWS Team.
Plese find attached Correspondence regarding the Coastal Barrier Resources Act along with an opinion from the SOL concluding that the exemption within Section 6(a)(6)(G) of the Act is not limited to shoreline stabilization projects occuring within the Coastal Barrier Resources System. And sand from within a System unit may be used to renourish a beach that is located outside the System, provided the project furthers the purposes of the Act.

I am working with Gary Frazer and his team to identify our existing Service guidence that needs to be updated to align with the SOL guidence. Please take the opportunity to understand the Oct 30th memo from SOL and let me know if you have any questions. We will make sure to communicate the updates that we have made to our existing gudience on this issue as they are made. Please make sure to communicate this information to any of your staff members who are working on this issue so our recomendations and opinions are consistent with the SOL memo.

Best
Margaret

--
Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

--

Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

From:	Bohn, Cynthia
To:	Niemi, Katie; Wright, Dana K
Subject:	Fwd: Scanned CBRA doc2
Date:	Friday, November 15, 2019 11:48:15 AM
Attachments:	CBRA docs2.pdf
Importance:	High

sent to R5...

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Bohn, Cynthia** <cynthia_bohn@fws.gov>
Date: Fri, Nov 15, 2019 at 11:36 AM
Subject: Fwd: Scanned CBRA doc2
To: ES Field Sups <fw5_es_field_office_supervisors@fws.gov>, Sarah Nystrom <sarah_nystrom@fws.gov>, Troy Andersen <troy_andersen@fws.gov>, Carlo Popolizio <carlo_popolizio@fws.gov>, Chris Guy <chris_guy@fws.gov>, Eric Schrading <eric_schrading@fws.gov>, Genevieve LaRouche <genevieve_larouche@fws.gov>, Gregory Breese <gregory_breese@fws.gov>, Kimberly Smith <kimberly_smith@fws.gov>, Maria Tur <maria_tur@fws.gov>, Steve Papa <steve_papa@fws.gov>, Trevor Clark <Trevor_Clark@fws.gov>, Wende Mahaney <wende_mahaney@fws.gov>
Cc: Spencer Simon <spencer_simon@fws.gov>, Pamela Toschik <pamela_toschik@fws.gov>, Kathryn Jahn <kathryn_jahn@fws.gov>, Martin Miller <martin_miller@fws.gov>, Diane Lynch <diane_lynch@fws.gov>, Christine Eustis <christine_eustis@fws.gov>

> (It you do not work on the Coastal Barrier Resources Act please disregard and excuse this interruption.)
>
> Hello CBRA folks and field supervisors,
>
> Per my discussion with Acting ARD Pam Tochik and Deputy Spencer Simon, I wanted to reach out to you to provide an update and ask for your coordination on the Solicitor's memo

on sand mining in a CBRS Unit. (Please see the memo attached and the message from the Director below for background information) The Solicitor's memo reads in its conclusion, "Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act."

In a nutshell, here are the things you may need to know:

- (b) (5) [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Thank you all for your attention and patience as we work to provide the best possible guidance for furthering the purposes of CBRA to "minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers,". As always, please feel free to contact me at any time.

Cindy

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 14, 2019 at 9:46 AM
Subject: Fwd: Scanned CBRA doc2
To: Cynthia Bohn <cynthia_bohn@fws.gov>

Hi Cindy,
Here's what we sent to our FOs.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Toschik, Pamela** <pamela_toschik@fws.gov>
Date: Thu, Nov 7, 2019 at 12:27 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5 ES Field Office Supervisors <fw5_es_field_office_supervisors@fws.gov>
Cc: Spencer Simon <spencer_simon@fws.gov>, Jahn, Kathryn <kathryn_jahn@fws.gov>, Martin Miller <martin_miller@fws.gov>, Diane Lynch <diane_opper@fws.gov>

Hi team,
Please see below and attached, and note we are anticipating additional guidance from HQ. If you have a CBRA action come up before we receive guidance, please coordinate with the RO and HQ.
Best wishes,
Pam

---------- Forwarded message ---------
From: **Wendi Weber** <wendi_weber@fws.gov>
Date: Tue, Nov 5, 2019 at 6:45 PM
Subject: Fwd: Scanned CBRA doc2
To: FW5_Regional_Directorate@fws.gov <FW5_Regional_Directorate@fws.gov>

Please share with your staff as appropriate. Thank you

Sent from my iPhone

Begin forwarded message:

From: "Everson, Margaret" <margaret_e_everson@fws.gov>

Date: November 5, 2019 at 6:42:59 PM EST
To: FWS Directorate & Deputies <fwsdirectanddep@fws.gov>
Cc: Melissa Beaumont <melissa_beaumont@fws.gov>, "Morris, Charisa" <charisa_morris@fws.gov>, "Kodis, Martin" <Martin_Kodis@fws.gov>
Subject: Fwd: Scanned CBRA doc2

FWS Team.
Plese find attached Correspondence regarding the Coastal Barrier Resources Act along with an opinion from the SOL concluding that the exemption within Section 6(a)(6)(G) of the Act is not limited to shoreline stabilization projects occuring within the Coastal Barrier Resources System. And sand from within a System unit may be used to renourish a beach that is located outside the System, provided the project furthers the purposes of the Act.

I am working with Gary Frazer and his team to identify our existing Service guidence that needs to be updated to align with the SOL guidence. Please take the opportunity to understand the Oct 30th memo from SOL and let me know if you have any questions. We will make sure to communicate the updates that we have made to our existing gudience on this issue as they are made. Please make sure to communicate this information to any of your staff members who are working on this issue so our recomendations and opinions are consistent with the SOL memo.

Best
Margaret

--
Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

--
Pamela Toschik (she, her)
Acting Assistant Regional Director - Ecological Services
North Atlantic-Appalachian Region
Dept of the Interior
U.S. Fish & Wildlife Service
Phone: (413) 253-8610

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

Memorandum

To: Rob Wallace, Assistant Secretary for Fish and Wildlife and Parks
Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Secretary

Subject: Coastal Barrier Resources Act

Attached is correspondence regarding the above-referenced statute. Please notify your staffs of our position on this matter going forward, and modify any communications to bring them in compliance with the Department of the Interior's understanding of the language.

Attachment

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

Congress of the United States
Washington, DC 20515

October 25, 2019

The Honorable David Bernhardt
Secretary, U.S. Department of Interior
1849 C St., NW
Washington, DC 20240

Dear Secretary Bernhardt:

We write to you about an interpretation of the Coastal Barrier Resources Act (CBRA) that could jeopardize public and private infrastructure, small businesses and regional economies. The interpretation unnecessarily results in increased ecological impacts as well as increased Federal expenditures. In 2016, the U.S. Fish and Wildlife Service ("Service") issued an interpretation of a 1994 Solicitor's Opinion that has caused several ongoing coastal storm damage reduction (CSDR) projects from moving forward, even though these projects meet all the appropriate requirements of the CBRA and National Environmental Policy Act (NEPA). We believe that correcting the 2016 interpretation and the underlying 1994 Solicitor's Opinion is consistent with our infrastructure focus and small business support while retaining CBRA and NEPA regulatory compliance.

In 1982, the CBRA was enacted into law and established the John H. Chafee Coastal Barrier Resources System (System) to "minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers" in coastal areas along the Atlantic Ocean, Gulf of Mexico, Great Lakes, Puerto Rico, and the Virgin Islands. One objective was to ensure the proper balance of ecological, community and economic considerations on undeveloped coastal barriers. As such, CBRA prohibits new federal financial assistance in System "units" with exceptions outlined in Section 6 of the statute (16 U.S.C. 3505). While the original intent of the law is laudable, the current interpretation has unintended consequences, particularly as they relate to CSDR projects that are partially federally funded, resource management and economic impacts.

In our congressional districts, coastal storm damage reduction projects carried out by the U.S. Army Corps of Engineers (USACE) in partnership with our respective states have been stalled, and their costs have ballooned, because of a 2016 interpretation of a 1994 Department of Interior Solicitor's Opinion (FWS.CW.0380) by the Service that essentially states that sand from a System unit cannot be placed on a non-CBRA shoreline. This decision suddenly prohibited sand recycling from certain System units - despite the Service in 1996 having previously allowed sand recycling from these same System units per CBRA's exceptions.

For example, the congressionally authorized *New Jersey Shore Protection, Townsends Inlet to Cape May Inlet* project had previously accessed System unit NJ-09 as a borrow site multiple times with the consent of the Service. Yet the 2016 Service interpretation suddenly prevented access to the borrow site, despite the environmental benefits of the project, and increased project costs by at least $6.5 million, stalling the required periodic nourishment. As a result of the determination by the Service that sand cannot be beneficially used from CBRA units, specifically NJ-09, to benefit land immediately adjacent to but not located within the CBRA unit, Stone Harbor and North Wildwood are directly impacted to such an extent that they are facing loss of their economic ability to meet the USACE's Project Cooperation Agreement requirements. Moreover, the significant environmental benefits of CSDR projects such as improved wildlife habitat conditions that have occurred over the past several years are being jeopardized directly as a result of the Service's 2016 decision. Likewise, similar challenges exist with the CSDR projects at Carolina Beach and Wrightsville Beach, NC. These projects have used passive-infill inlet borrow sites in CBRA zones for decades. If forced to use offshore borrow sites instead because of the Service's interpretation, these projects would incur greater environmental impacts and costs to the federal government.

CSDR projects not only protect public and private infrastructure, but often have the added benefit of enhancing the environmental condition e.g. turtle and shorebird usage. These projects meet both NEPA and CBRA's goals to "minimize the loss of human life; wasteful expenditure of federal revenues; and the damage to fish, wildlife, and other natural resources associated with coastal barriers." A CSDR project typically dredges sand from an approved borrow site and deposits that sand within a defined and approved shoreline template imitating a nature based infrastructure system therefore, meeting the exception definition under 16 USC 3505(a)(6)(G) of "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Beaches represent a natural stabilization system and a CSDR is simply a restoration of that natural stabilization system. Furthermore, evidence shows that CSDRs have contributed and benefited "the study, management, protection, and enhancement of fish and wildlife resources and habitats, including acquisition of fish and wildlife habitats and related lands, stabilization projects for fish and wildlife habitats, and recreational projects" as defined in 16 U.S.C. 3505(a)(6)(A).

In our reading the statute, we feel that the current NEPA compliant inlet borrow sites meet the spirit and intent of CBRA. Therefore, we ask for your favorable consideration to allow continued use of these inlet borrow sites as allowed exceptions under CBRA. In light of our reading of the statute, we have a question for the Department of Interior to consider.

1. Does the Department take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

We thank you for your leadership and attention to this matter that is of grave importance to our communities.

Sincerely,

Jeff Van Drew
Member of Congress

David Rouzer
Member of Congress

Garret Graves
Member of Congress

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Richard Burr
United States Senate
Washington, DC 20510

Dear Senator Burr:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Thom Tillis
United States Senate
Washington, DC 20510

Dear Senator Tillis:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Doug Lamborn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Lamborn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Neal Dunn
U.S. House of Representatives
Washington, DC 20515

Dear Representative Dunn:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Randy Weber
U.S. House of Representatives
Washington, DC 20515

Dear Representative Weber:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 0 4 2019

The Honorable Frank Pallone
U.S. House of Representatives
Washington, DC 20515

Dear Representative Pallone:

Based on your previous interest in this matter, please find enclosed a letter regarding the Coastal Barrier Resources Act.

Sincerely,

Secretary of the Interior

Enclosure

United States Department of the Interior

OFFICE OF THE SOLICITOR
Washington, D.C. 20240

IN REPLY REFER TO:

OCT 30 2019

Memorandum

To: Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Peg Romanik, Associate Solicitor, Division of Parks and Wildlife

Subject: Coastal Barrier Resources Act

Introduction

You have requested our opinion as to whether Section 6(a)(6)(G) of the Coastal Barrier Resources Act ("CBRA" or "Act"), 16 U.S.C. § 3505(a)(6)(G), permits Federal funding for utilizing sand removed from a Coastal Barrier Resources System ("System") unit to renourish beaches located outside the System.

After considering the plain language of the Act, we conclude that the exemption in Section 6(a)(6)(G) is not limited to shoreline stabilization projects occurring within the System. Thus, sand from within a System unit may be used to renourish a beach that is located outside of the System. However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects.

Background

When it enacted the CBRA, Congress found that coastal barriers contain significant cultural and natural resources, including wildlife habitat and spawning areas, and function as natural storm protective buffers. *See* 16 U.S.C. § 3501(a). Congress further found that coastal barriers are generally unsuitable for development. *Id.* § 3501(a)(3). It enacted the CBRA to restrict Federal expenditures that encourage development of coastal barriers, thus minimizing the loss of human life and damage to natural resources within those areas. *Id.* § 3501(b). Section 5(a) of the Act prohibits most new Federal expenditures and financial assistance for activities occurring within the System. *Id.* § 3504(a). Section 6 of the Act sets forth exceptions to the prohibition, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems," if such projects are consistent with the purposes of the Act. *Id.* § 3505(a)(6)(G).

A 1994 legal memorandum from then Assistant Solicitor - Branch of Fish and Wildlife interpreting Section 6(a)(6)(G) concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit, and not to projects to renourish beaches outside the System. The 1994 opinion "interpret[s] section 6(a)(6) to refer to projects designed to renourish solely a beach within the [System unit]." We understand that local communities and members of Congress have recently raised concerns about their inability to receive Federal funds for beach nourishment and have asked the Department to revisit this issue

Discussion

Section 6 of the Act sets forth certain exceptions to the limitations on Federal expenditures within the System. The introductory paragraph of the Section provides that a Federal agency, after consultation with the Secretary, "may make Federal expenditures or financial assistance available within the [System]" for certain enumerated activities. 16 U.S.C. § 3505(a). The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g.*, *Hays v. Sebelius*, 589 F.3d. 1279, 1281 (D.C. Cir. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.") (citation omitted). Thus, the phrase applies solely to where the Federal expenditures or financial assistance may be applied. In this case, that means Federal funds associated with removing sand from a unit within the System.

By contrast, Section 3505(a)(6) does not contain language specifying that excepted actions must occur "within the [System]." That section permits certain "actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act." *Id.* § 3505(a)(6). Among those actions are "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G). The phrase "within the [System]" does not appear either in the introductory language to subsection 6 or in the subpart addressing shoreline stabilization projects. In sum, there is no express limitation on removing sediment from within the System and applying it to areas outside of the System for the purpose of shoreline stabilization.

The statutory language reflects that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Other provisions in Section 3505(a) indicate that Congress envisioned that the excepted activities might occur outside of the System. For example, Section 3505(a)(2) allows for the dredging of existing Federal navigation channels within the System, and the disposal of the dredge materials does not have to occur within the System. The House and Senate Reports specify that the "disposal site need not ... be consistent with the purposes of the Act" as the dredge materials may contain contaminants, and returning the contaminants to the system would not further the purposes of the CBRA.[1] Within Section 3505(a)(6), subparts (A) and (D) are similar in providing an exception for research for barrier resources, including fish and wildlife, which may require the study site to extend beyond the System to be most effective.

Alternatively, to the extent the statutory language could be viewed as ambiguous, our interpretation is reasonable and it furthers the purposes of the Act. There is no indication that Congress intended to conserve coastal barrier resources only within the System. Indeed, in calling for "coordinated action by Federal, State, and local governments," Congress appears to

[1] CBRA Senate Report (May 26, 1982) at 7, and CBRA House Report (September 21, 1982) at 16.

have envisioned the protection of broad swaths of coastal land. *Id.* § 3501(a)(1)(5). Our interpretation of Section 6(a)(6)(G) gives Federal agencies more flexibility to permit or undertake shoreline stabilization projects that will protect coastal resources, even if those resources are located outside of the System. These resources, identified in the CBRA's purpose, are "of significant value to society,"[2] providing over $1 billion in 1980 dollars for commercial fisheries, and high recreational value for people participating in sport fishing and waterfowl and duck hunting.[3]

Our interpretation also allows for projects that indirectly benefit coastal barrier resources within the System. For example, the U.S. Army Corps of Engineers ("Corps"), could use sand from a unit within the System to renourish a beach that is adjacent to that unit, but outside of the System. Stabilizing the adjacent beach could have positive effects on habitat located within the unit. The interpretation of Section 6(a)(6)(G) in the 1994 memorandum would preclude this project despite its beneficial effect on coastal barriers within the System.

Our interpretation does not alter the Service's (nor the action agency's) responsibility to consider on a case-by-case basis whether the proposed project is consistent with the purposes of the Act. *See id.* § 3505(a)(6). For example, the removal of the sand from within the System may not frustrate the "long-term conservation of these fish, wildlife, and other natural resources" associated with coastal barriers. *Id.* §3501(b). Thus, the Service should consider whether the sand could be removed without damage[4] to the natural resources within the System. Likewise, the project should not encourage development of coastal barriers in a manner that could result in "threats to human life, health, and property." *Id.* § 3501(a)(4). In addition, the Service should review whether the proposed project meets the limitations of the exception. That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to "mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G).

Conclusion

We recognize that our interpretation is a change from the conclusion presented in the 1994 legal memorandum. As noted above, however, that memorandum contained no analysis. After reviewing the legislative history and reading the plain language of the Act, we conclude a more reasoned interpretation is that the exception for shoreline stabilization projects is not expressly limited to projects occurring wholly within the System. And, to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act.

---

[2] CBRA House Report (September 21, 1982) at 8.
[3] CBRA Senate Report (May 26, 1982) at 2, CBRA House Report (September 21, 1982) at 8.
[4] We note that "damage" here would have to cause more than insignificant impact to the natural resources. That is, it would have to be damage that would frustrate the purposes of the Act in some meaningful manner.

From: Niemi, Katie
To: BalisLarsen, Martha
Cc: Phinney, Jonathan T; Shaughnessy, Michelle; Wright, Dana K
Subject: coastal geologist to support CBRA Program
Date: Monday, November 18, 2019 2:55:11 PM
Attachments: Guilfoyle et al 2019 Developing BMPs Coastal Engineering USACE Tech Note.pdf
mining_winter04.zip

Martha,

b5-DPP

[redacted]

Katie

---------- Forwarded message ---------
From: **Wright, Dana** <dana_wright@fws.gov>
Date: Fri, Nov 15, 2019 at 10:37 AM
Subject: Fwd: [EXTERNAL] Coastal Engineering References
To: Cynthia Bohn <cynthia_bohn@fws.gov>, Katie Niemi <Katie_Niemi@fws.gov>

Katie and Cindy,

I had a good chat with Tracy this morning - she pointed me in the direction of the attached technical paper from USACE (Guilfoyle et al), which looks very promising. Please take a look

Thanks,

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)

703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Tracy Rice** <tracymrice@yahoo.com>
Date: Fri, Nov 15, 2019 at 9:59 AM
Subject: [EXTERNAL] Coastal Engineering References
To: Dana Wright <dana_wright@fws.gov>

Dana -

Attached is the Technical Note from the Corps regarding coastal engineering BMPs, which you should find useful.

While looking for those old BOEM (MMS) studies, I found in my literature files that the Journal of Coastal Research (JCR) did a special issue back in 2004 on offshore sand mining impacts that I'd forgotten about. I zipped all those papers into a folder for you to give you some of the scientific research regarding borrow areas offshore.

I'll attach the MMS / BOEM studies to a separate email for ease of attachment size limitations.

It was great talking with you this morning, and please don't hesitate to contact me if you have any additional questions in the future -

Tracy

p.s. If you want to look up specific papers referenced in the Corps TN or any of my reports, and can't find them readily, let me know and I'll see if I have electronic copies in my files that I can send to you. I should have digital copies of just about anything I reference in a report. Anne Hecht in the Hadley regional office, and Wendy Walsh in the New Jersey FO, also have significant digital libraries of recent scientific studies related to coastal ecosystems. And Melissa Bimbi in Charleston ES and Kathy Matthews in Raleigh ES should have the latest unpublished monitoring results / studies going on in the Carolinas, where much of the best research is going on nowadays, at least the monitoring not directly tied to listed sea turtles.

ERDC/TN-EMRRP-SI-38
June 2019

Developing Best Management Practices for Coastal Engineering Projects that Benefit Atlantic Coast Shoreline-dependent Species

by Michael P. Guilfoyle, Jacob F. Jung, Richard A. Fischer and Dena D. Dickerson

PURPOSE: This Technical Note (TN) was developed by the U.S. Army Engineer Research and Development Center-Environmental Laboratory (ERDC-EL), to summarize known impacts on seasonal habitats used by migratory shoreline-dependent birds (primarily shorebirds and seabirds) and nesting sea turtles along the Atlantic Coast by U.S. Army Corps of Engineers (USACE) coastal engineering activities. The USACE is responsible for maintaining coastal infrastructure including ports, harbors, shoreline stabilization, and maintenance of the Intracoastal Waterway System (ICWW) along the Atlantic Coast. This infrastructure is essential to the long-term sustainability of national and economic prosperity by ensuring navigation through ports and harbors that transport goods necessary for national and international commerce. Coastal shoreline stabilization and sediment management can also provide opportunities for reductions in storm surge, flood control, residential growth, recreational activities, coastal habitat restoration, and fisheries management. Routine engineering actions by the USACE includes maintenance dredging and dredged material deposition, beach nourishment, inlet realignment and shoreline stabilization, and dike, sea wall, terminal groin and revetment construction. These actions can alter the shape, structure and function of coastal habitats, and have the potential for both positive and negative seasonal effects on shoreline-dependent organisms. The objectives of this technical note include the following: (1) introducing issues concerning coastal engineering impacts on shoreline-dependent birds and sea turtles, (2) providing suggestions on specific management approaches that can be used to minimize these impacts, and (3) developing insights for future research and monitoring that should be undertaken to ensure that management actions are having the desired effect on target populations.

BACKGROUND: The U.S. Atlantic coast supports more than 35 shorebird species and an additional 13 tern and skimmer species (Sibley 2016). Five species of sea turtles are known to nest on beaches along the U.S. Atlantic or Gulf Coasts. Many North American birds and sea turtles are highly dependent upon coastal, sediment-based habitats, including beaches, inlets, marshes, bays, and estuaries. Maintenance and enhancement of navigation infrastructure often requires large expenditures in equipment, and the design and implementation of engineering projects to build, maintain, or enhance existing coastal infrastructure. Harbors, ports, approach channels, and the ICWW require sufficient depths to permit navigation of large oceanic cargo vessels used for the transport of goods to desired destinations. Subsequently, maintenance dredging moves hundreds of millions of cubic yards of sediment each year. Strategic placement of dredged material can be used to restore eroded beaches (Figure 1), restore wetland or mudflat habitats, be deposited on off-shore islands, or be deposited at sea. Such beneficial use of dredged material is an essential element in the USACE Regional Sediment Management (RSM) (*http://rsm.usace.army.mil/*) and Engineering With Nature® (EWN) *(https://ewn.el.erdc.dren.mil/*) programs. A small proportion of dredged material, mostly from urban and industrial regions, may be sufficiently contaminated to require deposition in a confined disposal facility (CDF) or other disposal mechanism to reduce environmental and human exposure.

Figure 1. Coastal engineering operations may alter seasonal habitats for shoreline-dependent birds and nesting sea turtles by disturbing habitats during critical nesting, migratory or wintering periods, altering the size and shape of available habitats, and burying or reducing benthic organisms used as prey. (Photo Credit: Walker Golder, National Audubon Society, NC Field Office).

Other engineering projects entail stabilization efforts to minimize erosional processes that endanger human residential and commercial areas. Stabilization, coastal armoring, and sediment management structures include sea walls, jetties, dykes, revetments, and terminal groins. These structures are designed to minimize damage from erosion and storm surge during hurricanes and major storms. These engineered structures can modify ocean current and wave action, and also reduce the meandering nature of estuarine, inlet, and coastal currents and may direct sediment disposition away from navigation channels. The combination of deep navigation channels and stabilization structures can erode existing coastal habitats, and reduce or eliminate formation of natural sand spits, beaches, wetlands, marshes, inlets, and islands that are used by shoreline-dependent birds and nesting sea turtles. Inlets are important seasonally for foraging shorebirds, particularly during migration, but these features are often the first areas to receive sediment deposition as a means of shoreline stabilization, or are areas where sediments are mined for other coastal projects (Harrington 2008). Deposition of dredged material can temporarily lower site quality for invertebrate populations important in the diets of many migratory shorebirds. The growing human populations along the coast, plus sea level rise and storm intensity due to climate instability, increases the need, rate, and extent of coastal engineering and shoreline stabilization activities, and hastens the potential for large-scale degradation of coastal habitats for shoreline-dependent organisms.

Many shoreline-dependent species along the Atlantic Coast are experiencing significant population declines. While conservation efforts to protect and enhance rare or endangered sea turtles along the Atlantic Coast are having a positive impact (Mazaris et al. 2017), beach nourishment and residential growth along coastal areas continue to negatively impact nesting sea turtles (Dickerson et al. 2006). In addition, some Atlantic Coast shorebird populations have declined by 70% or more. The rapid decline of the *rufa* subspecies of Red Knot (*Calidris canutus rufa*) resulted in the listing of this species in 2014 by the U.S. Fish and Wildlife Service as threatened under the Endangered Species Act (ESA) (Figure 2). Further declines in other sensitive shorebird and seabird populations could result in the future listing of the Semipalmated Sandpiper (*Calidris pusilla*), Whimbrel (*Numenius phaeopus*), Atlantic Coast population of Least Tern (*Sternula antillarum*), and Greater Yellowlegs (*Tringa melanoleuca*), among other species. Additional coastal species that become listed for ESA protection could compromise ongoing efforts by USACE to meet mission objectives to maintain or enhance coastal structures and navigation capacity. A proactive approach to coastal engineering and sediment management along the Atlantic Coast is needed to provide and protect important habitat that will promote sustainable populations for imperiled shoreline-dependent species.

Figure 2. The *rufa* Red Knot (*Calidris canutus rufa*) was listed as threatened under the ESA in 2014. This is a migratory species dependent upon high-quality enroute stopover habitat along the Atlantic Coast (Photo Credit: Walker Golder, National Audubon Society, NC Field Office).

INCOMPATIBLE COASTAL ENGINEERING ACTIVITIES: To promote effective strategies for managing coastal sediments and habitats for shoreline-dependent species, it is necessary to identify the primary coastal engineering actions that may negatively impact these species. Table 1 provides a list of common coastal engineering actions that likely have the most negative impacts on these species during some time of the year, but note that coastal engineering and conservation of habitats for shoreline-dependent species are not always incompatible, and the USACE is invested to integrating these two needs (Fischer et al. 2004, 2010; Guilfoyle et al. 2006, 2007). While negative impacts on sea turtles focus on nesting habitat and nest success, impacts on birds are more complicated. First, many migratory bird species do not breed or winter along the Atlantic Coast, but do require sufficient amount and quality of stopover habitat during spring and fall migration. Long distance migration is an essential feature of the life history of many of these birds. Many of these species breed in the Arctic regions of Canada and Alaska, and spend the winter in the Caribbean, Mexico, and Central and/or South America. Migration is a period of high mortality for these birds, especially for hatch-year individuals, and population demographics and sustainability require that sufficient high quality stopover areas be available (Newton 2004; Kirby et al. 2008). Without sufficient stopover habitat, the high energetic requirements for a successful migration may not be met, leading to an increase in mortality rates and population declines. Some of these migratory species winter along the Atlantic and Gulf Coasts, and their coastal wintering habitats also can be degraded by coastal engineering activities and expanding residential areas that reduce habitat and increase human disturbance (e.g., cats, dogs, pedestrians). While assessment of habitats for breeding birds can be determined by the numbers of nesting pairs and overall nesting success (e.g., number of fledged young per nest), the assessment of wintering and migratory habitats is more difficult. Efforts to create non-breeding habitat may require some unpredictable time before birds locate and start using the habitat regularly. Also, while data on the abundance of shorebirds using migratory and wintering habitat is important, overall survival and physiological condition of birds using these habitats (Gibson et al. 2018) may provide better information on the quality of the habitat and its overall capacity to support and enhance non-breeding populations.

Table 1. Coastal engineering actions that potentially degrade, reduce or eliminate habitat for shoreline-dependent birds and nesting sea turtles.

Engineering Action	Potential Impacts on Shorebirds	Impacts on Nesting Sea Turtles	Consequences of Impacts
Beach Nourishment	Covers existing intertidal zone prey base; degrades or reduces value of site for foraging shorebirds during all seasons. (Properly engineered beaches can enhance nesting and foraging habitats).	May reduce nesting by sea turtles if incompatible sediment sources are used, and/or if slope and beach topography are no longer suitable for nesting.	Primarily affects shorebirds by degrading foraging value of beach, impacting reproductive success and survival during non-breeding seasons; initially lowers nesting attempts and overall success for sea turtles. Nourished areas may require several seasons to recover.

Inlet Relocation	Moving or altering shoreline habitat may reduce size or quality of shorebird foraging habitat during all seasons.	May move or alter beach habitat; shifting beach location or altering shape/ structure of beach may reduce nesting.	Degrading quality of foraging habitat may negatively affect survival and reproductive success for shoreline-dependent species; lowers reproductive success of nesting sea turtles.
Sea Wall, Riprap and other Hard Structure Constructions to Stabilize Shorelines	Immediately removes potential foraging sites for all shoreline-dependent birds; may disrupt natural deposition patterns, inhibiting formation of dunes, sand spits, inlets and other coastal habitats	May immediately alter areas previously used for nesting.	Removes potential foraging habitat for birds and nesting habitat for sea turtles; disruption of natural sediment deposition patterns may reduce or eliminate natural formation of habitats used by shoreline-dependent species

BEST MANAGEMENT PRACTICES FOR COASTAL ENGINEERING PROJECTS: The USACE needs improved approaches to offset potential negative impacts of coastal engineering and shoreline stabilization actions and that will create better conditions for shoreline-dependent birds, sea turtles, and other sensitive or rare flora and fauna. Such approaches, referred to as Best Management Practices (BMPs) (Rice 2009), need to be developed, tested and verified locally, and then implemented widely to provide guidelines that will help avoid, minimize, or mitigate negative impacts, or enhance positive impacts of coastal engineering projects along the Atlantic Coast. These BMPs should then be incorporated into the USACE planning, design, and construction stages of all coastal engineering projects. Pre- and post-project monitoring will be necessary to assess whether specific BMPs are benefiting targeted species as designed. BMPs also will likely need to be developed to address coastal engineering actions impacting specific coastal habitats including beaches, inlets, nearshore and offshore sites, barrier islands, dunes, estuaries, marshes, and mudflats. In addition, BMPs will need to be cost-effective to meet USACE mission objectives for coastal engineering projects. Increased engineering costs should not be more that 10 or 15 percent of baseline project expenditures. Therefore, it should be understood that BMPs implemented during a single project, by itself, may not provide great benefits to seasonal shoreline-dependent species. It is hoped that cumulative benefits of BMPs will be observable as a variety of BMPs are adopted and implemented in project after project, year-after-year, along the entire Atlantic Coast and other coastal regions in the U.S.

Atlantic Coast BMPs. BMPs have been developed for coastal stabilization efforts along the Atlantic Coast (Rice 2009). These BMPs have been adopted by the U.S. Fish and Wildlife Service (USFWS) for efforts to protect breeding Piping Plovers (*Charadrius melodus*), and will likely play a role in any Biological Opinions (BiOps) that concern the management or conservation of this species. These BMPs represent a first attempt to provide avoidance, minimization, and mitigation measures for the impacts of coastal stabilization on a breeding shorebird along the Atlantic Coast, but will need to be expanded to include other shoreline-dependent species including impacts during the non-breeding seasons (Figure 3). However, these BMPs were not developed specifically for USACE coastal engineering projects, and therefore, these approaches will probably require significant modifications to be practical for most engineering actions without compromising mission objectives along the Atlantic Coast. Moreover, these BMPs have not yet received rigorous testing and assessment. Application of BMPs developed for conditions along the Atlantic Coast may not be applicable along the Pacific or Gulf Coasts. Table 2 outlines the BMPs from Rice (2009) and how they could be applied more widely to benefit shoreline-dependent species.

Figure 3. Mixed flocks of migratory shorebirds require sufficient foraging habitats along the Atlantic Coast including beaches, inlets, bayside shores, sand spits and mudflats (Photo Credit: J. Stevan Calver).

Table 2. Recommended BMPs to implement during coastal stabilization projects to benefit shoreline-dependent species (modified from Rice 2009).

Habitat Type	Proposed BMP/Action	Desired Impacts for Shorebirds/Turtles
Dunes	Create new dunes using native vegetation; avoid use of heavy equipment.	Builds natural dunes over time; reduces impact from heavy equipment; lower disturbance to seasonal birds; embryonic dunes and overwash fans may provide some habitat for seasonal coastal birds.
	Use sand fences in developed areas and small scale projects; intermittent placement to promote passage for sea turtles and shorebird chicks; do not leave fence material on beach.	Reduces impact from heavy equipment; provides habitat in developed areas.
	Identify dune restoration goals by geomorphological survey of adjacent natural or undisturbed areas to target features for replication.	Promote creation of habitat to mimic natural habitats lost or degraded.
Beaches	Avoid all use of hard structures (e.g., sea walls, revetments, riprap), except in highly urbanized areas.	Avoid use to protect remaining habitats; provide opportunities for restoration.
	Match sediment grain sizes to life-history needs of species; avoid sediment of different grain size, composition or structure; test areas of beach and filled areas to ensure compatibility.	Promotes integrity of restored beach for nesting seabirds, shorebirds, and sea turtles; promotes re-colonization of area by native benthic organisms.
	Replicate, as much as possible, the natural beach profile including bar and trough morphology.	Promotes integrity of restored beach for nesting turtles and seasonal shoreline-dependent birds.
	Beach fill should be kept at thinnest depth possible ($\leq$30 cm), especially in intertidal zones.	Promotes integrity of restored beach for nesting turtles and seasonal shorebirds; promotes re-colonization of intertidal areas by native benthic species.
	Fill should be placed in non-continuous sections ($\leq$600 m) of the beach in important areas for birds and turtles; subsequent renourishment can alternate sections that receive fill.	Mimics natural structure of the original beach; promotes integrity of beach for sea turtles and shorebirds; promotes re-colonization of filled areas by adjacent benthic organisms; leaves undisturbed refugia for fish and wildlife resources.
	Identify sensitive or essential habitats and maintain buffers (100–200 m) around sea turtle nesting sites, nesting waterbird colonies, and foraging/roosting sites for other shoreline-dependent birds; create 10 m buffers around sensitive plants.	Protects breeding/foraging/roosting areas from disturbances; maintains habitat for birds and nesting sea turtles.
Nearshore	Identify and maintain buffers ($\leq$ 500 m) around all reef, hardbottoms, submerged aquatic vegetation and habitat areas of concern.	Promotes integrity of habitat for fish community, seabirds, shorebirds, and sea turtles.
	Work to ensure sediment compatibility.	Promotes integrity of habitat for benthic organisms important to foraging birds.

	Avoid use of heavy equipment; do not use nearshore sandbars as sand sources for beach nourishment projects.	Promotes integrity of habitat for wildlife; protects/lowers wave energy; reduces need for future shoreline stabilization.
Offshore	Protect and buffer all reefs and hardbottom habitats; locate areas mined for sediment away from all sensitive habitats.	Promotes integrity of habitat for fish and wildlife.
	Mining efforts should not significantly alter bathymetry; use shallow/staggered digs; retain significant layer of sediment that matches original surface.	Promotes integrity of habitat for fish and wildlife; retains areas as refugia and source for recolonization of benthic organisms.
Inlets	Minimize disturbance to inlet habitats; do not dredge inlets for sediments or stabilize using hard structures.	Promotes integrity of habitat for seasonal wildlife.
	In existing navigation channels, dredged material can be relocated within inlet systems; minimize disturbance with infrequent large scale maintenance; use small scale impacts as practical.	Placement of sediment can downdrift to beaches during wave and tidal processes; replicates sediment processes to maintain habitats below inlet; promotes integrity of habitats for shorebirds and nesting turtles.
	Prevent off-road vehicles on inlet resources.	Promotes integrity of habitats for shorebirds and nesting sea turtles.
Estuarine	Do not use sediments in estuaries as source for stabilization projects; keep all dredged material in local area.	Protects foraging habitats for shoreline-dependent birds and protects benthic and fish communities.
	Do not bury marshes, benthic communities, oyster reefs, clam beds, or other valuable benthic and fish habitats.	Protects foraging habitat for shoreline-dependent birds; protects sensitive habitats for benthic and fish communities.
	Maintain overwash material, fans and flats.	Promotes integrity of habitat for seasonal wildlife; protects potential nesting habitat for turtles.
	Do not use hard structures along estuarine shorelines.	Protects shoreline habitats for foraging birds and potential nesting habitat for turtles.
	Finger canals and sand spits should not be dredged in estuarine and bayside habitats.	Protect foraging, roosting and loafing habitat for shoreline dependent birds; protects potential nesting habitat for turtles; protects habitat for benthic and fish communities.

Pacific Coast BMPs. The USACE Los Angeles District led the development of BMPs for the threatened Western Snowy Plover (*Charadrius alexandrines nivosus*) along the California Coast. These BMPs were designed to avoid and minimize impacts of maintenance dredging and deposition activities largely on non-breeding Western Snowy Plovers (Ryan and Hamilton 2009; Merkel and Associates 2017). BMPs were developed for maintenance dredging and beach nourishment operations at Oceanside Harbor, CA (Merkel and Associates 2017) and were implemented prior to project initiation and before any movement of construction equipment or creation of debris. These BMPs were developed for conditions along the Pacific Coast and may not be applicable for conditions along the Atlantic or Gulf Coasts. Key elements of the BMPs to protect Western Snowy Plovers included the following (from Merkel and Associates 2017):

1. Project site will be monitored daily for presence of plovers and other protected shorebirds. Monitors will inform when birds are in the work area; efforts will be made to avoid disturbance and work will not continue until birds are out of work area.
2. If an active nest is discovered, no work will occur in area until young have fledged and are independent from adults.
3. Vehicles and equipment will be limited to the installation, maintenance, and removal of discharge pipeline and facilities, and trips to monitor beach discharge operations.
4. During all dredged pipeline activities (including mobilization, moving, maintenance, and demobilization), biological monitors will survey area for plovers and other protected birds prior to contractor entry and remain on site during all activities.
5. Beach re-contouring during dredge pipeline use or demobilization is limited to footprint of 50 ft wide corridor. No beach combing after pipeline demobilization is permitted.
6. During activities, number of vehicle trips shall be minimized to extent possible.
7. Vehicle use on approved beach areas is limited to activities associated with dredging operations; no recreational use by the contractor is authorized.
8. The biological monitor shall contact local law enforcement if public or dogs are observed in the exclusion area.

Efforts to minimize disturbance of Western Snowy Plovers focus on reducing or eliminating the flushing of roosting or foraging birds. During dredging and deposition, few or no disturbances were noted, but birds often were disturbed by local residents, unleashed dogs, and activities of other local county employees (Ryan and Hamilton 2009). While these efforts should successfully minimize impacts on birds during dredging and nourishment operations, the USACE should work in closer collaboration with local authorities and municipalities to ensure enforcement of restrictions on public access to areas utilized by sensitive birds and other shoreline-dependent species. In addition, more research may be needed to ensure that efforts provide population sustainability for non-breeding populations comparable to non-impacted areas.

Gulf Coast BMPs. Specific recommendations to protect shorebirds, particularly Piping Plovers, and other shoreline-dependent species, were developed by the USFWS and included in BiOps related to efforts along the Florida Gulf Coast along the Pensacola and Panama City Beaches (USFWS 2014). These recommendations may be formulated as BMPs; however, these BMPs may not be applicable along the Pacific or Atlantic coasts. Examples of specific recommendations include the following:

1. Avoid removing wrack line material from relatively undeveloped portions of the beach.
2. Identify and protect all areas designated as Piping Plover Optimal Habitats.
3. Protection of geomorphologic processes that lead to habitat renewal, including sand placement in areas that will not impede washover areas and avoid filling ephemeral pools.
4. Prior to disposition of dredged material, qualified personnel will mark all areas to be avoided using obvious identifiers.
5. Conduct bi-monthly surveys for Piping Plovers in the inlet area including shoals, bayside flats, bayside and ocean beaches using USFWS guidelines.
6. Post-construction bird surveys shall occur twice per month and annual spatial measurements of optimal habitat is to occur six months after sand placement; surveys shall continue for no less than five years.

7. Minimize all beach driving activities for law enforcement, beach patrol and beach vendors.
8. Post and rope off designated Piping Plover roosting and foraging areas.
9. Place educational signs where appropriate.
10. Prohibit planting of vegetation in Optimal Piping Plover habitat.
11. Within 400 m of project site, install predator-proof trash receptacles.
12. Minimize occurrence of dredging in adjacent inlets unless for emergency purposes.

BMPs for shoreline-dependent species have not yet been developed for other coastal habitats, including barrier islands, estuaries, salt marshes or mud flats. Coastal engineering projects that adopt approaches to create, protect or enhance these habitats will need pre- and post-project monitoring to test and evaluate successes and failures such that these respective approaches can be modified and optimized overtime. This approach will be consistent with adaptive management policies practiced by USACE Districts. In addition, efforts within the USACE Dredging Operations Environmental Research (DOER) and EWN programs have developed natural and nature-based designs along coastal shorelines to promote coastal resilience (Bridges et al. 2015). Natural and nature-based features (*https://ewn.el.erdc.dren.mil/nnbf.html#*) seek to use coastal engineering approaches that mimic natural systems on shorelines, barrier islands, dune systems, and other coastal habitats to provide natural stabilization protection from storm surge and sea-level rise. Several of the approaches described by Bridges et al. (2015) target habitat along coastal shorelines to benefit threatened and endangered species (TES). These approaches could be formulated as BMPs to be developed for seasonal shoreline-dependent species, tested and assessed, and then made available for USACE Districts along the Atlantic, Gulf and Pacific Coasts to use during engineering project planning, design, construction, and maintenance activities. For example, while Rice (2009) strongly recommends the exclusion of hard structures along the Atlantic Coast for shoreline stabilization, particularly in inlets, natural and nature-based substitutions for hard structures may be able to provide habitat for some species (Bridges et al. 2015).

BENEFICIAL USES OF DREDGED MATERIAL: The USACE has a long history of utilizing dredged material to benefit coastal and riverine bird communities (Fischer et al. 2004, 2010; Guilfoyle et al. 2006, 2007). Designing and implementing projects that use dredged material for environmental benefits can enhance coastal resilience and provide opportunities to create habitats for many coastal species (U.S. Environmental Protection Agency (EPA) 2007). Dredged material (e.g., from maintenance dredging) has been used to create over 2,000 small islands along the Atlantic Coast. Many shorebirds now depend on these islands for breeding, with some islands supporting large proportions of the local, regional and global populations (Fischer et al. 2004, 2010; Guilfoyle et al. 2006, 2007). Extensive research on the seasonal use and distribution of birds nesting on these islands was conducted in the latter decades of the 20th century by the USACE Dredged Material Research Program (DMRP) (Soots and Landin 1978). Examples of islands created with dredged material that provide important habitats for many coastal bird species today, include Queen Bess Island, LA, and Gaillard Island, AL. These islands, and others, are well documented to support critical nesting habitat for many imperiled coastal birds, including Gull-billed Terns (*Gelochelidon nilotica*), Least Tern, American Oystercatcher (*Haematopus palliatus*) and Brown Pelican (*Pelecanus occidentalis*) (Soots and Landin 1978; Fischer et al. 2004, 2010; Guilfoyle et al. 2006, 2007). These islands likely provide important habitat for a wide variety of migratory and wintering birds, but data on bird communities during the non-breeding seasons generally are poor or not available. Specific aspects of coastal islands, including sediment characteristics, size, extent, shape, and topography (Golder et al. 2008) are likely to influence the frequency of use by shoreline-dependent birds. Also, plant succession on these islands can reduce, degrade, or eliminate habitat for many breeding coastal birds. Vegetation management via herbicide or mechanical removal, or by re-application of dredged material on these islands, may serve to maintain habitat for some birds, but management actions are typically irregular or non-existent for many coastal islands. In addition, many islands are subjected to erosion from sea-level rise and riverine levee systems that reduce the flow of sediments into coastal bays and estuaries. The current status and habitat value of many of these islands for birds needs to be investigated further.

Beach nourishment activities by the USACE typically provide dredged material for highly eroded beaches, either in high recreational use areas, or sites in need of additional shoreline protection after storms. Beach nourishment can also be used to rebuild beaches for a variety of shoreline-dependent birds and sea turtles (Dickerson et al. 2006) (Figure 4), and BMPs can be developed and standardized for projects to benefit these species (Table 2). These BMPs should address the physical (e.g., applying appropriate sediments that closely approximate the size, topography, structure and composition of sediments of the local beach system) (Dickerson et al. 2006), spatial (size and extent of projects), and temporal considerations (e.g., avoid actions during critical nesting, migrating or wintering seasons for shorebirds and recruitment periods for infaunal benthic communities) (Rosov et al. 2016).

RESEARCH AND MONITORING NEEDS: More research is needed to develop and test BMPs that will be effective in supporting shoreline-dependent species throughout their annual life cycle. Specific features for creating successful nesting habitat for sea turtles are better understood (Dickerson et al. 2006) than for seasonal shorebirds, but BMPs need to be standardized and implemented widely in USACE coastal engineering projects to promote demonstrable benefits to shoreline dependent populations. The development and testing of BMPs need to begin in pre-project planning and monitoring, and continue after the engineering action has been completed. Habitat needs for many migratory and wintering shorebirds and seabirds are poorly understood; however, Piping Plovers associated with disturbance in coastal habitats, including coastal habitat modifications, have been shown to have lower survival and be in poorer physiological condition during the non-breeding season (Gibson et al. 2018). Assessing short-term benefits of BMPs to non-breeding shoreline-dependent birds will be difficult and results may be unclear initially. Migratory shorebirds often follow weather frontal systems and may bypass quality stopover areas to benefit from conditions that promote timely arrival on breeding or wintering grounds. Size, shape and position of quality stopover habitat in the landscape may also impact use by migratory shorebirds (Gillespie et al. 2017). Juvenile and hatch-year birds typically experience higher mortality than adults, but significant changes to coastal habitats may negatively impact older, more experienced birds as well. For example, the *rufa* Red Knot, which was listed as federally Threatened under ESA in 2014, is known to focus its diet on eggs of horseshoe crabs (*Limulus polyphemus*) during spring migration in the Delaware Bay and elsewhere along the Atlantic Coast. Overharvesting of horseshoe crabs has reduced migratory *rufa* Red Knot populations by over 70%, with significant mortality among adults (Niles et al. 2009). Poor stopover habitat may incur adult mortality enroute during migration, or it may lead to poor reproductive success upon arrival to the breeding grounds or lower survival upon arrival on the wintering grounds. While numerous states have enacted stricter harvest regulations for horseshoe crabs (Niles et al., 2009), higher egg abundance and documented increases in *rufa* Red Knot migratory populations have not materialized. However, horseshoe crabs require nearly ten years to reach sexual maturity, so it could take many years before populations are restored. In the meantime, populations of *rufa* Red Knots and other migratory shorebirds that rely on this food resource remain vulnerable. While efforts to create high-quality stopover habitat may take years to be established, once the sites are adopted by shorebirds, they will likely be used regularly.

Figure 4. Beach nourishment has the potential to create suitable nesting habitat for sea turtles if the correct sediment sources is used, and if the shape, contour, and access to the beach matches the natural topography (Dickerson et al. 2006) (Photo Credit: Public Domain image, U.S. Geological Survey, *https://www.usgs.gov/media/images/loggerhead-hatchling-makes-its-way-sea*).

A key element of BMPs for shoreline-dependent birds is the protection or restoration of the intertidal benthic organisms upon which these birds feed. Following beach nourishment, several seasons may be necessary for restoration of the benthic community under some conditions (Rakocinsiki et al. 1996; Burlas et al. 2001; Colosio et al. 2007; Rosov et al. 2016; Wooldridge et al. 2016). Often, the impacts of beach nourishment on the benthic community is difficult to discern, since most permitting and monitoring requirements lack scientific rigor in the final reports (Peterson and Bishop 2005). However, monitoring efforts on benthic communities have documented recovery of the community in one year or less when proper sediment is used and when timing of the nourishment operation does not conflict with peak larval recruitment or natural seasonal infaunal declines (Rosov et al. 2016; Wooldridge et al. 2016). Moreover, monitoring of bird communities has shown that if coastal engineering projects can create a diverse mix of breeding, foraging, and loafing habitat, particularly moist substrate habitats in bay-side intertidal areas with ephemeral pools, moist overwash zones, and mudflats, then long-term negative impacts may be minimized (Guilfoyle et al. 2006, 2007).

Coastal engineering impacts on birds will need to be assessed by a before-after control-impact (BACI) design where pre- and post-project monitoring of species richness and abundance metrics are undertaken. The goals of implementing BMPs should be to reduce the difference in these metrics between impacted and control sites. Quantifying foraging behavior, including number of prey consumed per unit time (Van Gils et al. 2006), may also convey information on the success of BMPs to successfully create high quality foraging habitat. Assessing physiological condition and application of an Integrated Population Modeling (IPM) approach can provide information on shorebird survival during the non-breeding season (Gibson et al. 2018). These efforts should focus on documenting the success of BMP implementation to create and enhance coastal habitats for breeding and nonbreeding shoreline-dependent birds and nesting sea turtles. Successful monitoring efforts can also act to promote adaptive management responses to alter BMPs as necessary to meet goals to improve conditions for target populations.

ESA SECTION 7(a)(1) CONSERVATION PLANNING: The USACE is working on new approaches to address the conservation and recovery of Federally listed species that impact mission areas. The ERDC-EL Threatened and Endangered Species Team (TEST) is investigating the use of Endangered Species Act Section 7(a)(1) conservation planning (Hartfield et al. 2017; Li 2017) as a viable means to reduce long-term expenditures, and reduce mission impacts from management actions taken for TES. The USACE has recently advocated a commitment to the Section 7(a)(1) conservation planning approach that calls for a proactive management of species listed under the ESA (Hartfield et al. 2017), while also managing lands and implementing projects so as to minimize the probability that other rare or sensitive species will become listed. Increased costs already associated with species such as the interior population of Least Terns, coastal Piping Plovers, and the recently listed *rufa* Red Knot, and confusion on how to manage future potential listings, has created a strong need for the USACE to determine how and when to implement the Section 7(a)(1) process, and proactive management of coastal resources for imperiled shoreline-dependent species provides one such opportunity. Moreover, the Section 7(a)(1) process requires a multi-agency collaboration that works hand-in-hand with other stakeholders. The Atlantic Flyway Shorebird Initiative (AFSI) is a collaborative organization of international and national government agencies, universities, and non-government organizations dedicated to the conservation of breeding, migratory and wintering shorebirds along the Atlantic Flyway. This effort is hemispheric in scope, addressing shorebird conservation issues on arctic breeding grounds, migratory habitat along the Atlantic Coast, and wintering habitats in Central and South America. By working proactively with AFSI, the USACE can address concerns of stakeholders involved with shorebird conservation. Numerous projects along the Atlantic Coast, funded by the National Fish and Wildlife Foundation (NFWF) for AFSI, provide opportunities for data sharing, project development, and long-term monitoring to assess success, as demonstrated by the effort to improve population metrics for the America Oystercatcher (Ens et al. 2017). The AFSI already provides organizational and collaborative engagements to meet the needs of critical stakeholders. In addition, because the AFSI works at the international and hemispheric scales, this ensures the USACE will not solely bear the burden of creating and assessing habitats for shoreline dependent species along the Atlantic Coast.

DISCUSSION: The USACE needs to find new approaches for conducting coastal engineering operations along the Atlantic Coast. Many TES and other rare or sensitive species are dependent on benthic and intertidal features of the coastal sediments that provide critical breeding, foraging, roosting and loafing habitats during the breeding, winter, and migratory seasons. Coastal habitats used by these species may be degraded by USACE coastal engineering operations that are essential for the creation, enhancement and maintenance of our coastal infrastructure. This TN introduces the issues concerning USACE coastal engineering operations and potential BMPs that could be developed or refined to avoid, minimize or mitigate the impacts of engineering for shoreline-dependent species. Moreover, efforts to create or enhance habitats for TES and other rare or sensitive species could be included in a ESA Section 7(A)(1) conservation consultation process with the USFWS. Working proactively with the USFWS and other stakeholders, including the AFSI, could provide more flexibility to meet mission objectives along the Atlantic Coast, lower long-term costs associated with management of TES, while acting to provide demonstrable benefits to target populations. Working proactively with other agencies can assist with pre- and post-project monitoring that will be necessary to test and assess effectiveness of BMPs for coastal engineering projects. Another benefit would be to lower probability that other rare or sensitive species may become listed under ESA.

Much more work is needed to effectively manage coastal habitats for shoreline-dependent species during USACE coastal engineering projects along the Atlantic Coast. First, existing BMPs will have to be modified to be cost-effective for USACE engineering operations and new BMPs may be needed to address specific coastal habitats or mission conditions along the Atlantic, Pacific, or Gulf Coasts. The pre- and post-project impacts of BMPs will need to be assessed to document benefits for TES and other rare and sensitive species. Second, consultation with the USFWS will be needed to determine credit under the ESA Section 7(A)(1) process and to establish future agreements that may lead to reduced restrictions from environmental windows, or other incentive-based options, in exchange for efforts that provide demonstrable benefits to target populations. Third, effective BMPs will need to be identified, clearly described in proper context of USACE mission objectives, and included in coastal engineering manuals or other documents. This information will need to be distributed to various USACE District offices along the Atlantic, Pacific and Gulf Coasts as needed. The approach outlined in this TN provides the best option to restore and protect our nation’s imperiled shorebird and sea turtle populations, and other shoreline-dependent species, along the Atlantic Coast.

SUMMARY: The USACE is mandated to create, maintain, and enhance our coastal infrastructure, including ports and harbors, and the ICWW. To meet this mission goal, the USACE designs, plans, and implements coastal engineering projects along the Atlantic Coast. However, these actions can alter and degrade habitats for TES, and other sensitive or rare shoreline-dependent species that utilize coastal habitats. Engineering actions likely to negatively impact these species are introduced (e.g., dredged material deposition, shoreline stabilization), along with a series of proposed BMPs to mitigate, enhance, or create habitat for imperiled shoreline-dependent species such as shorebirds, seabirds, and sea turtles. Research and long-term monitoring are needed to test effectiveness of BMPs to provide quality seasonal habitats that serve to benefit and support sustaining populations. Integrating these approaches in concert with proactive actions under the ESA Section 7(a)(1) conservation planning process with the USFWS provides an opportunity for the USACE to meet mission goals and increase flexibility during coastal engineering operations, while providing demonstrable benefits to listed species and reducing the probability that other species will become listed.

ACKNOWLEDGEMENTS: Funding was provided by the Ecosystem Management and Restoration Research Program (EMRRP). The Technical Director for the EMMRP Program is Dr. Trudy Estes. Technical reviews were provided by Dr. Burton Suedel, and Ms. Denise Lindsay, both of ERDC/EL, and Dr. Tim Welp of ERDC/CHL.

POINTS OF CONTACT: For additional information, contact Dr. Michael P. Guilfoyle (601-634-3432; *Michael.P.Guilfoyle@usace.army.mil*), Dr. Richard A. Fischer (502-641-7824; *Richard.A.Fischer@usace.army.mil*), or the Program Manager of the Ecosystem Management and Restoration Research Program (EMRRP), Dr. Trudy Estes (601-634-2125; *Trudy.J.Estes@usace.army.mil*).

This technical note should be cited as follows:

> Guilfoyle, M. P., J. F. Jung, R. A. Fischer, and D. D. Dickerson. 2019. *Developing Best Management Practices for Coastal Engineering Projects that Benefit Atlantic Coast Shoreline-dependent Species.* EMRRP Technical Notes Collection. ERDC/TN EMRRP-SI-38. Vicksburg, MS: U.S. Army Engineer Research and Development Center. *http://el.erdc.usace.army.mil/emrrp/techran.html*

REFERENCES

Bridges, T. S. P. W. Wagner, K. A. Burkes-Copes, M. E. Bates, Z. A. Collier, C. J. Fischenich, J. Z. Gailani, L. D. Leuck, C. D. Piercy, J. D. Rosati, E. J. Russo, D. J. Shafer, B. C. Suedel, E. A. Vuxton, and T. V. Wamsley. 2015. *Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience*. ERDC/EL-SR-15-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center. https://dots.el.erdc.dren.mil/elpubs/pdf/sr-15-1.pdf.

Burlas, M., G. L. Ray, and D. G. Clarke. 2001. *The New York District's biological monitoring program for the Atlantic coast of New Jersey, Ashbury Park to Manasquan Section beach erosion control project*. Final Report, prepared by U.S. Army Engineer Research and Development Center for U.S. Army Engineer District, New York.

Collins, J. T., R. Powell, and R. Conant. 1998. *Peterson Field Guide to Reptiles and Amphibians of Eastern and Central North America*. New York, NY: Houghton Mifflin Company.

Colosio, F., M. Abbiati, and L. Airoldi. 2007. Effects of beach nourishment con sediments and benthic assemblages. *Marine Pollution Bulletin* 54(8):1197–1206. https://doi.org/10.1016/j marpolbul.2007.04.007.

Dickerson, D. D., J. Smith, M. Wolters, C. Theriot, K. J. Reine, and J. Dolan. 2006. A review of beach nourishment impacts on marine turtles. *Shore and Beach* 75(1):1–8.

Ens, B. J., and L. G. Underhill. 2014. Synthesis of oystercatcher conservation assessments: General lessons and recommendations. *International Wader Studies* 20:5–22.

Fischer, R. A., M. P. Guilfoyle, C. A. Lott, and D. N. Pashley. 2004. Application of dredged material disposal for enhancement of bird habitat: Past and current efforts by the U.S. Army Corps of Engineers. Pages 95–103 In C. A. Fleming, ed., 3rd Missouri River and North American Piping Plover and Least Tern Symposium, Sioux City: NE.

Fischer, R. A., M. P. Guilfoyle, C. Lott, and A. Hannes. 2010. Engineering along coastlines and interior rivers – how is the U.S. Army Corps of Engineers integrating bird conservation with dredging/beach nourishment activities in North America? Beijing, China: 19th World Dredging Congress. 1122–1135.

Gibson, D., M. K. Chaplin, K. L. Hunt, M. J. Friedrich, C. E. Weithman, L. M. Addison, V. Cavalieri, S. Coleman, F. J. Cuthbert, J. D. Fraser, W. Golder, D. Hoffman, S. M. Karpanty, A. Van Zoeren, and D. H. Catlin. 2018. Impacts of anthropogenic disturbance on non-breeding body condition, survival, and population growth of a shorebird. *Condor* 120(3):566–580. https://doi.org/10.1650/CONDOR-17-148.1.

Gillespie, C. R., and J. J. Fontaine. 2017. Shorebird stopover habitat decisions in a changing landscape. *Journal of Wildlife Management* 81(6):1051–1062. https://doi.org/10.1002/jwmg.21271.

Golder, W., D. Allen, S. Cameron, and T. Wilder. 2008. *Dredged Material as a Tool for Management of Tern and Skimmer Nesting Habitat*. DOER Technical Notes Collection ERDC TN-DOER-E24. Vicksburg, MS. U.S. Army Engineer Research and Development Center. https://erdc-library.erdc.dren mil/xmlui/handle/11681/8757.

Guilfoyle, M. P., R. A. Fischer, D. N. Pashley, and C. A. Lott. 2006. *Summary of First Regional Workshop on Dredging, Beach Nourishment, and Birds on the South Atlantic Coast*. DOER Technical Report ERDC/EL TR-06-10. Vicksburg, MS. U.S. Army Engineer Research and Development Center. https://el.erdc.dren.mil/elpubs/pdf/trel06-10.pdf.

Guilfoyle, M. P., R. A. Fischer, D. N. Pashley, and C. A. Lott. 2007. *Summary of Second Regional Workshop on Dredging, Beach Nourishment, and Birds on the South Atlantic Coast*. DOER Technical Report ERDC/EL TR-07-26. Vicksburg, MS. U.S. Army Engineer Research and Development Center. https://el.erdc.dren.mil/elpubs/pdf/trel07-26.pdf.

Harrington, B. R. 2008. *Coastal Inlets as Strategic Habitat for Shorebirds in the Southeastern United States*. DOER Technical Notes Collection ERDC TN-DOER-E25, Vicksburg, MS. U.S. Army Engineer Research and Development Center. https://erdc-library.erdc.dren.mil/xmlui/handle/11681/8756.

Hartfield, P., J. G. Brown, and R. A. Fischer. 2017. *The Role of Interagency Cooperation in the Conservation of Threatened and Endangered Species*. DOER technical Notes Collection. ERDC TN-DOER-40. Vicksburg, MS. U.S. Army Engineer Research and Development Center. https://doer.el.erdc.dren.mil/notes_reports html.

Kirby, J. S., A. J. Statterfield, S. H. M. Butchart, M. I. Evans, R. F. A. Grimmett, V. R. Jones, J. O'Sullivan, G. M. Tucker, and I. Newton. 2008. Key conservation issues for migratory land- and waterbird species on the world's major flyways. *Bird Conservation International* 18:S49–S73. https://doi.org/10.1017/S0959270908000439.

Li, Y-W. 2017. Invigorating a neglected tool for endangered species recover. American Bar Association: Section of Environment, Energy, and Resources. *American Bar Association Section of Environment, Energy, and Resources: Endangered Species Committee Newsletter* 16(1):6–9.

Mazaris, A. D., G. Schofield, C. Gkazinou, V. Almpanidou, and G. C. Hays. 2017. Global sea turtle conservation successes. *Science Advances* 3 2017(3):e1600730.

Merkel and Associates, Inc. 2017. Final Oceanside Harbor (2017) maintenance dredging, San Diego County, CA: Western Snowy Plover monitoring and avoidance plan. Prepared for Manson Construction, Long Beach, CA.

Newton, I. 2004. Population limitation in migrants. *British Ornithologists' Union, Ibis* 146:197–226.

Niles, L. J., J. J. Bart, H. P. Sitters, A. D. Dey, K. E. Clark, P. W. Atkinson, A. J, Baker, K. A. Bennett, K. S. Kalasz, N. A. Clark, J. Clark, S. Gillings, A. S. Gates, P. M. Gonzalez, D. E. Hernandez, C. D. T. Minton, R. L. G. Morrison, R. R. Port, R. K. Ross, and C. R. Veitch. 2009. Effects of horseshoe crab harvest in Delaware Bay on Red Knots: Are harvest restrictions working? *Bioscience* 59(2):153–164. https://doi.org/10.1525/bio.2009.59.2.8.

Peterson, C. H., and M. J. Bishop. 2005. Assessing the environmental impacts of beach nourishment. *Bioscience* 55(10):887–896. https://doi.org/10.1641/0006-3568(2005)055[0887:ATEIOB]2.0.CO;2.

Rakocinski, C., R. Heard, S. LeCroy, J. McLelland, and T. Simmons. 1996. Responses by microbenthic assemblages to extensive beach restoration at Perdido Key, FL, USA. *Journal of Coastal Research* 12(1):326–353. https://www.jstor.org/stable/4298484

Rice, T. M. 2009. Best management practices for shoreline stabilization to avoid and minimize adverse environmental impacts. Prepared for the U.S. Fish and Wildlife Service, Panama City Ecological Services Field Office by Terwilliger Consulting, Inc., Locustville, VA.

Rosov, B., S. Bush, T. R. Briggs, and N. Elko. 2016. The state of understanding the impacts of beach nourishment activities on infaunal communities. *Shore and Beach* 84(3):51–55.

Ryan, T., and R. Hamilton. 2009. Surfside beach sand replenishment project Western Snowy Plover Monitoring. Final Report. Prepared for Manson Construction, San Pedro, CA.

Sibley, D. S. 2016. *The Sibley Field Guide to Birds of Eastern North America: Second Edition*. New York, NY: Alfred A. Knopf, Inc.

Soots, R. F., Jr., and M. C. Landin. 1978. *Development and Management of Avian Habitat on Dredged Material Islands*. DMRP Technical Report DS-78-18. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

U.S. Environmental Protection Agency (EPA). 2007. Identifying, planning, and financing beneficial use projects using dredged material: Beneficial use planning manual. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2015-08/documents/identifying_planning_and_financing_beneficial_use_projects.pdf.

U.S. Fish and Wildlife Service (USFWS). 2014. Conservation Measures to Protect Shorebirds and Piping Plovers on Panama City and Pensacola Beach, FL. Washington, DC: U.S. Fish and Wildlife Service.

Van Gils, J. A., B. Spaans, A. Dekinga, and T. Piersma. 2006. Foraging in a tidally structured environment by red knots (*Calidris canutus*): ideal but not free. *Ecology* 87:1189–1202. https://doi.org/10.1890/0012-9658(2006)87[1189:FIATSE]2.0.CO;2.

Wooldridge, T. H., H. J. Henter, and J. R. Kohn. 2016. Effects of beach replenishment on intertidal invertebrates: a 15-month, eight beach study. *Estuarine Coastal and Shelf Science* 175:24–33. https://doi.org/10.1016/j.ecss.2016.03.018.

Journal of Coastal Research	20	1	6–24	West Palm Beach, Florida	Winter 2004

Physical and Biological Effects of Sand Mining Offshore Alabama, U.S.A.

Mark R. Byrnes†, Richard M. Hammer‡, Tim D. Thibaut§, and David B. Snyder‡

†Applied Coastal Research and Engineering, Inc.
766 Falmouth Road, Suite A-1
Mashpee, MA 02649, U.S.A.

‡Continental Shelf Associates, Inc.
759 Parkway Street
Jupiter, FL 33477, U.S.A.

§Barry A. Vittor & Associates, Inc.
8060 Cottage Hill Road
Mobile, AL 36695, U.S.A.

ABSTRACT

BYRNES, M.R.; HAMMER, R.M.; THIBAUT, T.D., and SNYDER, D.B., 2004. Potential physical and biological effects of sand mining offshore Alabama, U.S.A. *Journal of Coastal Research,* 20(1), 6–24. West Palm Beach (Florida), ISSN 0749-0208.

Physical processes and biological data were collected and analyzed at five sand resource areas offshore Alabama to address environmental concerns raised by potential sand dredging for beach replenishment. Nearshore wave and sediment transport patterns were modeled for existing and post-dredging conditions, with borrow site sand volumes ranging from 1.7 to 8.4 $\times$ 10^6 m^3. Wave transformation modeling indicated that minor changes will occur to wave fields under typical seasonal conditions and sand extraction scenarios. Localized seafloor changes at borrow sites are expected to result in negligible impacts to the prevailing wave climate at the coast. For all potential sand excavation alternatives at borrow sites offshore Alabama, maximum variation in annual littoral transport between existing conditions and post-dredging configurations was approximately 8 to 10%. In general, increases or decreases in longshore transport rates associated with sand mining at each resource area amounted to about 1 to 2% of the net littoral drift, distributed over an approximate 10 km stretch of shoreline. Because borrow site geometries and excavation depths are similar to natural ridge and swale topographic characteristics on the Alabama Outer Continental Shelf, infilling rates and sediment types are expected to reflect natural variations within sand resource areas.

Impacts to the benthic community are expected from physical removal of sediments and infauna. Based on previous studies, levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition may take longer. Western areas can be expected to recover more quickly than eastern areas because of opportunistic life history characteristics of numerically dominant infauna west of Mobile Bay.

ADDITIONAL INDEX WORDS: *Bathymetric change, benthic, infauna, sediment transport, shoreline change, wave modeling.*

INTRODUCTION

The coastal zone is a unique geological, physical, and biological area of vital economic and environmental value. HOUSTON (1995, 2002) discusses the value of beaches to America's economy and their maintenance via beach nourishment. In addition, MILLER (1993) stresses the importance of coastal and marine tourism as the world's largest industry, noting its continual rise in economic importance over the past 50 years. Beaches not only are the dominant component of most coastal economies, but also provide protection against storm winds and waves. Coastal community master plans are being developed and revised to address concerns associated with storm protection, population growth, recreation, waste disposal and facilities management, and zoning (WILLIAMS, 1992). Often, these management issues are confounded by natural coastal processes, particularly coastal erosion and storm winds and waves. Replenishing beaches with sand from coastal and nearshore sources as protection for community infrastructure has increased in direct relation to population growth. As sand mining depletes coastal and nearshore borrow areas, alternate sources of beach fill must be located and knowledge of the environmental consequences of offshore sand mining must be expanded. In many cases, sand extraction from the Outer Continental Shelf (OCS) may prove environmentally preferable to nearshore borrow areas because potential changes to waves and currents resulting from dredging large quantities of sand from the seafloor may be more pronounced in shallow water.

This paper discusses some physical and benthic biological aspects of a study whose purpose and objectives were specified by the U.S. Department of the Interior, Minerals Management Service (MMS). The study purpose was to address environmental concerns associated with potential sand mining operations at five OCS sand resource areas offshore Alabama for beach replenishment. Four objectives addressed the study purpose, including: (1) document potential modifications to waves due to offshore sand mining at proposed borrow sites; (2) evaluate impacts of offshore sand mining and consequent beach replenishment in terms of potential alterations to sediment transport patterns, sedimentary environments, and local shoreline processes; (3) characterize benthic ecological conditions in and around five sand resource areas using existing information and data collected from field surveys; and (4) evaluate infaunal assemblages and assess potential effects of offshore sand mining on these organisms,

03602A received and accepted in revision 18 August 2003.

including an analysis of recolonization periods and success following dredging. Because monitoring surveys of actual sand mining operations were not to be conducted, the assessment of potential infaunal effects was based only on benthic infaunal characterization field surveys and existing literature. This paper focuses on physical and infaunal effects from sediment removal. It also provides statistical properties of local infaunal assemblages that will assist in designing future sand resource area monitoring programs. Other potential impacts from sediment suspension/dispersion (turbidity) and deposition are addressed in BYRNES *et al.* (1999).

STUDY AREA

The study area was located within the inshore portion of the continental shelf, seaward of the Federal-State OCS boundary and within the Alabama Exclusive Economic Zone (EEZ) (Figure 1). The seaward limit of the study area was defined by the 30°N latitude line. The project area was located within the east Louisiana-Mississippi-Alabama Shelf. The continental shelf surface within the study area is relatively broad and featureless west of the Mobile Bay entrance; however, the Alabama shelf east of the entrance channel contains many northwest-southeast trending shoreface sand ridges, as well as other shoals.

Five potential sand resource areas, located at least 4.5 km seaward of the shoreline, were defined within the study area through a Federal-State cooperative agreement between the MMS and Geological Survey of Alabama. PARKER *et al.* (1993, 1997) characterized the sand resource potential for each area based on surface sediment samples and vibracore data. HUMMELL and SMITH (1995, 1996) provided detailed geologic information on Sand Resource Area 4 to supplement existing information, identifying a specific low-relief shoal in the southeast quadrant of the sand resource area as a prime borrow site.

REGIONAL SETTING

The Alabama continental shelf can be divided into two regions based on geomorphology and hydrology (PARKER *et al.*, 1997). The eastern shelf extends from the Alabama-Florida state boundary to Mobile Pass (Figure 1). The western shelf extends from Mobile Pass to the Alabama-Mississippi State boundary at Petit Bois Pass. The large ebb-tidal delta at Mobile Pass is approximately 16 km wide, extends about 10 km offshore (HUMMELL, 1990), and separates the two regions.

The eastern portion of the study area is characterized by numerous shelf and shoreface sand ridges and swales that trend northwest to southeast (Figure 1; MCBRIDE and BYRNES, 1995; PARKER *et al.*, 1997). Ridges are considered shoreface-attached and shoreface-detached (PARKER *et al.*, 1992), and form oblique angles to the shoreline that open to the east. Ridges average 6 km in length and range from 1 to

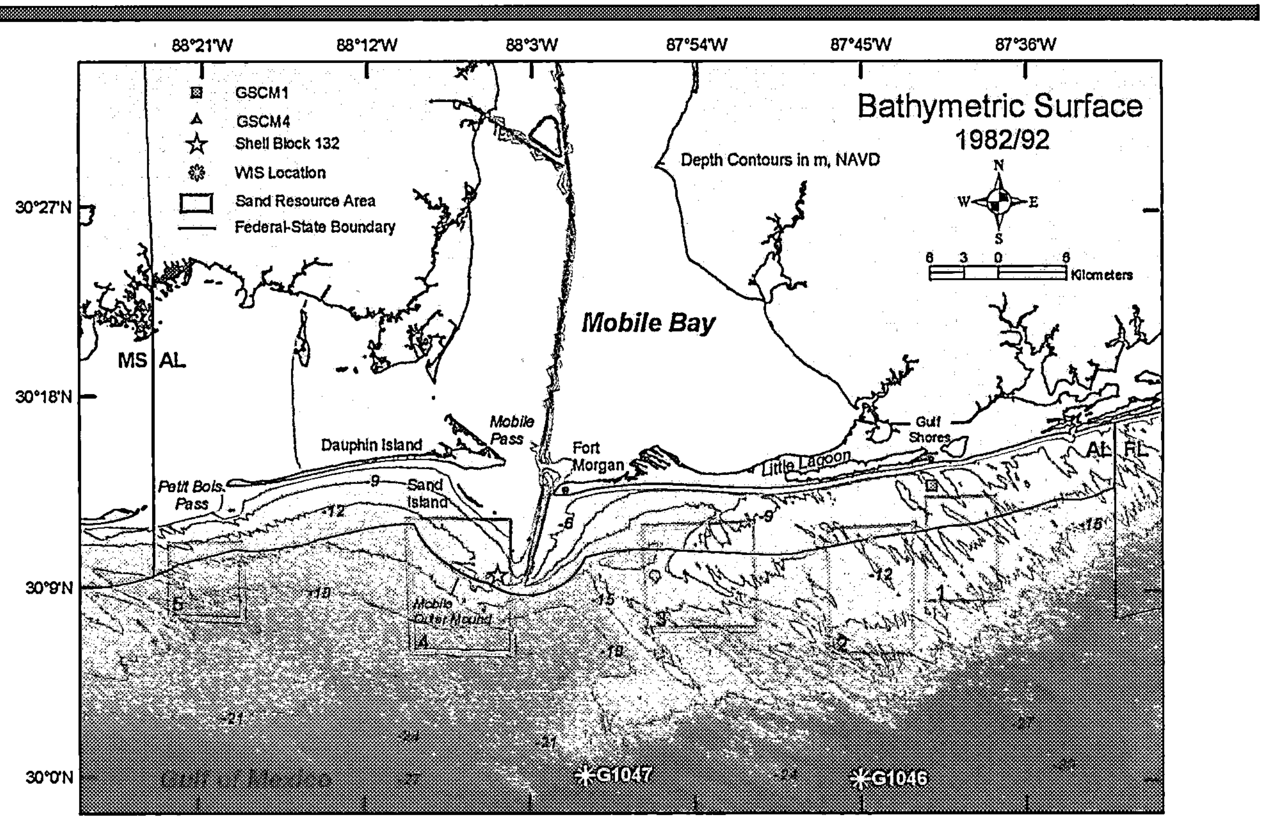


Figure 1. Location diagram illustrating sand resource areas, current measurement locations, WIS stations, and the Federal-State boundary relative to 1982/92 bathymetry.

11 km long. Ridge widths range from 1 to 4 km with spacing between ridges varying between 1 and 7 km. Ridge side slopes average about 1°, and relief above the surrounding seafloor ranges from 1 to 5 m (McBride and Byrnes, 1995). Shoreface-attached or shoreface-detached ridges generally form opening angles with the east-west trending shoreline of 30 to 60°. Shoals formed as pre-Holocene paleotopography generally are oriented nearly perpendicular to the shoreline, reflecting their fluvial origin.

The western half of the study area, from Mobile Pass west to Petit Bois Pass, has relatively few geomorphic features compared with the eastern part of the study area. Shoals associated with deposition near the entrances to Mobile Pass and Petit Bois Pass are prominent; however, the shelf seaward of Dauphin Island is smooth and concave. Marginal shoals of the ebb-tidal delta are quite shallow to the west of Mobile Pass. Hummell (1990) and Douglass (1994) discuss the significance of these features to sediment transport patterns along the shoreline of eastern Dauphin Island. Overall, the shelf surface in the western half of the study area slopes at about 1.5 m/km.

METHODS

Existing literature and data describing the physical and benthic biological environments in the study area were analyzed to evaluate potential consequences of offshore sand mining activities. In addition, physical and benthic characterization field surveys were conducted to fill information gaps present in existing data sets according to the following methods.

Physical Processes

Waves

The U.S. Army Corps of Engineers (USACE) Wave Information Study (WIS) results (1976 to 1995) for offshore Alabama (WIS Stations G1047 and G1046) provided a detailed description of the regional wave climate used to develop representative wave spectra. Rather than selecting the most common wave heights and directions as model input, WIS information was summarized into average seasonal wave conditions and spectra. Directional and energy spectra also were estimated from previous storm spectra to simulate conditions for a 50-year event. A storm surge value for the estimated 50-year event was included in the wave modeling simulation to represent increased water level experienced during the passage of a large storm. Surge values for 25 storms impacting the study area between 1772 and 1969 were used in an extremal analysis to estimate a height of 3 m for a 50-year storm surge.

The spectral wave transformation model REF/DIF S (Kirby and Özkan, 1994) was used to evaluate changes in wave propagation across the Alabama continental shelf relative to potential sand mining configurations. Differences in wave heights between existing conditions and post-dredging simulations were computed at each grid point within the model domain to document potential changes caused by specific sand mining scenarios. Proposed sand extraction volumes and sediment characteristics for borrow sites in Sand Resource Areas 1 through 4 are listed in Table 1. Each borrow site was numerically excavated to simulate potential impacts of offshore dredging on physical processes. Sand extraction from Area 5 was not simulated because the location of potential sand deposits was not well suited for beach replenishment needs in coastal Alabama. Existing condition wave simulations were subtracted from post-dredging wave results so that positive (negative) differences indicated an increase (decrease) in wave height related to sand mining at each borrow site.

Currents

Two current meter data sets were used to evaluate seasonal and annual flow variations throughout the study area. Continental Shelf Associates, Inc. provided current meter observations near Area 4 for the period September 28, 1987 to October 24, 1988 (approximately 1.6 m above the seafloor in approximately 12-m water depth; Hart *et al.*, 1989). The mooring was deployed west of the main ship channel in Shell Block 132, due east of the dredged material disposal mound known as Mobile Outer Mound (Figure 1). A series of five moorings were deployed near Areas 1 and 2 by the Environmental Protection Agency (EPA) for the period March 1986 to March 1987. Mooring 1M (GSCM1) had mid-depth observations collected in approximately 5-m water depth. Mooring 4 (GSCM4) was located in approximately 10-m water depth with observations recorded at near-surface (4S) and near-bottom (4B).

Field measurements of currents within Sand Resource Areas 2 and 4 were conducted in May and September of 1997 to observe spatial flow variations in eastern and western portions of the study area. Four surveys were completed; one survey per season in each of Areas 2 and 4. Each survey recorded measured currents during an approximate 12-hour period. A survey transect grid was created with transect lines

Table 1. *Sand resource characteristics at potential borrow sites in resource areas offshore Alabama.*

Resource Area	Surface Area ($\times10^6$ m^2)	Sand Volume ($\times10^6$ m^3)	Excavation Depth (m)	D10 (mm)	D50 (mm)	D90 (mm)
1	1.94	5.8	3	0.93	0.25	0.18
2	0.57	1.7	3	0.44	0.22	0.14
3	1.19	4.7	4	0.44	0.27	0.14
4	2.80	8.4	3	0.50	0.34	0.20
5	Resource area location not suited for beach replenishment needs in the Alabama coastal zone					

D10 = grain diameter above which 10% of the distribution is retained; D50 = median grain diameter; D90 = grain diameter above which 90% of the distribution is retained.

traversed repeatedly throughout the survey (BYRNES *et al.*, 1999). Currents were measured using an acoustic doppler current profiler (ADCP) mounted rigidly to a small vessel. The ADCP collected high-resolution measurements of the vertical structure of current flow beneath the instrument transducer. Repeating transects at regular time intervals throughout a complete tidal cycle documented spatial and temporal variation in current structure. Measurements of flow variations throughout the region were analyzed with long-term historical current data to enhance understanding of flow characteristics in the Alabama sand resource areas.

Sediment Transport

Three independent sediment transport analyses were completed to evaluate physical environmental impacts due to offshore sand mining. First, historical sediment erosion and accretion trends were quantified with sequential shoreline and bathymetric surveys to document long-term sediment movement (*e.g.*, BYRNES and HILAND, 1995). Historical map compilation and analysis procedures for surveys of coastal Alabama are documented in BYRNES *et al.* (1999). Second, annualized sediment infilling rates were estimated for each borrow site using analytical expressions developed by MADSEN and GRANT (1976) that incorporate information on wave orbital velocities, local current measurements, and sediment textural characteristics at borrow sites. Third, numerical techniques were developed to use nearshore wave information derived from REF/DIF S to evaluate changes in longshore sediment transport patterns (beach erosion and accretion) resulting from potential offshore sand mining activities. This involved application of a wave-induced current model where the depth-averaged continuity equation and depth-averaged x and y momentum equations were integrated and time averaged (WINER, 1988; RAMSEY, 1991).

Benthic Infaunal Characterization Surveys

Sampling Design

During each benthic infaunal characterization field survey (May and December 1997), 20 grab samples (one per station) for infauna and sediment grain size were collected inside and adjacent to each of the five sand resource areas (Figure 2). Station depths ranged from a minimum of 8 m to a maximum of 23 m, though most were located at depths between 10 and 20 m. An unaligned grid approach was used to provide uniform coverage of target populations (GILBERT, 1987). To achieve uniform sampling coverage, 4 × 4 grids (=16 cells) were placed over figures of each sand resource area. For Areas 1, 2, 3, and 5, the 16-cell grid was placed over a map of the entire sand resource area in Federal waters. Because the

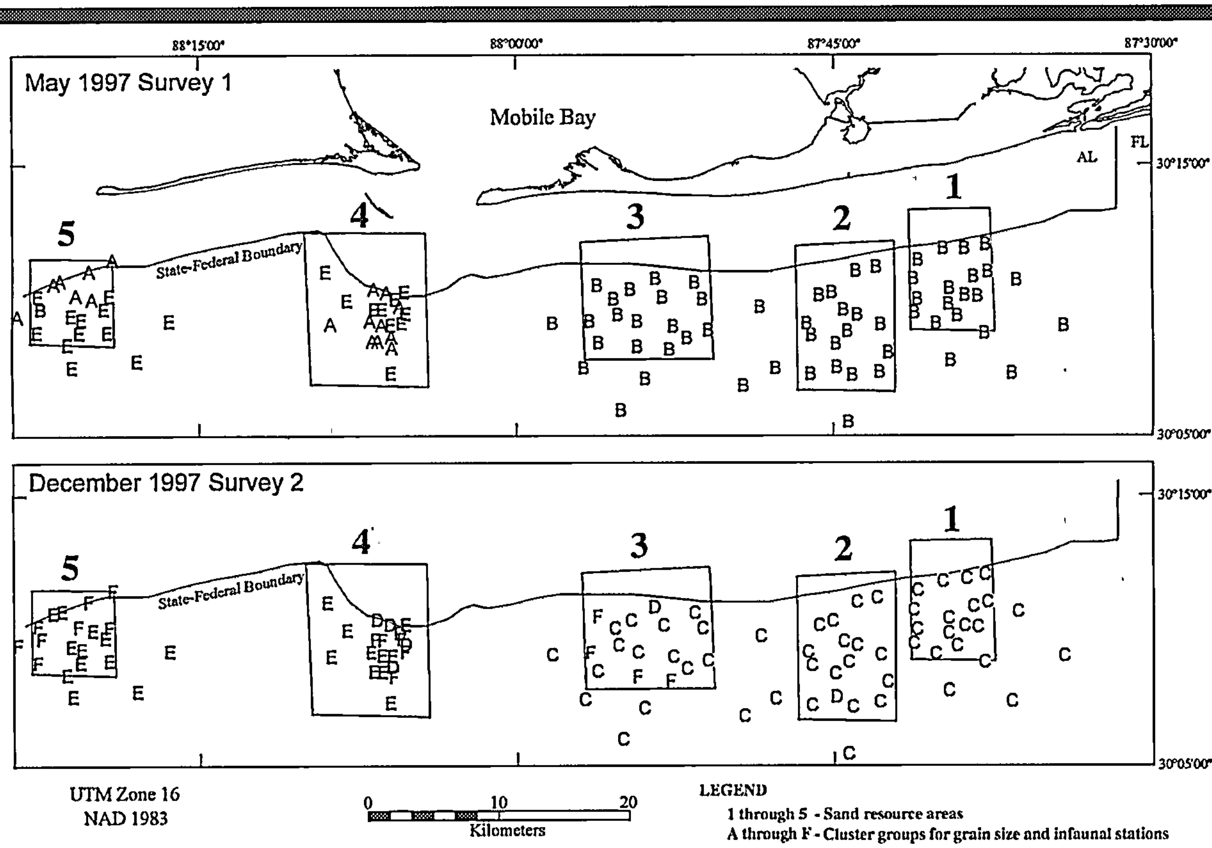


Figure 2. Distribution of Station Groups A through F resolved from cluster analysis and multidimensional scaling of infaunal data collected from five offshore Alabama sand resources areas during May and December 1997.

borrow site within Area 4 was very localized based on surficial sediment samples and subsurface core data of PARKER *et al.* (1993, 1997) and HUMMELL and SMITH (1995, 1996), the 16-cell grid was placed over this specific target site within Area 4. To achieve independence, one sampling station then was placed using randomly generated coordinates within each grid cell of each sand resource area. Randomizing within grid cells eliminated biases that could be introduced by unknown spatial periodicities in the sampling area. All station locations then were pre-plotted on maps from PARKER *et al.* (1993, 1997) and HUMMELL and SMITH (1996). A differential global positioning system was used to navigate the survey vessel to all sampling stations. Temperature, conductivity, and dissolved oxygen were measured near bottom with a portable Hydrolab unit near the northern (depths ranged from 10 to 16 m) and southern (depths ranged from 14 to 19 m) limits of each sand resource area (n = 2/area/survey).

Sediment Grain Size

One grab sample was taken with a Smith-McIntyre grab at each pre-plotted sediment/infaunal sampling station, for a total of 100 samples per survey (n = 20/area/survey). A subsample (about 250 g) of sediment for grain size analyses was removed from each grab sample with a 5-cm diameter acrylic core tube, placed in a labeled plastic bag, and stored on ice. In the laboratory, grain size analyses were conducted using combined sieve and hydrometer methods according to recommended American Society for Testing Materials procedures. Samples were washed in demineralized water, dried, and weighed. Coarse and fine fractions were separated by sieving through a U.S. Standard Sieve Mesh No. 230 (62.5 μm). Sediment texture of the coarse fraction was determined at 0.5-phi intervals by passing sediment through nested sieves. Weight of materials collected in each particle size class was recorded. Boyocouse hydrometer analyses were used to analyze the fine fraction (<62.5 μm). A computer algorithm determined size distribution and provided interpolated size information for the fine fraction at 0.25-phi intervals. Percentages of gravel, sand, and fines (silt + clay) were recorded for each sample.

Infauna

After removing the sediment sample from the grab, the remaining grab sample was sieved through a 0.5-mm sieve for infaunal analyses. Infaunal samples were preserved in 10% formalin with rose bengal stain. In the laboratory, organisms were identified to lowest practical taxon and counted.

Univariate summary statistics including number of taxa, number of individuals, density, Shannon's index of diversity (H') (PIELOU, 1966), Pielou's index of evenness (J') (PIELOU, 1966), and Margalef's index of species richness (D) (MARGALEF, 1958) were calculated for each sampling station. Station means of these summary statistics were then calculated for each sand resource area.

Spatial and temporal patterns in infaunal assemblages were examined using several multivariate techniques, including non-metric multidimensional scaling (MDS), cluster analysis, similarity percentage breakdown (SIMPER), and analysis of similarities (ANOSIM). These analyses were performed on a similarity matrix constructed from a raw data matrix consisting of taxa and samples (station-survey). The data matrix was constructed using taxa that collectively contributed to 95% of the total abundance over all samples. This produced a data matrix of 135 taxa by 200 stations. To weight the contributions of common and rare taxa, raw counts of each individual infaunal taxon in a sample (n) were transformed to logarithms [$\log_{10}(n+1)$] prior to similarity analysis. A sample similarity matrix was generated using the Bray-Curtis similarity index (BRAY and CURTIS, 1957). This matrix was clustered using the group averaging method that describes mean levels of similarity between groups of stations (FIELD *et al.*, 1982). Cluster analysis was followed by MDS ordination of the similarity matrix to corroborate cluster results. Species accounting for observed assemblage differences among groups and within groups of samples were identified using the SIMPER procedure, which determines the average contribution of each species to characterizing a sample group or discriminating between pairs of sample groups (CLARKE, 1993). The hypothesis of no difference in assemblage composition among sand resource areas or between surveys was examined using a two-way ANOSIM procedure (CLARKE, 1993). Working from the similarity matrix, ANOSIM calculates a test statistic, R, that reflects differences between sand resource areas contrasted with differences among stations within sand resource areas, ignoring surveys, and conversely, differences between surveys contrasted with differences among stations within surveys while ignoring sand resource areas. The significance of the calculated R values was tested against null distributions of R generated by 999 random permutations of the data matrix. These analyses (MDS, SIMPER, ANOSIM) were performed with the PRIMER v5 package (CLARKE and GORELY, 2001).

The extent to which station groups formed by cluster analysis and ordination of infaunal data could be explained by environmental variables was examined by canonical discriminant analysis (CDA) (SAS INSTITUTE, INC. STAFF, 1989), which identifies the degree of separation among pre-defined groups of variables in multivariate space. Environmental variables included survey (categorical), water depth, percent gravel, percent sand, and percent fines.

RESULTS

Physical Processes

Wave Transformation Modeling

Wave refraction and diffraction generally result in an uneven distribution of wave energy along the coast that affects sediment transport in a region. Wave spectra developed for the Alabama coast illustrated that all seasonal waves propagate from east-to-west. Wave transformation modeling results provided information on wave propagation across the continental shelf to the shoreline, revealing areas of wave energy convergence and divergence. These results also supplied input for nearshore circulation and sediment transport models.

Existing Conditions. For a typical spring season along the shoreline east of Mobile Pass and Fort Morgan, areas of wave convergence and divergence were caused by irregular bathymetry and the southwest-oriented seaward extending shoal near Area 3 (Figure 1). Wave energy converged in regions where bathymetric contours were aligned shore perpendicular, as waves refracted relative to bathymetry. Summer, fall, and winter season results indicated similar patterns of wave convergence and divergence. There were no visible differences in wave height patterns for different seasons. The winter season was slightly more energetic (wave heights approximately 0.2 to 0.3 m greater). However, spring and fall simulations were almost identical, with only a slight variation in directional spreading.

Seaward of Dauphin Island for a typical spring season, significant wave focusing was evident behind the Mobile Outer Mound dredged material placement area (shoal feature west of Mobile Pass channel; Figure 1). Wave refraction around this feature created increased wave heights of approximately 0.25 to 0.5 m in the lee of the shoal and decreased wave heights adjacent to the feature. Wave focusing caused by Mobile Outer Mound produced an increase in energy that advanced toward Sand Island, the western subaerial portion of the Mobile Pass ebb-tidal delta. Sand Island offers a natural protective buffer against wave action for the eastern end of Dauphin Island, as indicated by a wave shadow zone behind the island. A similar increase in wave energy was evident near the western end of Dauphin Island as bathymetric contours redirected wave energy toward the western terminus of the island.

Simulations for the winter season produced results that were very similar to results discussed for a typical spring season. Minor differences occurred due to increased significant wave height and subtle changes in the frequency and directional spread of the incident wave spectrum (BYRNES *et al.*, 1999). Slightly greater increases in wave energy were located in areas where wave shoaling was identified for the spring season. During a typical summer season, average wave heights were reduced significantly (approximately 0.3 to 0.5 m) in regions where wave shoaling was apparent. Wave focusing caused by Mobile Outer Mound and regions near the dredged navigation channel was less severe. Fall season results were similar to results for a typical summer season, except wave heights during fall were 0.5 to 0.6 m higher than summer.

Storm wave propagation patterns were similar to those documented for seasonal trends. However, during a 50-year storm, Mobile Outer Mound concentrated a 4.0- to 4.5-m wave field on southeastern Sand Island, and a significant reduction in wave height was evident adjacent to this area. Wave shoaling in other areas (*e.g.*, dredged navigation channel) appeared less important when considering larger storm waves. Wave approach directions were modified farther offshore because large storm waves interacted with the seafloor in deeper water than average seasonal waves.

Existing Conditions Versus Post-Dredging Results. Figure 3 illustrates wave height differences for the spring season seaward of the shoreline east of Fort Morgan. Wave height modifications were greatest for borrow sites seaward of eastern Alabama beaches, with maximum changes in wave height approaching 0.3 to 0.4 m. The increase in wave height was due to borrow site location relative to the shoreline and borrow site size and orientation. A maximum wave height increase of 0.2 to 0.4 m along the western edge of Areas 1, 2, and 3 resulted from the large sediment extraction scenarios for a typical spring season simulation. A maximum decrease of 0.4 m was evident in the lee of the dredged borrow sites. The shadow zone behind the Area 2 borrow site was more concentrated due to borrow site orientation. However, energy dissipated as waves advanced toward the shoreline, and negligible increases in wave height (0.1 m or less) were observed along the coast.

During summer, fall, and winter, patterns of wave modifications were comparable. Maximum increases/decreases in wave height were slightly smaller ($\pm$0.2 to 0.3 m) than observed during spring. For fall simulations, modifications to the wave field were less consolidated due to the less focused wave approach direction. During summer and winter, a small area of increased wave height observed at the western edge of the borrow site within Area 3 appeared to propagate to the shoreline (at approximately 412,500 Easting; 3,344,000 Northing; Figure 3). However, changes at the shoreline were negligible. Overall, potential shoreline impacts caused by simulated dredging at all offshore sand borrow sites under normal wave conditions were small relative to wave propagation under existing conditions.

Figure 4 illustrates a wave height difference plot between existing conditions and post-dredging simulations for the spring season offshore Dauphin Island, indicating that sand mining creates a zone of decreased wave energy behind the borrow site and increased energy adjacent to the borrow site. A maximum increase and decrease of approximately 0.2 m (11% change relative to offshore significant wave height) resulted from the sediment extraction scenario for Area 4 during a typical spring season. Increased wave energy was focused near the southwest end of Sand Island and on the eastern end of Dauphin Island. A decrease in wave energy was evident in the lee of the borrow site, and therefore reduced the magnitude of wave height focused by Mobile Outer Mound.

Winter season differences indicated a slight shift in the impact zone to the east due to variations in peak spectral wave approach. The magnitude of wave height differences was slightly smaller than illustrated for spring simulations, and the western edge of Sand Island experienced an insignificant increase in wave height (0.02 to 0.04 m). For summer season simulations, waves were smaller with shorter periods, and the directional spread was quite wide. Wave field modifications were not well-defined, and changes were negligible. Fall season model runs produced slightly larger changes in wave height differences on a portion of Sand Island; however, changes were determined to be negligible (0.05- to 0.06-m increase) relative to existing conditions.

A similar distribution of wave energy change as that indicated for seasonal results was illustrated for 50-year storm simulations (*i.e.*, wave energy reduction directly landward of the dredged area, and an adjacent increase in energy). A maximum increase in wave height of approximately 1.5 m (20% increase over offshore wave heights) and a wave height

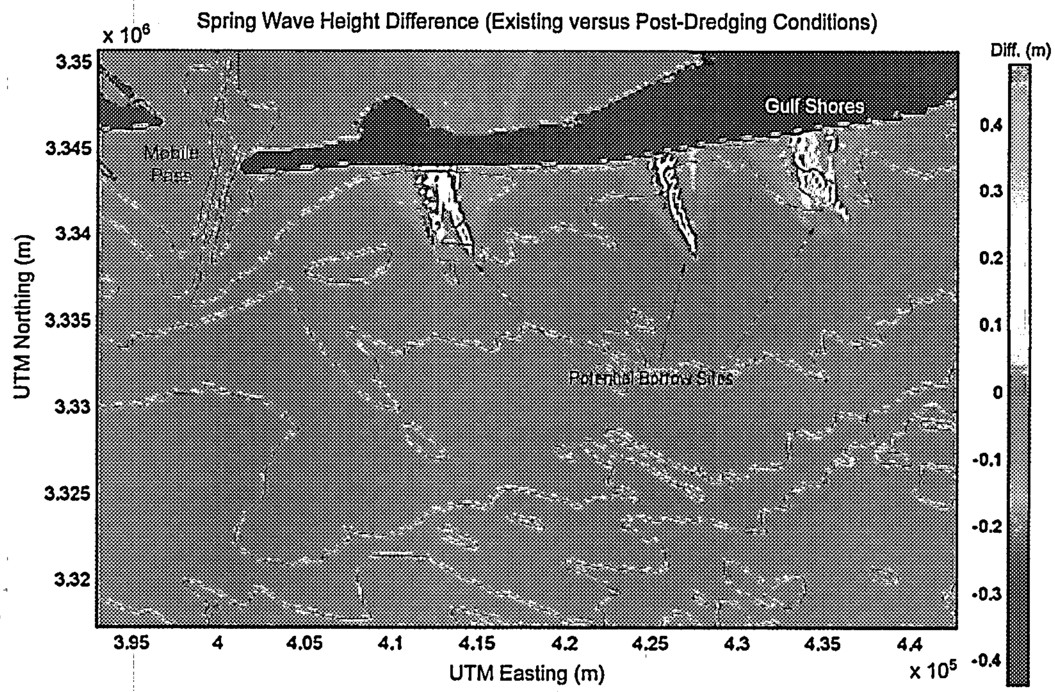


Figure 3. Wave height modifications resulting from potential offshore mining at Areas 1, 2, and 3 for a typical spring season.

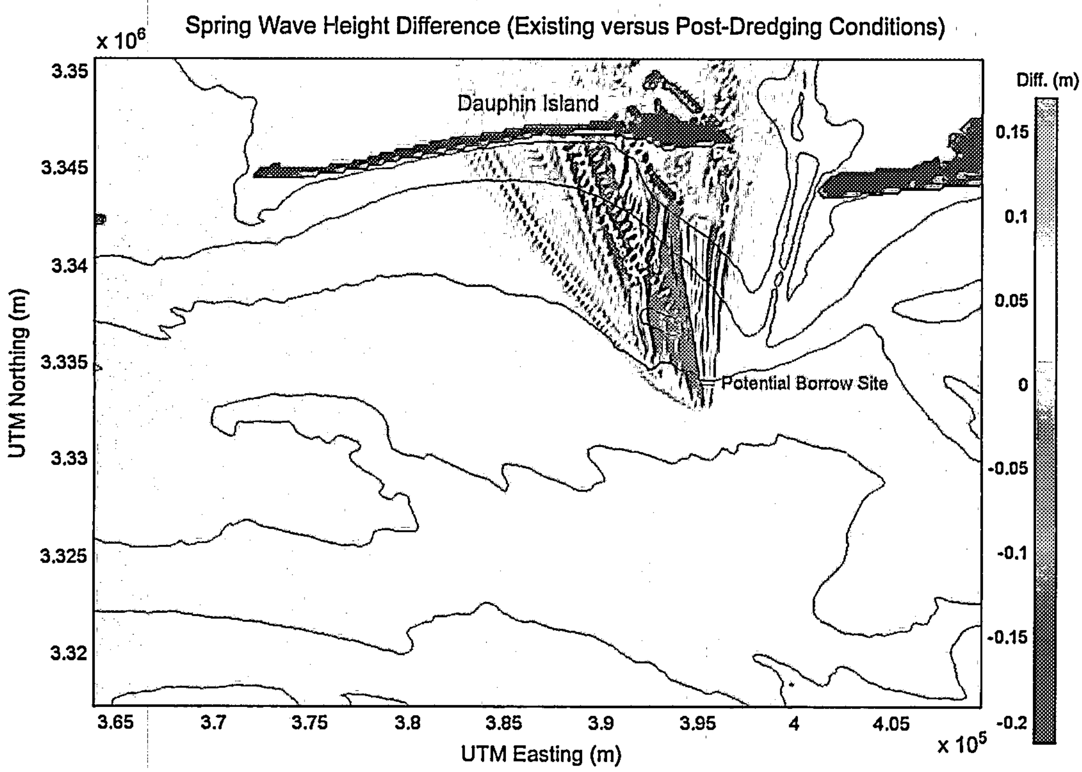


Figure 4. Wave height modifications resulting from potential offshore mining at Area 4 for a typical spring season.

reduction of 1.5 to 2.0 m were observed in the shadow zones of borrow sites.

Currents

Temporal Variability. Near-bottom currents west of the Mobile Bay entrance (Shell Block 132 mooring) typically were oriented along a northwest-southeast axis that is parallel to bathymetric contours at the site. Strongest flow was to the southeast with 15 to 25 cm/sec speeds occurring approximately 8 to 10% of the time (Figure 5). Current speeds exceeding 25 cm/sec were observed less than 2% of the time.

Currents to the east of Mobile Bay were strongest at the surface (Mooring 4S) and weakest at the bottom (Mooring 4B). Currents also were oriented primarily in the alongshore direction. While surface flow was oriented to the west and northwest approximately 33% of the time, this westward flow was typically weaker than flow to the east. Westward flow greater than 15 cm/sec at Mooring 4S occurred approximately 5% of the time, while eastward flow exceeding 15 cm/sec occurred approximately 17% of the time. Approximately 1% of the time, eastward flow exceeded 35 cm/sec, whereas westward flow never exceeded 35 cm/sec.

Wind-driven currents were the largest contributor to overall observed currents. Analysis of historical data sets also illustrated that wind-driven currents were oriented by local bathymetric features. Thus, predominant current directions were controlled not only by the direction of alongshore wind but also by shape of the shoreline and bottom boundaries. Directional distribution of flow changed little with season and maintained a predominant orientation parallel to isobaths. Highest current speeds occurred in winter, when flows exceeding 15 cm/sec were more frequent than at other times of year. Because strong northerly winds are common in winter, while mild southerly winds are predominant in summer, wind-driven currents maintained an alongshore direction (northwest to southeast) and generally were consistent with variations in seasonal wind strength. In summer, wind-driven currents exceeded 5 cm/sec approximately 23% of the time and exceeded 15 cm/sec about 3% of the time. In winter, wind-driven currents exceeded 5 cm/sec approximately 60% of the time, 15 cm/sec 13% of the time, and greater than 25 cm/sec 3% of the time. In summer, wind-driven flow did not exceed 25 cm/sec.

Spatial Variability. Comparison of May and September ADCP surveys revealed variations in vertical structure of the water column and the influence vertical stratification had on

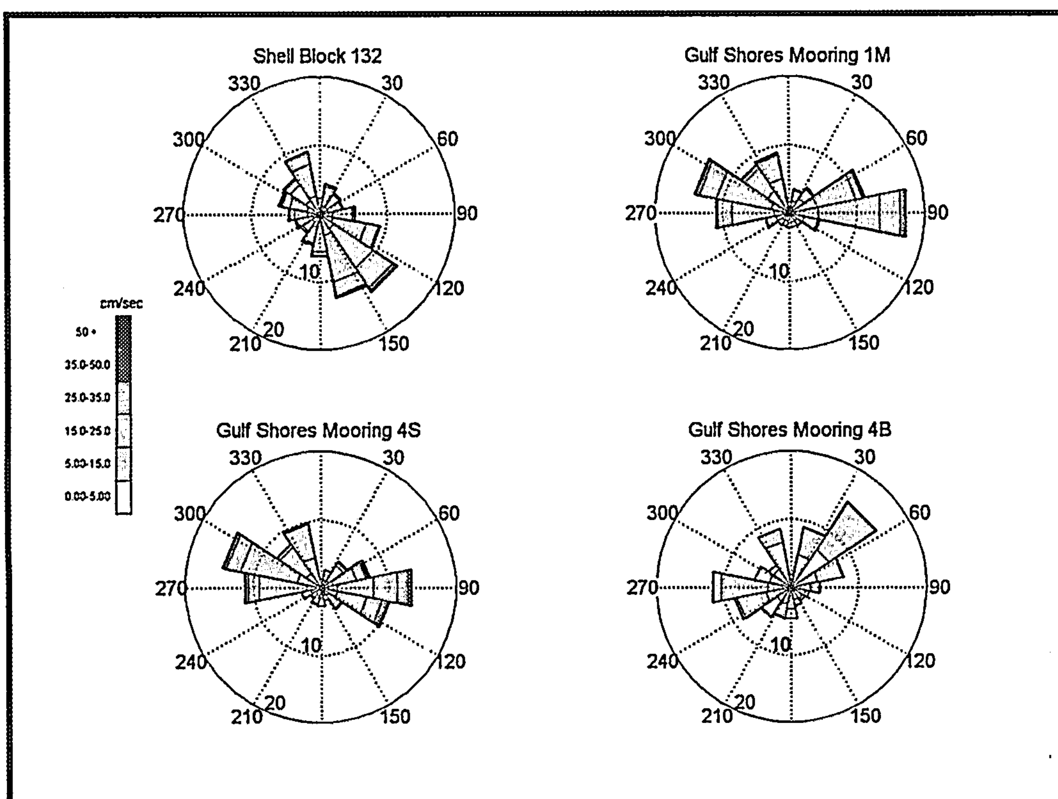


Figure 5. Rose diagrams illustrating four historical data sets of currents in the study area. Spokes of the diagram represent compass directions. Circumferential lines represent percent occurrence, with the inner annulus representing 10%, and the outside diameter representing 20% occurrence. Current speeds are represented by shading, with white (no shading) portions representing the fraction of time currents are between 0 and 5 cm/sec, and black portions indicating the percent occurrence of currents over 50 cm/sec.

the current field. East of Mobile Pass at Area 2, surface layer currents were relatively uniform during the May survey, with flows oriented north-northeast at speeds of approximately 15 to 30 cm/sec early in the day. Later in the day, surface currents shifted east-northeast and ranged from approximately 15 to 40 cm/sec. The entire surface flow field appeared oriented in a uniform direction with little horizontal directional variability. Mid-depth (10 to 35 cm/sec) and near-bottom (5 to 25 cm/sec) flows also indicated little horizontal variability.

Currents throughout Area 2 were quite uniform during the September survey as well. No significant horizontal variation was observed in the surface layer, as the flow field was uniformly directed to the east-southeast. Speeds were relatively consistent and ranged from approximately 25 to 50 cm/sec. Mean speed at the surface was approximately 40 to 45 cm/sec. Speeds in the middle layer were approximately 15 to 40 cm/sec. Near-bottom currents had slightly more directional variance, primarily due to influence of bathymetry. Mean speeds were approximately 20 cm/sec in the near-bottom layer.

During the May survey offshore Dauphin Island, vertical and horizontal flow variability at Area 4 occurred due to flow exchange with Mobile Bay and interaction with bathymetric features. Surface and mid-layer currents observed during the survey indicated minor horizontal variation. Flow in these layers was directed primarily west to east, responding to the westerly longshore component of wind that had been blowing for the previous few days. Overall, flow in the southern (deeper) portion of Area 4 was to the east, with amplitudes of approximately 25 to 35 cm/sec (Figure 6). Flow in the northern (shallow) regions was southeast, steered by local bathymetry around Sand Island, with a similar flow magnitude as in deeper areas.

For the September survey, surface flow throughout Area 4 generally followed depth contours, with currents in deeper regions oriented to the southeast. Surface layer current speeds ranged from 40 to 50 cm/sec. Mid-layer flow had speeds of approximately 25 to 35 cm/sec, and bottom flow was weakest at approximately 15 cm/sec.

Sediment Transport

Wave transformation modeling and current measurements provided baseline coastal processes information for the study

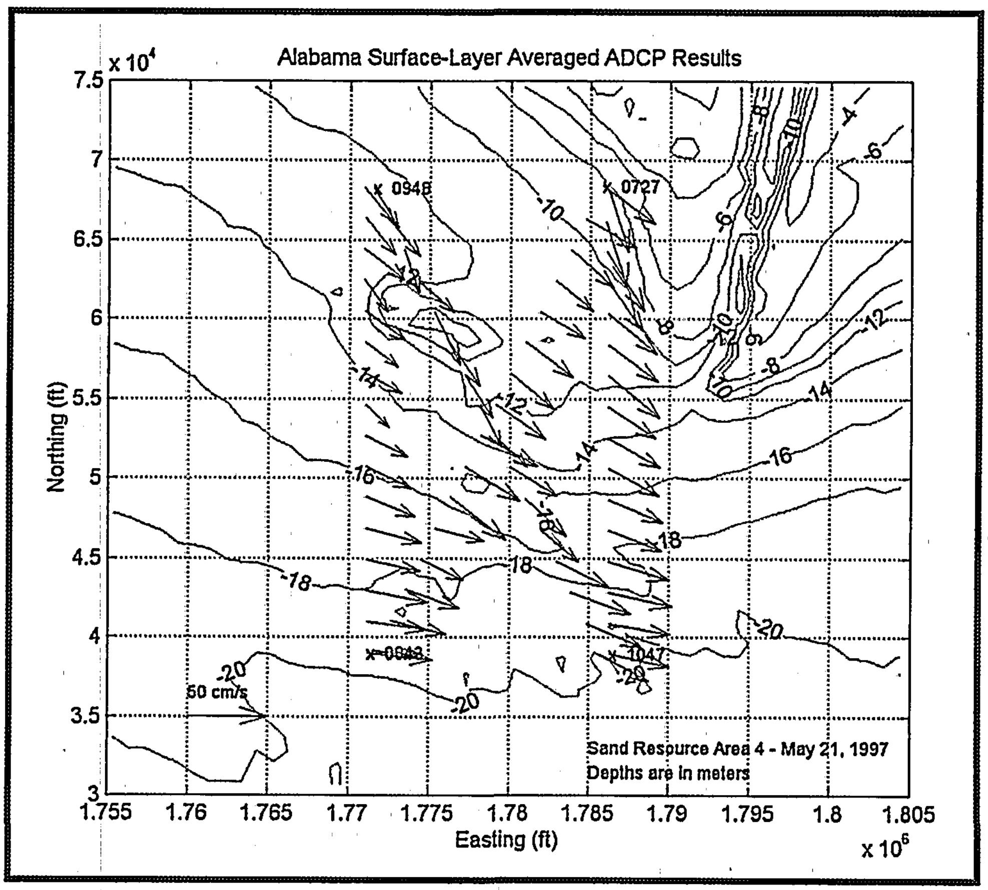


Figure 6. Vector map of observed flow patterns for Area 4; May 21, 1997 from 0727 hours to 1150 hours. Current vectors represent average flow in the surface layer (upper one-third of the water column). The numbers in each corner of the transect grid (0727, 0948, 0848, and 1047) refer to the time (hour of day) that the transect line was started.

area. However, the most important data sets for documenting physical processes impacts from offshore sand mining contain quantified changes in sediment transport dynamics resulting from potential sand extraction scenarios.

Regional Historical Trends. Regional geomorphic changes between 1917/20 and 1982/91 were documented for assessing long-term, net coastal sediment transport dynamics using shoreline and bathymetric surveys. Although these data do not provide information on potential impacts of sand dredging from proposed borrow sites, they do provide a means of verifying predictive sediment transport model results relative to infilling rates at borrow sites and net longshore sand transport rates. Between 1917/20 and 1982/91, net sediment movement was to the west throughout the Alabama coastal zone. This direction of transport was consistent with historical shoreline change trends (see BYRNES *et al.*, 1999) and dredging practice at Mobile Pass channel (disposal is always west of the channel).

At Area 1, net erosion and accretion rates associated with sand ridge migration were quite variable over short distances. Shoal migration near the sand resource area illustrated net transport to the west, but transport rates varied from 9,000 to 34,000 m^3/year. Net sediment volume change at the borrow site indicated no significant movement for the period of record; however, absolute sediment volume change (erosion plus accretion) averaged about 8,500 m^3/year. Although the potential for transport (and borrow site infilling) was high in this area, the average sand transport rate was consistent with other sand resource areas south and east of Fort Morgan and Gulf Shores.

Near the northern boundary of Area 2, a well-defined zone of erosion existed adjacent to a zone of deposition as a shoreface sand ridge migrated to the west under the influence of incident shelf processes (Figure 7). The zone of deposition indicated a net accumulation rate of about 6,200 m^3/year, whereas the net erosion rate was calculated as about 9,100 m^3/year (rates of change were normalized relative to borrow site surface area). As such, the average, long-term net transport rate for the borrow site was estimated as 7,300 m^3/year. For Area 3, net erosion at the borrow site was about 585,000 m^3, or about 8,800 m^3/year.

West of Mobile Pass at Area 4, three specific sub-sites documented sediment deposition at 1) the potential sand borrow site, 2) Mobile Outer Mound (constructed by the USACE), and 3) the dredged material disposal area used by the USACE during channel dredging operations (Figure 7). For the sand borrow site, total sediment deposition was about 4.8×10^6 m^3 between 1917/20 and 1991, or about 66,000 m^3/year accumulation.

Net alongshore changes in erosion and accretion, determined from seafloor changes in the littoral zone between Perdido Pass and Mobile Pass, indicated a gradient in transport to the west at about 106,000 m^3/year. Variations in longshore transport are evident in patterns of change recorded on Figure 7 (alternating zones of erosion and deposition along the shoreline). It appears that areas of largest net transport existed just east of Gulf Shores where coastal erosion was greatest in the littoral zone.

Borrow Site Infilling. Predicted sediment infilling rates ranged from a maximum of 117 m^3/day (42,700 m^3/year) at Area 1 to a minimum of 37 m^3/day (13,500 m^3/year) at Area 4. Sediment that replaces sand mined from a borrow site will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. However, infilling rates and sediment types are expected to reflect natural variations that currently exist within sand resource areas. As

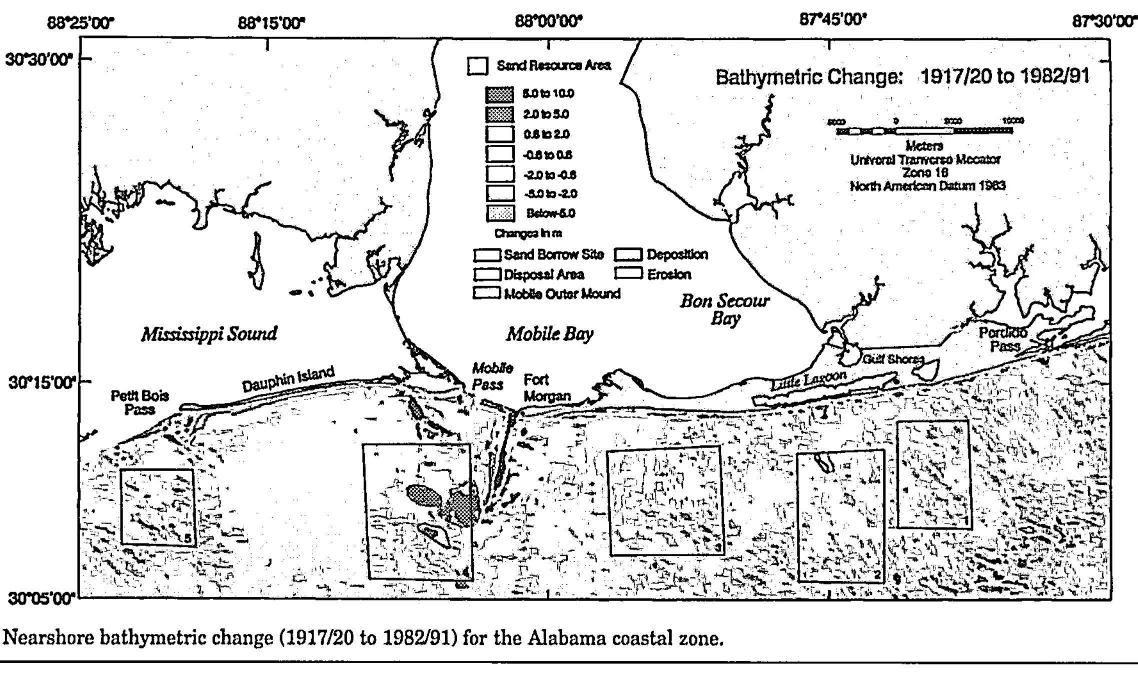


Figure 7. Nearshore bathymetric change (1917/20 to 1982/91) for the Alabama coastal zone.

such, borrow sites at Areas 1, 2, and 3 are expected to fill with material adjacent to the excavated sites (the entire shelf surface south and east of Fort Morgan is at least 95% medium-to-fine sand; Table 1; McBride and Byrnes, 1995; Byrnes *et al.*, 1999). Sediment type in this region is relatively consistent and compatible for beach nourishment. The borrow site at Area 4, however, likely will fill with fine-grained sediment (*i.e.*, fine sand to clay) exiting Mobile Bay by natural processes and maintenance channel dredging and disposal. Because the potential local infilling rate plus sediment flux from Mobile Bay is substantially greater than shelf transport rates alone, the borrow site in Area 4 should fill faster than other borrow sites, limiting the likelihood for multiple dredging events from the same area.

Nearshore Sediment Transport Modeling. Sediment transport modeling results for the coast east of Fort Morgan and Dauphin Island indicate large variations in transport magnitude; however, the overall tendency along both shorelines is east-to-west littoral drift. For Gulf Shores and vicinity, longshore sand transport rates generally increased from west-to-east (50,000 to 150,000 m³/year; Figure 8) for seasonal simulations. Due to specific regions of wave focusing associated with seasonal wave characteristics, variations in sediment transport potential existed along the shoreline. For example, sediment transport calculations for spring and winter seasons indicated relatively high transport rates just west of Gulf Shores and lower transport rates along the western shoreline near Fort Morgan.

Along the Dauphin Island shoreline, greater seasonal variability in transport rates was evident. As a result of wave sheltering provided by Sand Island and offshore shoals on the Mobile Pass ebb-tidal delta, there was a marked decrease in annualized transport rates between the central portion of the island (120,000 m³/year) and its eastern terminus (<10,000 m³/year). Because the net direction of transport is from east-to-west, an increase in modeled transport rates from the east end of Dauphin Island to the center of the island created a net erosional trend. This result compares well with observed shoreline change between 1847/67 and 1978/81, where peak observed erosion, as well as peak computed erosion, occur at approximately the same location.

Benthic Environment

Water Column

During the May survey, bottom temperatures averaged 21.5°C. Bottom salinities averaged 31.1 ppt and ranged from 28.2 ppt in Area 3 to 33.9 ppt in Area 4. Dissolved oxygen averaged 3.16 mg/L and ranged from 1.22 mg/L (hypoxia) in Area 4 to 6.19 mg/L in Area 1. Bottom temperatures during

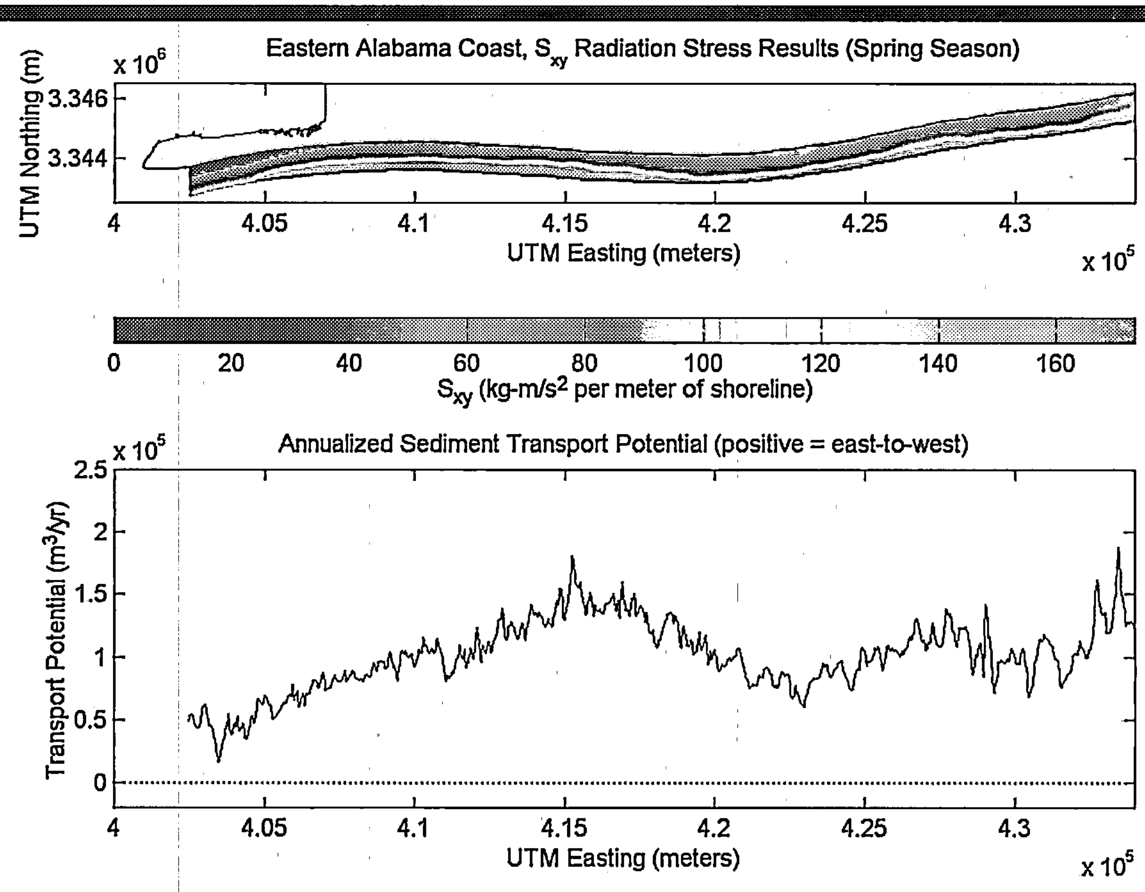


Figure 8. S_{xy} radiation stress values and annualized sediment transport potential for the spring season along eastern Alabama beaches.

the December survey averaged 16.9°C and ranged from 14.9°C in Area 2 to 18.5°C in Area 4. Salinities averaged 31.7 ppt and ranged from 31.2 ppt in Area 2 to 32.1 ppt in Areas 2 and 5. Dissolved oxygen values averaged 6.78 mg/L and ranged from 6.37 mg/L in Area 4 to 7.65 mg/L in Area 1.

Sediment Grain Size

Surficial sediments in Areas 1, 2, and 3 were primarily sand. In Area 1, all samples contained >95% sand with lesser amounts of gravel and no fines. All but two samples from Area 2 and two samples from Area 3 contained >96% sand with some gravel. Grain size was much more variable in Areas 4 and 5, where stations generally had substantial amounts of fines compared to Areas 1, 2, and 3. In Areas 4 and 5, <90% sand occurred in 43% and 45% of the samples, respectively.

Infauna

Infauna were more abundant during May (Table 2), when 64,613 individuals (70% of the project total) were collected. Numerical dominants were the gastropods *Caecum pulchellum* and *C. cooperi* that represented 24% and 9%, respectively, of all infauna collected during both surveys. *C. pulchellum* and *C. cooperi* occurred nearly exclusively in Areas 1, 2, and 3 during May (99.6% of all individuals) and December (99.8%) (Table 3). Areas 4 and 5 were numerically dominated by polychaetes during both surveys. Less than half (47%) of the 538 taxa censused were collected during both May and December. Most (70%) of the survey-restricted taxa were collected in May.

Mean number of infaunal taxa, individuals, and densities were higher at all areas during May than December (Table 2). Mean diversity (H') varied little among areas or between cruises. Mean values of H' ranged from 3.66 in Area 3 to 2.78 in Area 2 during May. Similarly, mean evenness (J') values varied little across areas and were consistently higher during the December survey than the May survey. Mean J' values ranged from 0.84 in Area 3 during December to 0.61 in Area 2 during May. Margalef's species richness (D) was consistently higher during May in all areas. The highest mean D value (15.21) was recorded from Area 3 during May, and the lowest D value (6.85) was recorded for Area 4 during December.

Cluster analysis and MDS identified six groups (A through F) of stations that were similar with respect to species composition and relative abundance (Figures 2 and 9). These analyses revealed a strong temporal effect (Figure 9a). With the exception of Group E, which has stations from both surveys, station groups included samples collected exclusively during one of the two surveys (Figure 9b). Station Groups B and C contained the *Caecum*-associated assemblage from Areas 1, 2, and 3 during the May and December surveys, respectively (Figure 2). Group E stations were in Areas 4 and 5 during both surveys, and were dominated by polychaetous annelids with respect to both the number of taxa and overall abundance. Sediment grain size characteristics indicated that, except for Station Group E where the fine sediment fraction was greater relative to the other station groups, sedimentary regime was largely homogeneous within station groupings (Table 4).

Species typifying station groups (A through F) were determined by SIMPER analyses (Table 5). Species that most contributed to similarity patterns were: Group A—polychaetes *Spiophanes bombyx* and *Apoprionospio pygmaea*; Group B—*C. pulchellum, S. bombyx,* and *C. cooperi*; Group C—*C. pulchellum* and *C. cooperi*; Group D—amphipods *Eudevenopus honduranus* and *Protohaustorius* sp. C; Group E—polychetes *Paraprionospio pinnata, Nereis micromma,* and *Magelona* sp. H; and Group F—sipunculid *Phascolion strombi* and *N. micromma.*

The two-way ANOSIM test indicated significant differences in infaunal composition between surveys averaged over all sand resource areas ($R = 0.556$, $p < 0.001$) and between sand resource areas averaged over surveys ($R = 0.516$, $p < 0.001$). Pairwise comparisons of R among sand resource areas (Table 6) revealed that Area 1 and Area 5 were least alike ($R = 0.904$, $p < 0.001$), while Areas 4 and 5 were most similar with respect to assemblage composition ($R = 0.104$, $p < 0.004$).

Station groups defined by normal cluster analysis were analyzed using CDA to determine which environmental factors correlated best with the distribution of infaunal assemblages.

Table 2. *Summary of infaunal statistics by survey and sand resource area.*

	No. of Taxa		No. of Individuals		Density (individuals/m²)		H' Diversity		J' Evenness		D Richness	
Area	Mean Per Station	Standard Deviation	Mean Per Station	Standard Deviation	Mean Per Station	Standard Deviation	Mean Per Station	Standard Deviation	Mean Per Station	Standard Deviation	Mean Per Station	Standard Deviation
May 1997												
1	84	18	838	503	8,384	5,031	2.96	0.61	0.67	0.14	12.69	2.14
2	95	15	1,182	527	11,823	5,274	2.78	0.61	0.61	0.13	13.54	2.05
3	99	21	643	286	6,433	2,858	3.66	0.41	0.80	0.07	15.21	2.75
4	49	13	305	146	3,046	1,464	2.82	0.74	0.72	0.15	8.52	2.35
5	62	20	262	158	2,622	1,582	3.32	0.55	0.81	0.08	11.01	3.02
December 1997												
1	67	20	571	389	5,714	3,891	2.97	0.59	0.71	0.13	10.63	2.97
2	57	18	345	187	3,447	1,867	2.93	0.36	0.73	0.08	9.69	2.40
3	47	11	184	83	1,839	831	3.20	0.25	0.84	0.06	8.99	1.53
4	35	12	145	73	1,449	725	2.83	0.41	0.81	0.09	6.85	1.90
5	36	15	123	60	1,229	603	2.85	0.59	0.81	0.12	7.27	2.51

Table 3. *Five most abundant infaunal taxa in grab samples collected during the May and December 1997 surveys.*

May 1997			December 1997		
Area	Taxonomic Name	Count	Area	Taxonomic Name	Count
1	*Caecum pulchellum*	5,866	1	*Caecum pulchellum*	3,835
	Caecum cooperi	2,296		*Caecum cooperi*	1,019
	Bivalvia spp.	781		*Polygordius* spp.	1,001
	Spiophanes bombyx	600		*Eudevenopus honduranus*	503
	Tellina spp.	379		*Scoletoma verrilli*	268
2	*Caecum pulchellum*	9,183	2	*Caecum pulchellum*	1,737
	Caecum cooperi	3,059		*Caecum cooperi*	623
	Bivalvia spp.	1,440		*Polygordius* spp.	615
	Spiophanes bombyx	766		*Scoletoma verrilli*	357
	Tellina spp.	557		*Eudevenopus honduranus*	190
3	*Caecum pulchellum*	960	3	*Polygordius* spp.	321
	Caecum cooperi	851		*Caecum pulchellum*	278
	Spiophanes bombyx	772		*Caecum cooperi*	244
	Bivalvia spp.	717		Oligochaeta spp.	165
	Mediomastus spp.	574		*Mediomastus* spp.	132
4	*Paraprionospio pinnata*	1,680	4	*Branchiostoma* spp.	250
	Mediomastus spp.	729		*Armandia maculata*	209
	Spiophanes bombyx	243		*Nereis micromma*	201
	Apoprionospio pygmaea	202		*Mediomastus* spp.	199
	Magelona sp. H	198		*Magelona* sp. H	172
5	*Paraprionospio pinnata*	561	5	*Nereis micromma*	341
	Bivalvia spp.	225		*Mediomastus* spp.	211
	Mediomastus spp.	192		*Armandia maculata*	205
	Aricidea taylori	189		*Phascolion strombi*	103
	Polygordius spp.	149		*Aricidea taylori*	75

The first two CDA axes were used to analyze variability among those station groups identified as being similar with respect to species composition and relative abundance (Figure 10). The first CDA axis strongly correlated with survey (0.9867) (Table 7). Within surveys, the second CDA axis correlated well with percent sand (0.9024) and percent fine sediment (−0.8857). The class means of CDA variables for Station Groups A through F were plotted on CDA Axes 1 and 2 (Figure 10). This plot effectively displays separation of station groups with respect to measured environmental variables. Axis 1 was highly correlated with survey category, and Axis 2 was highly correlated with sediment grain size, contrasting samples with high proportions of fine sediments with those stations with high percentages of sand. Station Groups A and B separated from Groups C, D, and F along CDA Axis 1. Station Group E separated from all other station groups along CDA Axis 2, reflecting differences in sediment grain size. These first two CDA axes explained 99.2% of the variation in the group separation.

DISCUSSION

Physical Processes

Wave Transformation Modeling

Wave transformation results identified key areas of wave convergence, wave divergence, and shadow zones. For seasonal simulations, significant wave heights and angles experienced little variation seaward of the 15-m depth contour, landward of which the wave field becomes influenced by bathymetry. Seaward of Dauphin Island, wave heights were relatively consistent along the shoreline while the eastern end of the island was protected from significant wave energy by a shadow zone produced by Sand Island and subaqueous shoals associated with the Mobile Pass ebb-tidal delta. DOUGLASS (1994) documented a similar trend with visual observations of wave height, period, and angle collected in 1991. Several areas of wave convergence were identified from simulations for offshore Dauphin Island, including those associated with Mobile Outer Mound, which focused wave energy near Sand Island during most seasons. Wave focusing caused by Mobile Outer Mound most likely resulted in an unnatural increase in erosion at Sand Island, and during a storm event may erode the protective island. Areas of wave convergence and divergence east of Fort Morgan primarily were caused by southwest-oriented shoals on the continental shelf. For the 50-year storm simulation, wave patterns were similar to normal seasonal results. An increase in wave height was substantial in many areas where wave convergence occurred. For example, Mobile Outer Mound concentrated 4.0- to 4.5-m wave heights on Sand Island during storm simulations.

Similar wave modifications were indicated for post-dredging simulations. Seaward of Dauphin Island, maximum wave height differences for seasonal simulations ranged from ±0.02 to 0.2 m. These maximum changes dissipated relatively rapidly as waves break and advance towards the coast. East of Fort Morgan, maximum wave height differences were slightly larger (±0.2 to 0.4 m) due to borrow site sizes and orientations, as well as their proximity to the shoreline. However, wave energy was dissipated as waves propagated toward the shoreline, and increases in wave height of 0.1 m or less were observed along the coast. During extreme wave conditions (*i.e.,* the 50-year storm), wave heights were modified

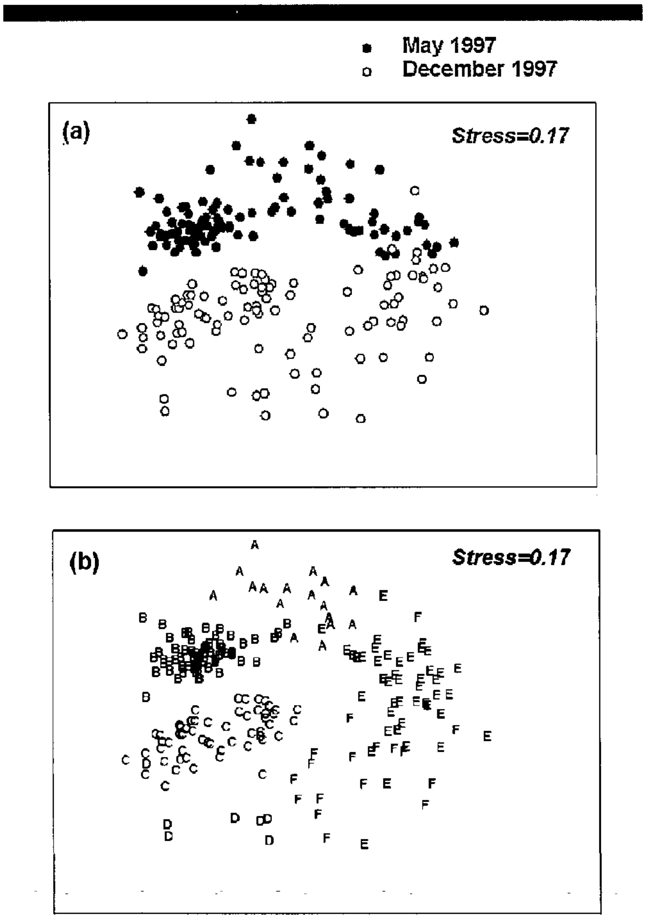


Figure 9. Multidimensional scaling plots of infaunal samples collected during May and December 1997 at five offshore Alabama sand resources areas labeled by (a) survey and (b) groups determined from cluster analysis.

between ±1.5 and 2.0 m, suggesting a rather large change. However, much of this wave energy was dissipated before waves reached the coast. For example, wave height increases were less than 0.5 m along most of Sand Island for storm simulations. Overall, wave modifications caused by offshore sand extraction during seasonal and storm simulations were minimal.

Currents and Circulation

Throughout the study area, currents were predominantly parallel to shelf depth contours and driven by wind stress. Winds were shown to produce an approximate five-fold increase in current speed, with about 10 cm/sec currents during mild wind conditions to about 50 cm/sec during strong wind conditions. Frictional effects on the continental shelf modified currents as well; currents were strongest in the surface layer and weaker along the bottom and nearshore boundaries. Major bathymetric and shoreline features, such as the ebb-tidal shoals encompassing Sand Island and vicinity at the western margin of Mobile Pass, modified predominant flow directions. Less significant bathymetric features, such as shore-oblique

Table 4. *Average percentages of gravel, sand, and fine sediments from samples collected within station groups determined from cluster analysis of infaunal samples.*

Station Group	Gravel	Sand	Fines
A	0.86	90.58	8.56
B	0.58	98.48	0.94
C	0.47	97.49	2.04
D	0.14	99.60	0.26
E	1.21	64.22	34.57
F	0.65	89.38	9.97

Table 5. *Average abundance of infaunal species accounting for at least 50% of the within group similarity in Station Groups A through F.*

Group	Species	Average Abundance	Average Similarity
A	*Spiophanes bombyx*	17.18	4.90
	Apoprionospio pygmaea	14.35	4.38
	Paraprionospio pygmaea	22.00	3.53
	Phascolion strombi	7.76	3.26
	Tectonatica pusilla	3.53	2.55
	Nassarius albus	7.59	2.20
B	*Caecum pulchellum*	262.90	4.79
	Spiophanes bombyx	35.52	4.48
	Caecum cooperi	102.34	4.05
	Prionospio cristata	12.38	2.70
	Paraprionospio pinnata	10.92	2.10
	Eudevenopus honduranus	9.20	2.05
	Nephtys picta	8.00	2.02
	Acteocina candei	7.95	1.73
	Ervilia concentrica	10.00	1.60
C	*Caecum pulchellum*	108.30	5.27
	Caecum cooperi	34.78	4.91
	Eudevenopus honduranus	14.06	3.38
	Scoletoma verrilli	13.22	3.27
	Armandia maculata	5.37	2.27
	Spiophanes bombyx	3.00	2.00
D	*Eudevenopus honduranus*	9.43	7.56
	Protohaustorius sp. C	7.29	5.86
	Armandia maculata	6.71	4.52
	Metharpinia floridana	3.71	2.87
E	*Paraprionospio pinnata*	45.50	6.53
	Nereis micromma	11.82	6.13
	Magelona sp. H	10.05	5.63
	Scoletoma verrilli	6.82	3.85
F	*Phascolion strombi*	8.71	7.12
	Nereis micromma	11.12	4.93
	Armandia maculata	12.29	3.32
	Tectonatica pusilla	2.12	2.66

Table 6. *Pairwise analysis of similarities tests comparing infaunal assemblage composition. Significance levels (in parentheses) are based on comparisons of actual R statistics with a distribution generated from 999 random permutations. *($p<0.001$), **($p<0.005$).*

Sand Resource Area	1	2	3	4
1				
2	0.279*			
3	0.437*	0.228*		
4	0.742*	0.655*	0.505*	
5	0.904*	0.820*	0.642*	0.104**

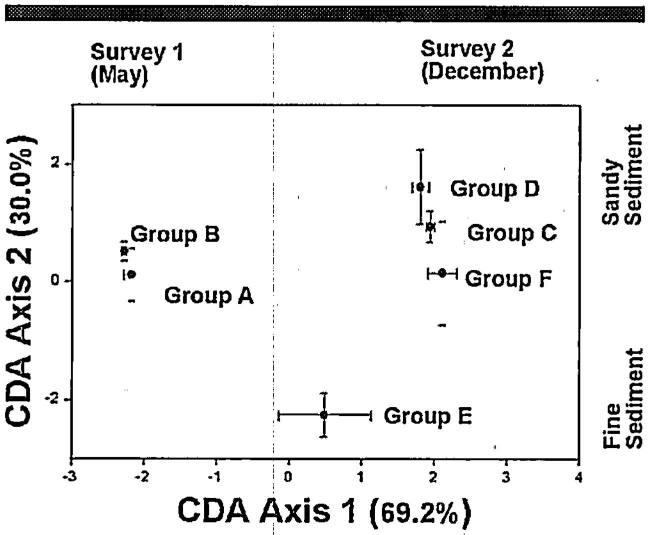


Figure 10. Means (± 95% confidence intervals) of canonical variables for infaunal Station Groups A through F plotted on Canonical Discriminant Analysis (CDA) Axes 1 and 2.

Table 7. *Correlations between the first two axes of canonical discriminant analysis and environmental variables recorded for Station Groups A through F.*

Variable	Axis 1	Axis 2
Survey	0.9867	0.1619
% Gravel	−0.0296	−0.2906
% Sand	−0.1382	0.9024
% Fines	0.1404	−0.8857
Water Depth	−0.0899	0.6118

shoals prevalent east of Mobile Pass or Mobile Outer Mound located in Area 4, had little effect on large-scale circulation.

For Areas 1, 2, and 3, surface shape is rough with numerous ridges and swales. Circulation in the region appeared to be affected by bottom friction, but the influence was recognized as weaker flow at the bottom and nearshore areas than at the surface. Because sand resource areas east of Mobile Pass contain numerous ridges and swales, it is doubtful that alteration of a single ridge would significantly impact bottom roughness or have measurable impact on regional current flow.

Currents in Area 4 were influenced primarily by Sand Island, which produced a significant steering effect to divert flow along a general northwest/southeast axis, parallel to bathymetric contours. ADCP field surveys showed highly localized bottom flow vectors influenced weakly by the presence of Mobile Outer Mound. Adjacent flow vectors did not appear to be influenced by the mound, but they were directed along depth contours, consistent with prevailing flow through the region. This suggested that small-scale bathymetric irregularities, such as a sand borrow site, while producing a localized effect on currents, is not expected to impact prevailing or ambient flow characteristics.

Sediment Transport

Borrow Site Infilling. Small changes in sediment transport at borrow sites are expected after sand mining is completed. Given the water depths and geometries at proposed borrow sites, minimal impacts to waves and natural sediment transport processes are anticipated during infilling. Volume and type of sediment that replace excavated sand from borrow sites will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. However, infill sediment is expected to reflect surface sediment texture at adjacent ridge and swale deposits.

Longshore Sediment Transport. For average annual conditions, mean longshore sand transport rates landward of borrow sites in Areas 1, 2, and 3 are approximately equal. Along the eastern portion of Dauphin Island (landward of Area 4), transport rates were estimated to be approximately 35% of the rates associated with the shoreline east of Fort Morgan. The absolute value of the mean difference between existing and post-dredging conditions generally decreased east-to-west, with a maximum difference of approximately 8,000 m^3/year (about 8%) along the shoreline influenced by dredging in Area 1. Because the net longshore sediment transport rate predicted landward of Area 4 was relatively low (approximately 33,000 m^3/year; similar to DOUGLASS [1994]), the percentage difference between existing and post-dredging conditions was greatest for this site (about 10%). Results from analyses of a 50-year event indicated similar trends.

KELLEY *et al.* (2004) developed an analytical approach for quantifying the significance of potential physical environmental impacts associated with offshore sand mining. The approach incorporates an analysis of nearshore wave transformation and wave-induced longshore sediment transport for existing and post-dredging conditions relative to temporal and spatial variations in the local wave climate. Based on wave transformation results and the natural variability of normal wave climate for coastal Alabama, predicted changes in longshore sediment transport rates resulting from offshore sand mining (up to 8 to 10% of existing conditions) are expected to have minimal impact along the shoreline.

Benthic Environment

Infaunal assemblages within the five sand resource areas included common taxa expected for similar sedimentary environments and water depths in the northern Gulf of Mexico (DAMES & MOORE STAFF, 1979; SHAW *et al.*, 1982). Statistical representation of the assemblages by univariate and multivariate analyses helped reduce the complexity inherent in such samples. Areas were effectively discriminated with respect to assemblage composition and basic patterns were linked to environmental variables. Understanding statistical properties of assemblages provides a strong basis for designing monitoring programs to evaluate impacts and recovery of future dredging projects in the areas.

Univariate and multivariate techniques used in our analyses actually provided differing perspectives on infaunal assemblages in the five areas. Univariate approaches such as H', J', and D that collapse all of the species-level information into a single index gave no indication of faunal composition in different areas. For example, mean values of H' and J' were very similar among sand resource areas and between surveys, giving the impression that infaunal assemblages in all areas were similar. In contrast, multivariate analyses revealed clear differences in assemblage composition between eastern (1, 2, and 3) and western (4 and 5) areas, as well as differences between surveys. This disparity in results from univariate and multivariate analyses of the same data set is a common finding with benthic assemblages (WARWICK and CLARKE, 1991). Although multivariate methods effectively uncover patterns from complex sets of multi-species data, results generated in the form of ordination diagrams cannot always be used to clearly demonstrate impacts. Single index statistics, despite their shortcomings, are better suited for documenting stress or direction of change. Therefore until a better method emerges, future monitoring and impact analyses should employ both univariate and multivariate approaches (WARWICK and CLARKE, 1991).

The field surveys also provide data properties that will greatly assist managers in designing monitoring programs to assess the impacts and recovery of infaunal assemblages following any future mining projects that may occur within the five areas. These properties (*e.g.,* inter-sample variability) can be used to calculate samples sizes necessary to achieve desired levels of precision, statistical power, or species accumulation. Such information often is lacking in the design phase of impact or monitoring studies.

Characterization of existing infaunal assemblages and their statistical properties provide a good basis for designing and analyzing future studies. Analyses of infaunal composition, distribution, and abundance will to some extent serve as a foundation for evaluating impacts and recovery by similar taxa in similar environments at locations other than the Alabama shelf.

Infaunal species assemblages exhibited a marked change from east to west in the study area. Overall, eastern sand resource areas (1, 2, and 3) were similar in assemblage composition and different from western areas (4 and 5), which were most similar in pairwise comparisons of all sand resource areas. Differences were most pronounced comparing Area 1 to Area 5. This broad-scale zonation is most likely due to the influence of discharges from Mobile Bay, which predominantly move toward the west-southwest along the inner shelf (DINNEL *et al.,* 1990; STUMPF *et al.,* 1993). River discharges affect adjacent shelf environments by changing salinity, temperature, nutrients, and other water column variables, as well as transporting fine particulates to the seafloor. These changes result in an offshore hydrographic structure resembling estuarine conditions (BLANTON and ATKINSON, 1978), which affects exploitation by infauna (HANSON *et al.,* 1981; TENORE, 1985). There also was spatial variability of infauna within resource areas, primarily in Areas 4 and 5. Homogeneous sand and infauna were characteristic of eastern areas, whereas for western areas, sand station assemblages were distinct from fine sediment (silt and clay) assemblages, regardless of survey season. Sand environments on the shelf east of Mobile Pass yielded assemblages that differed from sand assemblages west of Mobile Pass, suggesting that bay discharge was a prime determinant of broad spatial distributional patterns. In areas west of Mobile Pass, sediment type was a finer scale factor influencing habitat suitability for infauna, as illustrated by differences between sand and fine sediment assemblages. Because outwelling from Mobile Bay rarely flows to the east (DINNEL *et al.,* 1990; STUMPF *et al.,* 1993), assemblage differences between the east and west Alabama shelf are likely to be a persistent feature of benthic community structure in the area. RAKOCINSKI *et al.* (1998) also found alongshore faunal gradients in beach and shallow subtidal benthos when comparing areas just outside the eastern and western geographic boundaries of this study.

Between-survey differences in assemblage composition were striking, particularly fewer taxa overall and lower abundance during December. Like other benthic community parameters in open shelf systems, species richness varies on multiple temporal and spatial scales, and little is known of the manner and degree to which local patterns are influenced by broad geographic richness patterns (GRAY, 2002). Reasons for the strong temporal patterns observed in this study may be due to a variety of causes, including variations in reproductive times and subsequent settlement by component species. Sand bottoms across the area yielded different assemblages between surveys primarily because sand generalists (taxa that were collected from sand stations across the study area) either were greatly diminished in abundance or completely absent during December. Conversely, assemblages at most stations with measurable amounts of silt and clay (Group E stations) did not change with survey. Highly abundant taxa in fine sediment areas, such as *Magelona* sp. H (=*M.* cf. *phyllisae*), *Mediomastus* spp., and *Paraprionospio pinnata,* are widespread species also characteristic of northern Gulf estuaries (GASTON *et al.,* 1995). These species are components of a group of opportunistic infauna with high reproductive capacity and dispersal ability (GRASSLE and GRASSLE, 1974; GASTON and EDDS, 1994), also commonly occurring inshore to mesohaline (18 to 5 ppt) environments (MCBEE and BREHM, 1982; GASTON and EDDS, 1994; RUTH *et al.,* 1994; GASTON *et al.,* 1995). Such taxa tend to be surface and sub-surface deposit feeders adapted to living in fine sediments, and are able to rebound from periodic perturbations, such as summer hypoxia (HOLLAND, 1985; GASTON and EDDS, 1994). In fact, some near-bottom dissolved oxygen levels in Area 4 were hypoxic (< 2.0 mg/L) during the May survey. The relative environmental harshness of western areas was reflected in fewer taxa relative to Areas 1, 2, and 3 during May and December. Infaunal assemblages in Areas 4 and 5 thus include opportunistic species that colonize perturbed habitats in general.

Knowledge of faunal component lifestyles allows some predictions of dredging impacts and subsequent recolonization and recovery of community composition (NEWELL *et al.,* 1998). Although this study provides only benthic community characterization, review of previous dredging studies can be used to infer offshore mining effects on infaunal community patterns in the study area. This is the case with respect to seasonal timing of dredging, as well as disturbances from sand removal, including bathymetric form and depth of substratum changes.

Documented impacts of sand mining are varied with respect to infaunal recolonization and recovery at offshore dredged sites, depending particularly on examined community indices. While levels of abundance and diversity may recover within 1 to 2 years in certain cases (*e.g.,* SALOMAN *et al.,* 1982; JOHNSON and NELSON, 1985), it may take many years to recover in terms of sediment characteristics and species composition. WILBER and STERN (1992) reexamined infaunal data by grouping species into functional groups called ecological guilds based on similarities in feeding mode, locomotory ability, and sediment depth occurrence. They concluded that infaunal communities recolonizing borrow sites may remain in an early successional stage for 2 to 3 years or longer as opposed to being completely recovered in shorter time frames.

Because infaunal assemblages are affected greatly by sedimentary habitat, the recovery time of benthic assemblages can depend in large measure on the degree and duration of sediment alteration from sand borrowing (VAN DOLAH, 1996). Changes in sediment characteristics in borrow sites may occur because sediment texture of the newly exposed substratum is different from the removed sediments, or because the excavated site becomes a reservoir of fine sediments and organic material. A key assumption when supposing short-term (*i.e.,* within 2 years) mining-related effects is that dredging a pronounced bathymetric depression would be avoided. Many studies show decreases in mean grain size, and in some cases, increases in silt and clay content in borrow sites following dredging (NATIONAL RESEARCH COUNCIL, 1995), particularly in relatively steep bathymetric depressions sometimes formed by dredging.

In addition to the shape of topographic features created by offshore sand mining, reworking of exposed sediments is an important process in benthic recovery after dredging because it promotes diffusion of dissolved oxygen into soft substrata exposed during dredging. KENNICUTT *et al.* (1995) found that shelf sediments of the Alabama coastal region are continually reworked to 60-m depths, particularly due to storms and through influxes of terrestrial material associated with river discharges. The eastern portion of the study area apparently is not a fine-grained depositional environment, given the relative lack of fine sediments, and the western portion of the study area is greatly influenced by Mobile Bay discharges. Sediment reworking may be less important for assemblage recovery processes west of Mobile Pass compared to eastern areas because opportunistic taxa in Areas 4 and 5 presumably are better adapted to environmental stress. Physical dynamics of the study area would promote biological recovery of dredged sites through sediment reworking. Moreover, because sandy sediments on the eastern Alabama shelf are vertically uniform, sediments exposed by mining would be similar to those removed, thus allowing a similar suite of taxa to colonize dredged sites.

Early-stage recruitment of defaunated sediment has been found to occur rapidly in coastal systems (GRASSLE and GRASSLE, 1974; MCCALL, 1977; SIMON and DAUER, 1977; RUTH *et al.,* 1994). Dredged sites on the Alabama shelf would be colonized by opportunistic infauna relatively quickly, particularly taxa such as *Mediomastus ambiseta* (RUTH *et al.,* 1994), and *Magelona* sp. H and *Paraprionospio pinnata* (GASTON and EDDS, 1994). Timing to avoid dredging during the peak recruitment period of warm months would facilitate more rapid faunal recovery. It is likely that recolonization and recovery processes would differ between areas east and west of the mouth of Mobile Bay. Dredged sites in Areas 4 and 5 would be expected to recover more quickly than eastern areas because of the opportunistic nature of numerically dominant infauna west of the bay mouth. Sediment and infauna in eastern areas are homogeneous, which promotes benthic recovery after dredging through immigration of fauna from adjacent non-dredged areas (VAN DOLAH *et al.,* 1984), complementing colonization via larval recruitment. Preservation of non-dredged areas throughout an offshore borrow site has been cited as a factor potentially contributing to more rapid community recovery after dredging (JUTTE *et al.,* 2002). It is important to note that the nature of the reestablished community would not necessarily return to pre-dredged species composition. While levels of diversity and abundance may be reached or exceeded within a relatively short time after dredging, the pertinent goal of recovery success is for infaunal assemblages to become equivalent to nearby non-dredged areas within a relatively brief interval after dredging. Because assemblages vary over time, efforts to ascertain recovery success can be confounded by natural variability, and so overall temporal changes in community parameters of non-dredged areas should be taken into account.

CONCLUSIONS

Literature and data collected, analyses performed, and simulations conducted for this study indicate that sand mining at sites evaluated on the Alabama OCS should have minimal environmental impact on fluid and sediment dynamics. Although physical environmental impacts resulting from potential sand dredging alternatives tested in this study have been identified through wave and sediment transport simulations, under normal wave conditions, the maximum change in sand transport dynamics is about 8 to 10% of existing conditions. Based on wave transformation results and natural variability of the normal wave climate for coastal Alabama, predicted changes in longshore sediment transport rates resulting from offshore sand mining are expected to have minimal impact along the shoreline. Although changes during storm conditions illustrated greater variation, the relative impacts were similar to non-storm conditions. Furthermore, the ability of models to predict storm wave transformation and resultant sediment transport is less certain than for normal wave conditions.

Impacts to the benthic community are expected from physical removal of sediments and infauna. Based on previous studies, and assuming that dredging does not produce deep pits causing very fine sediment deposition or hypoxic or anoxic conditions, levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition may take longer. Offshore areas west of Mobile Bay can be expected to recover more quickly than areas seaward and east of Fort Morgan because of opportunistic life history characteristics of numerically dominant infauna.

ACKNOWLEDGMENTS

The MMS funded this project under Contract No. 14-35-01-97-CT-30840. Authors are grateful for assistance and expertise of numerous individuals who participated in this project. Contributors include J.S. Ramsey (Sediment Transport Modeling), J.D. Wood (Currents and Circulation), F. Li (Bathymetric Change), and E. Hunt (Report Preparation) from Applied Coastal Research and Engineering, Inc.; F.B. Ayer, III (Benthic Surveys Director), P.S. Fitzgerald (Benthic Survey 1 Scientist and Benthic Survey 2 Chief Scientist), A.D. Hart (Benthic Sampling Design and Statistical Analyses), and M.H. Schroeder, B.D. Graham, and B.E. Stanaland (Benthic Survey 2 Scientists) from Continental Shelf Associates, Inc.; B.A. Vittor (Benthic Manager), L.W. Sierke (Benthic Surveys Scientist and Taxonomic Supervisor), M.D. Williams (Benthic Survey 2 Scientist), and F. Fernandez (Benthic Data Entry) from Barry A. Vittor & Associates, Inc.; K.F. Bosma (Wave Transformation Modeling and Borrow Site Infilling Calculations) from Woods Hole Group; W.C. Isphording (Grain Size Analyses) from the University of South Alabama; and B.S. Drucker (Contracting Officer's Technical Representative) and J.M. Carlson (Contracting Officer) from the MMS. The manuscript was substantially improved by the thorough and insightful technical comments of two anonymous reviewers.

LITERATURE CITED

BLANTON, J.O. and ATKINSON, L.P., 1978. Physical transfer processes between Georgia tidal inlets and nearshore waters. *In:* M.L. WILEY (ed.), *Estuarine Interactions.* New York: Academic, pp. 515–532.

BRAY, J.R. and CURTIS, J.T., 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs,* 27, 325–249.

BYRNES, M.R. and HILAND, M.W., 1995. Large-scale sediment transport patterns on the continental shelf and influence on shoreline response: St. Andrew Sound, Georgia to Nassau Sound, Florida, U.S.A. *In:* LIST, J.H. and TERWINDT, J.H.J. (eds.), *Large-Scale Coastal Behavior. Marine Geology,* 126, 19–43.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; RAMSEY, J.S.; SNYDER, D.B.; BOSMA, K.F.; WOOD, J.D.; THIBAUT, T.D., and PHILLIPS, N.W., 1999. *Environmental Survey of Identified Sand Resource Areas Offshore Alabama.* Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals (INTERMAR) Division, *OCS Report MMS 99-0052,* 322p. + 113p. appendix. Online version of report at http://www.oceanscience.net/mms_nj_ny/related_al.htm

CLARKE, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology,* 18, 117–143.

CLARKE, K.R. and GORLEY, R.N., 2001. Primer v5: User Manual/ Tutorial PRIMER-E, Plymouth, UK.

DAMES & MOORE STAFF, 1979. The Mississippi, Alabama, Florida Outer Continental Shelf Baseline Environmental Survey; MAFLA, 1977/78. Washington, DC: U.S. Department of the Interior, Bureau of Land Management, Volume 1A, Program Synthesis Report, 278p.

DINNEL, S.P.; SCHROEDER, W.W., and WISEMAN, JR., W.J., 1990. Estuarine-shelf exchange using Landsat images of discharge plumes. *Journal of Coastal Research,* 6(4), 789–799.

DOUGLASS, S.L., 1994. Beach erosion and deposition on Dauphin Island, Alabama, U.S.A. *Journal of Coastal Research,* 10(2), 306–328.

FIELD, J.G.; CLARKE, K.R., and WARWICK, R.M., 1982. A practical strategy for analysing multispecies distribution patterns. *Marine Ecology Progress Series,* 8, 37–52.

GASTON, G.R. and EDDS, K.A., 1994. Long-term study of benthic communities on the continental shelf off Cameron, Louisiana: A review of brine effects and hypoxia. *Gulf Research Reports,* 9(1), 57–64.

GASTON, G.R.; BROWN, S.S.; RAKOCINSKI, C.F.; HEARD, R.W., and SUMMERS, J.K., 1995. Trophic structure of macrobenthic communities in northern Gulf of Mexico estuaries. *Gulf Research Reports,* 9(2), 111–116.

GILBERT, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring.* New York: Van Nostrand Reinhold, 320p.

GRASSLE, J.F. and GRASSLE, J.P., 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. *Journal of Marine Research,* 32, 253–284.

GRAY, J.S., 2002. Species richness of marine soft sediments. *Marine Ecological Progress Series,* 244, 285–297.

HANSON, R.B.; TENORE, K.R.; BISHOP, S.; CHAMBERLAIN, C.; PAMATMAT, M.M., and TIETJEN, J., 1981. Benthic enrichment in the Georgia Bight related to Gulf Stream intrusions and estuarine outwelling. *Journal of Marine Research,* 39, 417–441.

HART, A.D.; SHAUL, R.A., and VITTOR, B.A., 1989. *Environmental Monitoring in Block 132, Alabama State Waters.* Summary Report by Continental Shelf Associates, Inc., Jupiter, FL for Shell Offshore, Inc.

HOLLAND, A.F., 1985. Long-term variation of macrobenthos in a mesohaline region of Chesapeake Bay. *Estuaries,* 8(2A), 93–113.

HOUSTON, J.R., 1995. Beach nourishment. *Shore and Beach,* 63(1), 21–24.

HOUSTON, J.R., 2002. The economic value of beaches—a 2002 update. *Shore and Beach,* 70(1), 9–12.

HUMMELL, R.L., 1990. *Main Pass and the Ebb-Tidal Delta of Mobile Bay, Alabama.* Geological Survey of Alabama, *Circular 146,* 45p.

HUMMELL, R.L. and SMITH, W.E., 1995. *Geologic and Environmental Characterization and Near-term Lease Potential of an Offshore Sand Resource Site for Use in Beach Nourishment Projects on Dauphin Island, Alabama.* Final Report by the Geological Survey of Alabama, U.S. Department of the Interior, Minerals Management Service, MMS Cooperative Agreement No. 14-35-0001-30725, 165p.

HUMMELL, R.L. and SMITH, W.E., 1996. *Geologic Resource Delineation and Hydrographic Characterization of an Offshore Sand Resource Site for Use in Beach Nourishment Projects on Dauphin Island, Alabama.* Final Report by the Geological Survey of Alabama, U.S. Department of the Interior, Minerals Management Service, MMS Cooperative Agreement No. 14-35-0001-30781, 169p.

JOHNSON, R.O. and NELSON, W.G., 1985. Biological effects of dredging in an offshore borrow area. *Florida Scientist,* 48, 166–188.

JUTTE, P.C.; VAN DOLAH, R.F., and GAYES, P.T., 2002. Recovery of benthic communities following offshore dredging, Myrtle Beach, South Carolina. *Shore & Beach,* 70, 25–30.

KELLEY, S.W.; RAMSEY, J.S., and BYRNES, M.R., 2004. Evaluating the physical effects of offshore sand mining for beach nourishment. *Journal of Coastal Research,* 20(1), 89–100.

KENNICUTT, M.C., II; SCHROEDER, W.W., and BROOKS, J.M., 1995. Temporal and spatial variations in sediment characteristics on the Mississippi-Alabama continental shelf. *Continental Shelf Research,* 15(1), 1–18.

KIRBY, J.T. and ÖZKAN, H.T., 1994. *Combined Refraction/Diffraction Model for Spectral Wave Conditions, REF/DIF S. v. 1.1.* University of Delaware, Center for Applied Coastal Research, No. CACR-94-04.

MADSEN, O.S. and GRANT, W.D., 1976. *Sediment Transport in the Coastal Environment.* Massachusetts Institute of Technology, Department of Civil Engineering, *Report No. 209,* 105 pp.

MARGALEF, R., 1958. Information theory in ecology. *General Systematics,* 3, 36–71.

MCBEE, J.T. and BREHM, W.T., 1982. Spatial and temporal patterns in the macrobenthos of St. Louis Bay, Mississippi. *Gulf Research Reports,* 7(2), 115–124.

MCBRIDE, R.A. and BYRNES, M.R., 1995. Surficial sediments and morphology of the Southwestern Alabama/Western Florida panhandle coast and shelf. *Gulf Coast Association of Geological Societies Transactions,* 45, 393–404.

McCall, P.L., 1977. Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. *Journal of Marine Research,* 35(2), 221–266.

Miller, M.L., 1993. The rise of coastal marine tourism. *Ocean and Coastal Management,* 20, 181–199.

National Research Council, 1995. *Beach Nourishment and Protection.* Washington, DC: National Academy Press, 344p.

Newell, R.C.; Seiderer, L.J., and Hitchcock, D.R., 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology: An Annual Review,* 36, 127–178.

Parker, S.J.; Shultz, A.W., and Schroeder, W.W., 1992. Sediment Characteristics and Seafloor Topography of a Palimset Shelf, Mississippi-Alabama Continental Shelf. *In: Quaternary Coasts of the United States: Lacustrine and Marine Systems.* SEPM Special Publication 48, pp. 243–251.

Parker, S.J.; Davies, D.J.; Smith, W.E.; Crawford, T.G., and Kelly, R., 1993. *Geological, Economic, and Environmental Characterization of Selected Near-term Leasable Offshore Sand Deposits and Competing Onshore Sources for Beach Nourishment.* Final Report by the Geological Survey of Alabama, U.S. Department of the Interior, Minerals Management Service, MMS Cooperative Agreement No. 14-35-0001-30630, 223p.

Parker, S.J.; Davies, D.J., and Smith, W.E., 1997. *Geologic, Economic, and Environmental Characterization of Selected Near-term Leasable Offshore Sand Deposits and Competing Onshore Sources for Beach Nourishment.* Geologic Survey of Alabama, Environmental Geology Division, *Circular 190,* 173p. + app.

Pielou, E.C., 1966. Species-diversity and pattern-diversity in the study of ecological succession. *Journal of Theoretical Biology,* 10, 370–383.

Rakocinski, C.F.; Lecroy, S.E.; McLelland, J.A., and Heard, R.W., 1998. Nested spatiotemporal scales of variation in sandy-shore macrobenthic community structure. *Bulletin of Marine Science,* 63, 343–362.

Ramsey, J.S., 1991. A Study of Wave-Induced Currents Behind Shore Parallel Breakwaters. Department of Civil Engineering, University of Delaware, DE, M.C.E. Thesis, 101p.

Ruth, B.F.; Flemer, D.A., and Bundrick, C.M., 1994. Recolonization of estuarine sediments by macroinvertebrates: Does microcosm size matter? *Estuaries,* 17(3), 606–613.

Saloman, C.H.; Naughton, S.P., and Taylor, J.L., 1982. Benthic community response to dredging borrow pits, Panama City Beach, Florida. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, VA, *Miscellaneous Report No. 82-3,* 138p.

SAS Institute, Inc. Staff, 1989. *SAS/STAT ®User's Guide,* Version 6, Fourth Edition, Volume 1. Cary, North Carolina: SAS Institute, Inc., 943p.

Shaw, J.K.; Johnson, P.G.; Ewing, R.M.; Comiskey, C.E.; Brandt, C.C., and Farmer, T.A., 1982. *Benthic Macroinfauna Community Characterization in Mississippi Sound and Adjacent Waters.* Mobile, Alabama: U.S. Army Corps of Engineers, Mobile District, 442p.

Simon, J.L. and Dauer, D.M., 1977. Reestablishment of a benthic community following natural defaunation. *In:* Coull, B.C. (ed.), *Ecology of Marine Benthos.* Columbia, South Carolina: University of South Carolina Press, pp. 139–154.

Stumpf, R.P.; Gelfenbaum, G., and Pennock, J.R., 1993. Wind and tidal forcing of a buoyant plume, Mobile Bay, Alabama. *Continental Shelf Research,* 13(11), 1281–1301.

Tenore, K.R., 1985. Seasonal changes in soft bottom macrofauna of the U.S. South Atlantic Bight, p. 130–140 *In: Oceanography of the Southeastern U.S. Continental Shelf.* Atkinson, L.P.; Menzel, D.W., and Bush, D.W. (eds.). Washington, DC: American Geophysical Union.

van Dolah, R.F., 1996. Impacts of beach nourishment on the benthos: What have we learned? Proceedings of the Twenty-fourth Annual Benthic Ecology Meeting, Columbia, SC, p 82.

van Dolah, R.F.; Calder, D.R., and Knott, D.M., 1984. Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary. *Estuaries,* 7, 28–37.

Warwick, R.M. and Clarke, K.R., 1991. A comparison of methods for analyzing changes in benthic community structure. *Journal of the Marine Biological Association of the United Kingdom,* 71, 225–244.

Wilber, P. and Stern, M., 1992. A re-examination of infaunal studies that accompany beach nourishment projects. *Proceedings of the 5th Annual National Conference on Beach Preservation Technology, New Directions in Beach Management,* Florida Shore and Beach Preservation Association, Tallahassee, FL, pp. 242–257.

Williams, S.J., 1992. *Coasts in Crisis.* U.S. Geological Survey, *Circular 1075,* 32p.

Winer, H., 1988. *Numerical Modeling of Wave-Induced Currents Using a Parabolic Wave Equation.* Department of Coastal and Oceanographic Engineering, University of Florida, Gainesville, FL, Technical Report No. 80.

Journal of Coastal Research	20	1	25–43	West Palm Beach, Florida	Winter 2004

Effects of Sand Mining on Physical Processes and Biological Communities Offshore New Jersey, U.S.A.

Mark R. Byrnes†, Richard M. Hammer‡, Tim D. Thibaut§, and David B. Snyder‡

†Applied Coastal Research and Engineering, Inc.
766 Falmouth Road, Suite A-1
Mashpee, MA 02649, U.S.A.

‡Continental Shelf Associates, Inc.
759 Parkway Street
Jupiter, FL 33477, U.S.A.

§Barry A. Vittor & Associates, Inc.
8060 Cottage Hill Road
Mobile, AL 36695, U.S.A.

ABSTRACT

BYRNES, M.R.; HAMMER, R.M.; THIBAUT, T.D., and SNYDER, D.B., 2004. Potential effects of sand mining on physical processes and biological communities offshore New Jersey, U.S.A. *Journal of Coastal Research,* 20(1), 25–43. West Palm Beach (Florida), ISSN 0749-0208.

Physical processes and biological data were collected and analyzed for eight sand resource areas on the New Jersey Outer Continental Shelf to address environmental concerns raised by the potential for mining sand for beach replenishment. Nearshore wave and sediment transport patterns were modeled for existing and post-dredging conditions, with borrow site sand volumes ranging from 2.1 to 8.8 $\times$ 10^6 m^3. Wave transformation modeling indicated that minor changes will occur to wave fields under dominant directional conditions and selected sand extraction scenarios. Localized seafloor changes at borrow sites are expected to result in negligible impacts to the prevailing wave climate at the coast. At potential impact areas along the New Jersey coast, wave height changes averaged approximately $\pm$3 to 15% when compared with wave heights for existing conditions. For all selected sand borrow sites offshore New Jersey, average variation in annual littoral transport was approximately 10% of existing values. Because borrow site geometries and excavation depths are similar to natural ridge and swale topographic characteristics on the New Jersey OCS, infilling rates and sediment types are expected to reflect natural variations within sand resource areas.

Infaunal distribution and abundance correlated best with the relative percentages of gravel and sand in surficial sediments. In addition to sediment regime, other physical environmental differences between northern and southern portions of the study area also may have affected infaunal community patterns. Impacts to the benthic community are expected from physical removal of sediments and infauna. Based on previous studies, levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition may take longer. The nature and duration of benthic effects may differ with location of mined sites, due to physical and biological differences between northern and southern portions of the New Jersey shelf.

ADDITIONAL INDEX WORDS: *Bathymetric change, benthic, infauna, sediment transport, shoreline change, wave modeling.*

INTRODUCTION

Development of beaches for recreational purposes along the New Jersey coast started in the mid-1800s because of the attractive barrier island beaches and warm climate during summer. In addition, these beaches were near New York and Philadelphia metropolitan areas and accessible by boat, wagon, and rail (Quinn, 1977). The first beach developments were in Cape May, Long Branch, and Atlantic City (Wicker, 1951). Piers and boardwalks were built, along with shoreline protection structures to combat ocean wave forces at the coastline. Beach nourishment has been conducted since the 1950s at a number of vulnerable beach erosion hot spots to enhance recreation and protect upland areas from storm damage. The need for sand to replenish eroding beaches continues to concern local, State, and Federal resource agencies, prompting exploration and environmental evaluation of offshore sand resource areas for future use.

In recent years, there has been increasing interest in sand and gravel mining on the Outer Continental Shelf (OCS). The U.S. Department of the Interior, Minerals Management Service (MMS) has significant responsibilities with respect to potential environmental impacts of offshore sand and gravel mining. Existing regulations governing sand and gravel mining provide a framework for comprehensive environmental protection during operations. Guidelines for protecting the environment stem from a wide variety of laws, including the OCS Lands Act, National Environmental Policy Act, Endangered Species Act, Marine Mammal Protection Act, and others. Regulations require activities to be conducted in a manner which prevents or minimizes the likelihood of any occurrences that may cause damage to the environment.

This paper discusses some physical and benthic biological aspects of a study whose purpose and objectives were specified by the MMS. The study purpose was to address environmental concerns associated with potential sand mining operations at eight OCS sand resource areas offshore New Jersey for beach replenishment. Four objectives addressed the study purpose: 1) document potential modifications to waves due to offshore sand mining at selected borrow sites; 2) evaluate impacts of offshore sand mining relative to existing sediment transport patterns, sedimentary environments, and local shoreline processes; 3) characterize benthic ecological con-

03-708A received and accepted in revision 26 August 2003.

ditions in and around OCS sand resource areas using existing information and data collected from field surveys; and 4) evaluate infaunal assemblages and assess potential effects of offshore sand mining on these organisms, including an analysis of recolonization periods and success following dredging. Because monitoring surveys of actual sand mining operations were not to be conducted, the assessment of potential infaunal effects was based only on benthic infaunal characterization field surveys and existing literature. The paper focuses on physical and infaunal effects from sediment removal. It also provides statistical properties of local infaunal assemblages that will assist in designing future sand resource monitoring programs, which will set the stage for rigorous evaluations of post-mining conditions. Other potential impacts from sediment suspension/dispersion (turbidity) and deposition are addressed in Byrnes *et al.* (2000).

STUDY AREA

The inshore portion of the continental shelf, seaward of the Federal-State OCS boundary and within the Exclusive Economic Zone (EEZ), encompassed the study area from approximately 40°08′N latitude (Manasquan Inlet) to 38°55′N latitude (Cape May) (Figure 1). Although the Federal-State jurisdictional boundary marks the landward limit of the study area, the ultimate use of sand extracted from the OCS is for beach replenishment along the New Jersey coast. The seaward limit of the study area was within about 20 km of the shoreline. Sand resource areas were located between the 10- and 20-m depth contours. The continental shelf surface within the study area contains many morphologic features formed during the Holocene. Sand ridges 2 to 5 m high and 0.5 to 1.5 km apart were primary sand resource targets.

Eight sand resource areas were defined within the study area through a Federal-State cooperative agreement between the MMS and New Jersey Department of Environmental Protection (NJDEP), New Jersey Geological Survey (Uptegrove *et al.*, 1995). Seven borrow sites within Sand Resource Areas A1, A2, G1, G2, G3, C1, and F2 were defined to evaluate potential impacts of sand mining on wave and sediment transport processes (Figure 1). Sand Resource Area F1 was not included in the physical processes analysis because the quantity of sand was small ($<1 \times 10^6$ m^3) relative to beach replenishment needs, and water depths were greatest in this region, making potential dredging operations more complicated and costly.

REGIONAL SETTING

The outer coastline of New Jersey is approximately 210 km long and represents part of the passive, slowly subsiding, eastern North American continental margin (Klitgord *et al.*, 1988; Smith, 1996). Coastal features are represented by a series of barrier beaches and islands, punctuated by inlets that allow exchange of sediment and water between estuaries and the continental shelf (Figure 2), primarily as a function of tide.

Along the northern New Jersey coast, beaches formed at the base of Cretaceous, Tertiary, and Quaternary bluffs that extend up to 8 m above mean sea level (Uptegrove *et al.*, 1995). These eroding bluffs are the primary source of coastal sediment to adjacent beaches in northern New Jersey, where wave-generated longshore currents (Caldwell, 1966) distribute eroding sediment into spit deposits and barrier islands (*e.g.*, Sandy Hook Spit). Throughout this area, average grain size on beaches decreases southward from the eroding coastal bluffs and as mineralogical composition of sand changes south of Long Beach Island (Uptegrove *et al.*, 1995; Figure 2).

Along the barrier island shoreline from Manasquan Inlet south to Cape May, islands range in length from 8 to 29 km, protecting estuarine and coastal plain environments from direct wave attack. Estuaries, salt marshes, and tidal channels encompass the Intracoastal Waterway landward of barrier islands (Smith, 1996). Twelve inlets within the study area separate the barrier islands, resulting in complex tidal currents that produce lateral migration and redistribution of sand along adjacent shorelines (Ashley *et al.*, 1986; Ashley, 1987). To maintain navigability at these inlets, five have been stabilized with parallel rock jetties (Shark River, Manasquan, Barnegat, Absecon, and Cape May); three have been partially stabilized with one rock jetty or rock armoring on one shoreline (Great Egg, Townsends, and Hereford); and four have remained natural (Beach Haven, Little Egg, Brigantine, and Corson) (Uptegrove *et al.*, 1995). The five inlets with parallel rock jetties require regular maintenance dredging, and sand derived from these sites is placed on adjacent beaches as nourishment material in accordance with New Jersey's Rules on Coastal Zone Management (Mauriello, 1991).

METHODS

Existing literature and data were reviewed concerning offshore physical and benthic environments to evaluate potential changes resulting from sand mining. Regional geomorphic change, wave transformation, and circulation and sediment transport dynamics were analyzed, and two benthic characterization field surveys were conducted according to the following methods.

Physical Processes

Waves

The U.S. Army Corps of Engineers (USACE) Wave Information Study (WIS) results (1976 to 1995) for offshore New Jersey (WIS stations Au2067, Au2069, and Au2070) provided a detailed description of the regional wave climate for developing representative wave spectra. WIS stations are located at or near the offshore boundaries of wave transformation model grids (Figure 3). The closest available WIS station near the offshore boundary was used at each modeling reference grid. Rather than selecting average seasonal wave conditions, a detailed analysis was conducted to summarize existing WIS data into directional wave conditions and spectra. High-energy storm events were evaluated by reviewing existing literature on hurricanes and northeast storms (USACE, 1997) that passed through the New Jersey region. Analysis results, coupled with historical storm tracks and wave directions

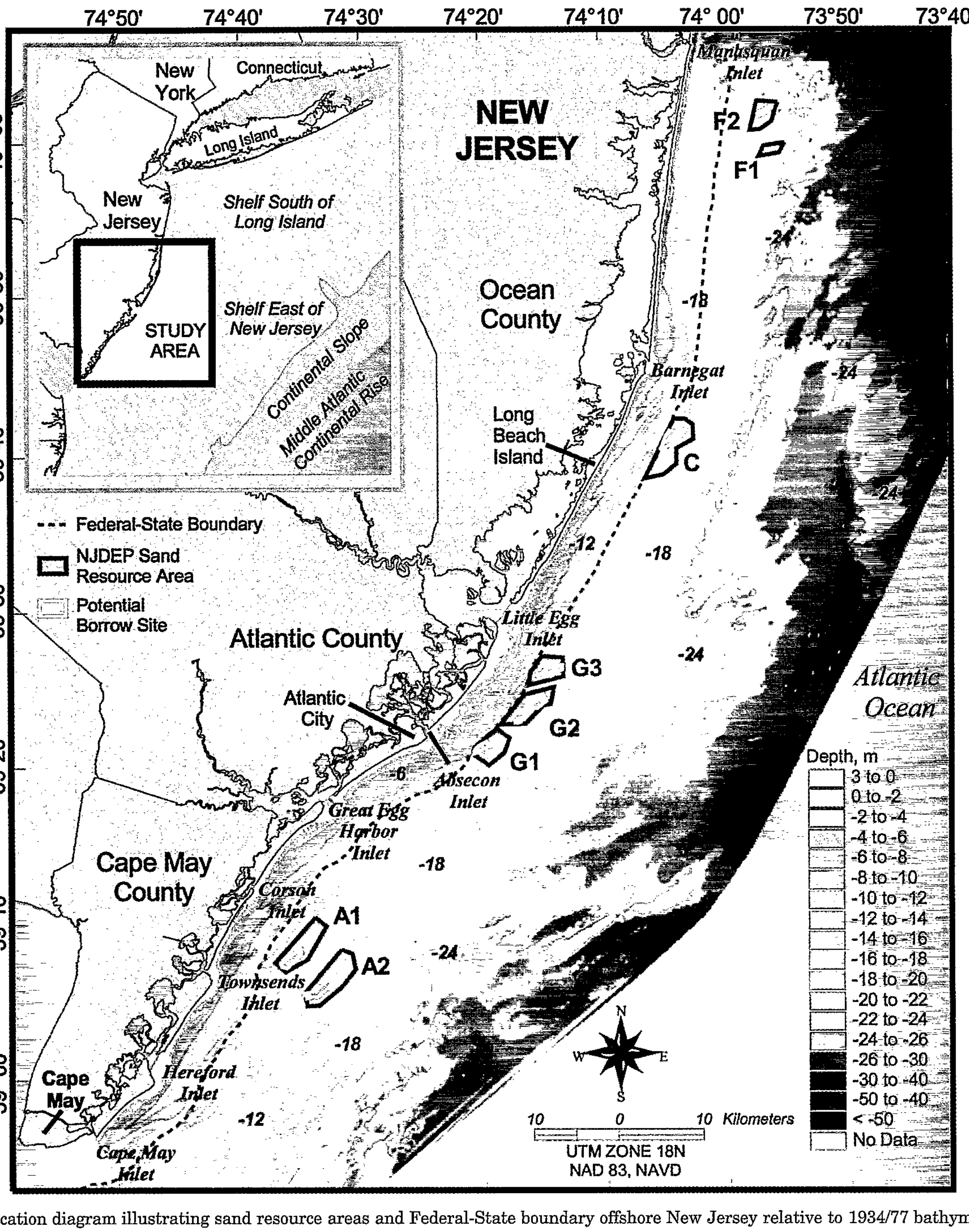


Figure 1. Location diagram illustrating sand resource areas and Federal-State boundary offshore New Jersey relative to 1934/77 bathymetry.

(1890 to 1997), were used to determine wave heights, directions, and frequencies for simulating 50-yr storm events. Surge values reported by KRAUS *et al.* (1988) for Monmouth Beach, New Jersey and GRAVENS *et al.* (1989) for Asbury Park to Manasquan, New Jersey documented storm surge levels associated with a 50-yr hurricane and northeaster. Storm surge heights of 2.71 m and 2.32 m were determined from the 50-yr hurricane and northeaster stage frequencies, respectively.

The spectral wave transformation model REF/DIF S (KIRBY and ÖZKAN, 1994) was used to evaluate changes in wave propagation across the New Jersey continental shelf relative to potential sand mining scenarios. Differences in wave heights between existing conditions and post-dredging sim-

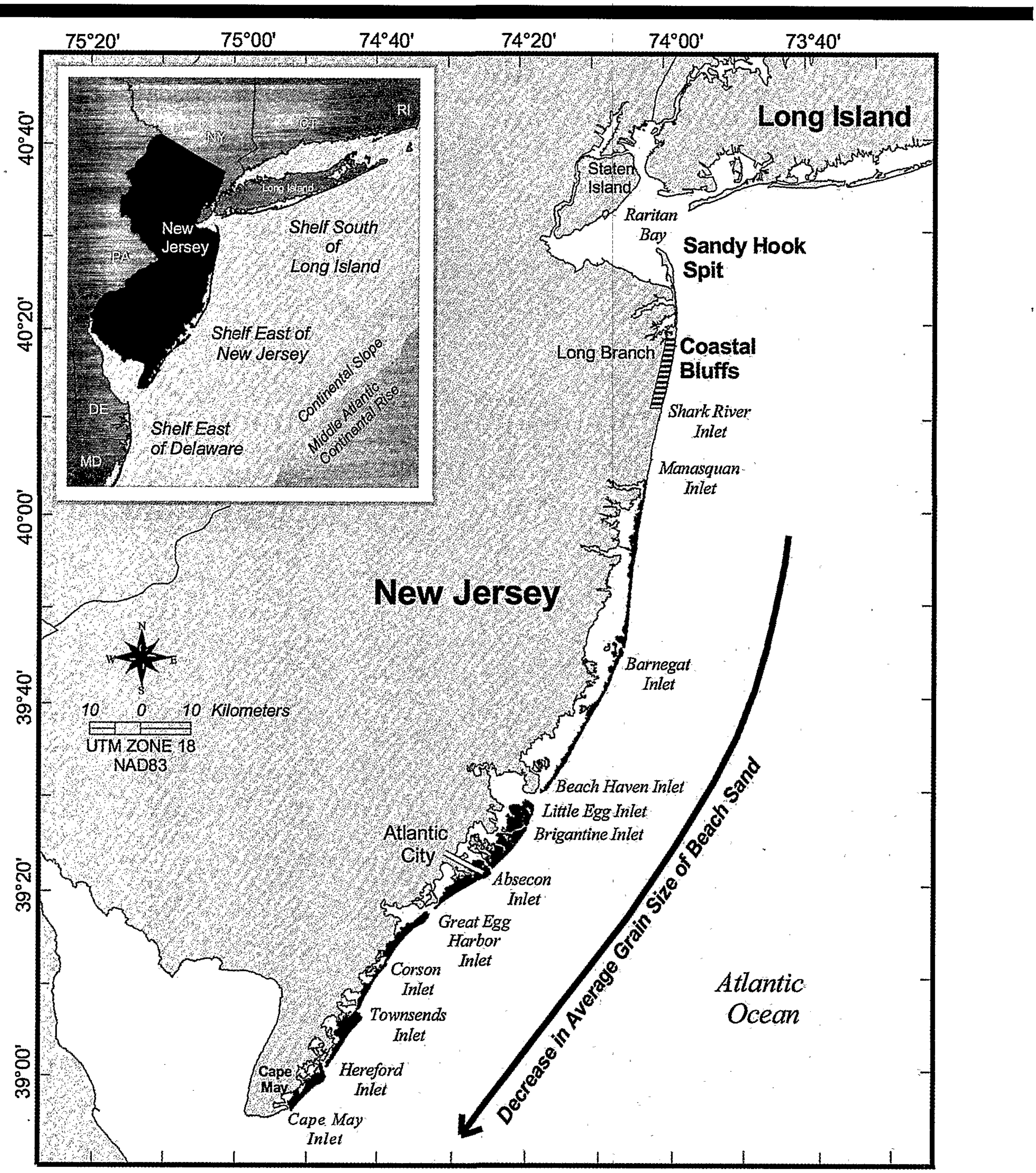


Figure 2. Trends in average grain size along New Jersey beaches (modified after SMITH, 1996).

ulations were computed at each grid point within the model domain to document potential changes caused by specific sand mining scenarios. The model domain is divided into four reference grids (A, B1, B2, and C) due to the large region required for wave transformation modeling (Figure 3). Grids B1 and C are characterized by relatively smooth bathymetry and a uniform shoreline without inlets, whereas Grids A and B2 contain complex bathymetry and irregular coastlines with numerous inlets. Local bathymetry in these areas consists of many shoreface sand ridges, extending to depths of 10- to 15-m along a northeasterly trend. These features have a significant impact on incoming wave spectra.

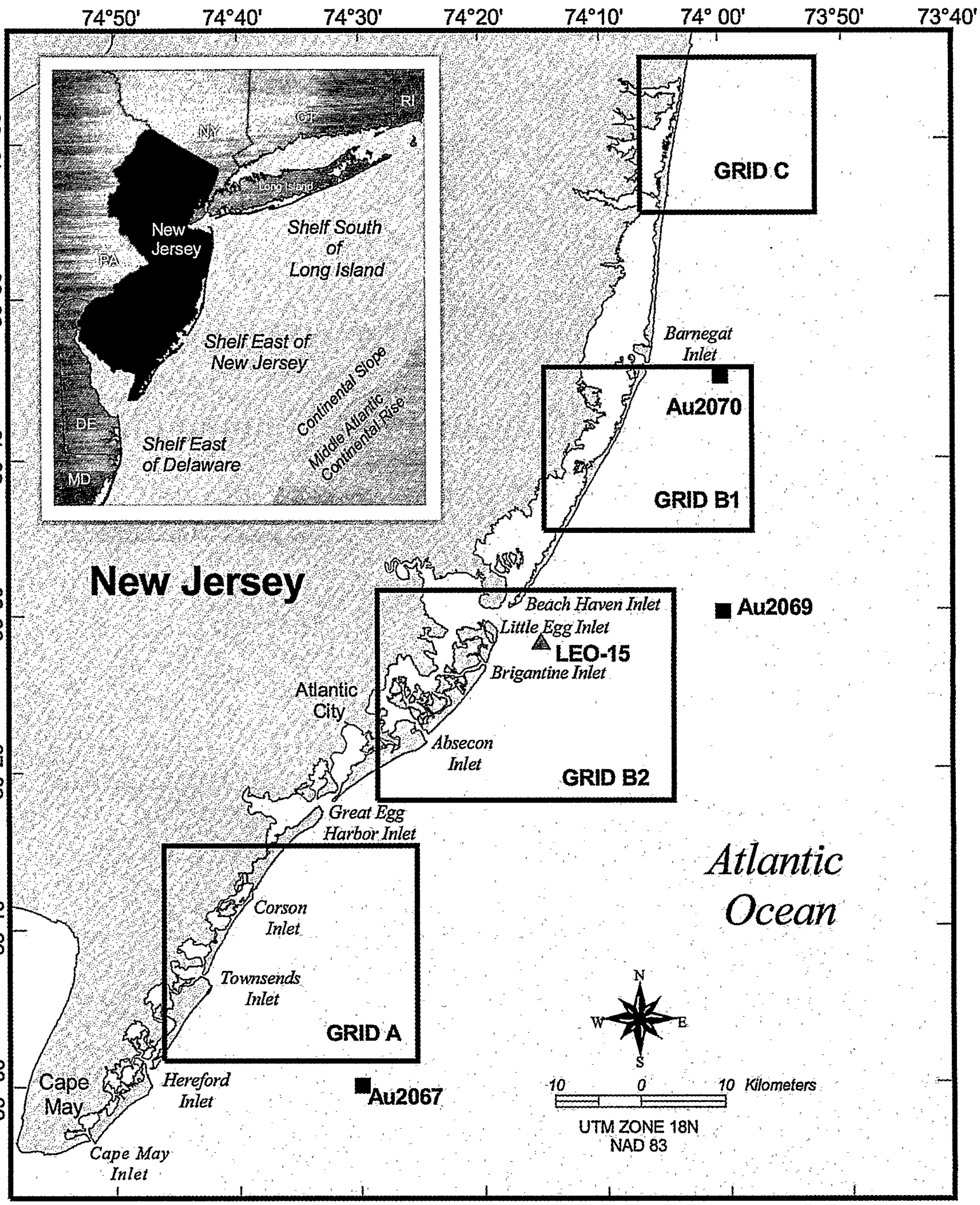


Figure 3. Locations of U.S. Army Corps of Engineers Wave Information Study (WIS) stations, current measurements, and wave modeling grids.

Proposed sand extraction volumes and sediment characteristics for borrow sites in Sand Resource Areas A1, A2, G1, G2, G3, C1, and F2 are listed in Table 1. Each borrow site was numerically excavated to simulate potential impacts of offshore dredging on physical processes. Existing condition wave simulations were subtracted from post-dredging wave results so that positive (negative) differences indicated an increase (decrease) in wave height related to sand mining at each borrow site.

Currents

Historical current records for data collected at LEO-15 (offshore Barnegat Inlet; Figure 3) were chosen for detailed analysis of current processes. The site is located in about 13-m water depth at 39°27.70′ N, 74°15.73′ W. Measurements were recorded by an S-4 current meter mounted approximately 1 m above the seafloor.

The LEO-15 measurements were obtained over an approx-

Table 1. *Sand resource characteristics at potential borrow sites in resource areas offshore New Jersey.*

Resource Area	Surface Area ($\times 10^6$ m^2)	Sand Volume ($\times 10^6$ m^3)	Excavation Depth (m)	D10 (mm)	D50 (mm)	D90 (mm)
A1	2.21	8.8	4	0.60	0.35	0.21
A2	2.60	7.8	3	1.60	0.62	0.30
G1	1.12	4.5	4	0.85	0.41	0.19
G2	1.44	4.3	3	1.40	0.66	0.30
G3	1.09	3.3	3	0.90	0.51	0.26
C1	2.04	6.1	3	0.40	0.20	0.14
F1	Too Small	Too Shallow	—	—	—	—
F2	0.69	2.1	3	2.40	0.46	0.27

D10 = grain diameter above which 10% of the distribution is retained; D50 = median grain diameter; D90 = grain diameter above which 90% of the distribution is retained.

imate two-year period (August 1993 through August 1995); however, gaps in the two-year record due to instrument maintenance and data recovery made numerical analysis of the entire record difficult. Therefore, data were analyzed as a series of 30-to-90-day blocks, with statistics generated for each data block. Current data were first rotated from a north/east coordinate system to a cross-shelf/along-shelf coordinate system. Positive across-shelf flow is directed onshore and positive along-shelf flow is directed approximately northward.

Sediment Transport

Three independent sediment transport analyses were completed to evaluate physical environmental impacts of offshore sand mining. First, historical sediment erosion and accretion trends were quantified with sequential shoreline and bathymetric surveys to document long-term sediment movement (*e.g.,* BYRNES and HILAND, 1995; BYRNES and BAKER, 2003). Historical map compilation and analysis procedures for surveys of coastal Alabama are documented in BYRNES *et al.* (2000). Second, annualized sediment infilling rates were estimated for each borrow site using analytical expressions developed by MADSEN and GRANT (1976) that incorporate information on wave orbital velocities, local current measurements, and sediment textural characteristics at borrow sites. Third, numerical techniques were developed to use nearshore wave information derived from REF/DIF S to evaluate changes in longshore sediment transport patterns (beach erosion and accretion) resulting from potential sand mining activities. This involved application of a wave-induced current model where the depth-averaged continuity equation and depth-averaged x and y momentum equations were integrated and time averaged (WINER, 1988; RAMSEY, 1991).

Benthic Infaunal Characterization Surveys

Sampling Design

Benthic characterization field studies were conducted 3 to 8 May and 18 to 21 September 1998 within the eight sand resource areas and at three adjacent stations between sand resource area groups. Survey scheduling was designed to sample infaunal assemblages after the initial spring recruitment period, and then after summer recruitment.

A prescribed number of benthic grab samples was apportioned among surveys and resource areas. To determine the number of infaunal and sediment grain size samples to collect in May, surface area and percent of total surface area for each area were calculated. The percent of the total surface area for each of the resource areas then was multiplied by the total number of stations available for the project minus three for the adjacent stations, resulting in the number of samples per resource area. The next step was to determine the placement of infaunal and sediment grain size stations within each area to characterize existing assemblages. The goal in placement of the sediment grain size stations was to achieve broad spatial and depth coverage within the sand resource areas and, at the same time, ensure that the samples would be independent of one another to satisfy statistical assumptions. To accomplish this goal, a systematic sampling approach was used to provide broad spatial and depth coverage. This approach can, in many cases, yield more accurate estimates of the mean than simple random sampling (GILBERT, 1987). Grids were placed over figures of each resource area. The number of grid cells was determined by the number of samples per area. One sampling station then was randomly placed within each grid cell of each sand resource area. Randomizing within grid cells eliminates biases that could be introduced by unknown spatial periodicities in the sampling area. During May, 89 stations were sampled for sediment grain size using a Smith-McIntyre grab. Grabs at 30 of the 89 stations also were analyzed for infauna.

Placement of infaunal and sediment grain size stations for September was determined based on bathymetric post-plots and analyses of infaunal and sediment grain size samples collected during May. The design rationale for the September field effort was to sample May stations for temporal comparisons and further investigate areas of heterogeneity. For September, 60 stations were grab sampled for infauna and sediment grain size. Thirty of these 60 stations were in the same locations as the 30 Smith-McIntyre infaunal stations sampled during May. The remaining 30 Smith-McIntyre stations for September were located to broaden geographic coverage within the resource areas. Detailed maps of station locations for each resource area are provided in BYRNES *et al.* (2000).

A differential global positioning system was used to navigate the survey vessel to all sampling locations. Temperature, conductivity, dissolved oxygen, and depth were measured near bottom with a portable Hydrolab to determine if anomalous temperature, salinity, or dissolved oxygen conditions existed during field surveys.

Sediment Grain Size

A sub-sample (about 250 g) of sediment for grain size analyses was removed from each grab sample with a 5-cm diameter acrylic core tube, placed in a labeled plastic bag, and stored on ice. In the laboratory, grain size analyses were conducted using combined sieve and hydrometer methods according to recommended American Society for Testing Materials procedures. Samples were washed in demineralized water, dried, and weighed. Coarse and fine fractions (sand/silt) were separated by sieving through a U.S. Standard Sieve Mesh No. 230 (62.5 μm). Sediment texture of the coarse fraction was determined at 0.5-phi intervals by passing sediment through nested sieves. Weight of materials collected in each particle size class was recorded. Boyocouse hydrometer analyses were used to analyze the fine fraction (<62.5 μm). A computer algorithm determined size distribution and provided interpolated size information for the fine fraction at 0.25-phi intervals. Percentages of gravel, sand, and fines (silt + clay) were recorded for each sample.

Infauna

After removing the sediment grain size sub-sample, the remaining grab sample was sieved through a 0.5-mm sieve for infaunal analyses. Infaunal samples were preserved in 10% formalin with rose bengal stain. In the laboratory, organisms were identified to lowest practical identification level (LPIL) and counted.

Univariate summary statistics including number of taxa, number of individuals, density, Shannon's index of diversity (H') (PIELOU, 1966), Pielou's index of evenness (J') (PIELOU, 1966), and Margalef's index of species richness (D) (MARGALEF, 1958) were calculated for each sampling station. Station means of these summary statistics were then calculated for each resource area.

Spatial and temporal patterns for infaunal assemblages were examined using multivariate techniques, including cluster analysis, non-metric multidimensional scaling (MDS), and similarity percentage breakdown (SIMPER). These analyses were performed on a similarity matrix constructed from a raw data matrix consisting of taxa and samples (station-survey). The data matrix was constructed using taxa that contributed at least 2% of total infaunal abundance. This produced a data matrix of 67 taxa by 90 stations. To weight the contributions of common and rare taxa, raw counts of each taxon in a sample (n) were transformed to logarithms [$\log_{10}(n+1)$] prior to similarity analysis. Both normal (stations) and inverse (taxa) similarity matrices were generated using the Bray-Curtis index (BRAY and CURTIS, 1957). This matrix was clustered using the group averaging method that describes mean levels of similarity between groups of stations (FIELD *et al.,* 1982). Inverse similarity matrices were clustered using the flexible sorting method of clustering, performed with $\beta = -0.25$, a widely accepted value for this analysis (BOESCH, 1973). Cluster analysis was followed by MDS ordination of the similarity matrix to corroborate cluster results. Species accounting for observed assemblage differences among groups and within groups of stations were identified using the SIMPER procedure, which determines the average contribution of each species to characterizing a station group or discriminating between pairs of station groups (CLARKE, 1993). These analyses (MDS, SIMPER) were performed with the PRIMER v5 package (CLARKE and GORELY, 2001).

The extent to which station groups formed by normal cluster analysis of infaunal data could be explained by environmental variables was examined by canonical discriminant analysis (CDA) (SAS INSTITUTE, INC. STAFF, 1989), which identifies the degree of separation among pre-defined groups of variables in multivariate space. Environmental variables used for the CDA were survey (categorical), water depth, percent gravel, percent sand, and percent fines.

RESULTS

Physical Processes

Wave Transformation Modeling

Potential dredging impacts at offshore borrow sites were determined by wave modeling to estimate refraction, diffraction, shoaling, and wave breaking. Wave refraction and diffraction generally result in an uneven distribution of wave energy that determines the magnitude and direction of sediment transport along a coast. For the outer coast of New Jersey, wave spectra indicated that the dominant direction of wave propagation was from north-to-south. Wave modeling results also supplied input for nearshore circulation and sediment transport models.

Existing Conditions. Wave transformation simulations identified specific areas of wave convergence, divergence, and shadow zones. Non-storm significant wave heights and angles experienced little variation seaward of the 20-m depth contour, where the wave field began to be influenced by bathymetry. Significant bathymetric features (*e.g.,* shore-attached, northeast extending linear ridges and swales, offshore shoals, bathymetric depression, *etc.*) within each modeling grid were the primary cause of increases and decreases in wave height and angle. Influence of these bathymetric features on the wave field along the coast changed as waves approached from various directions.

The region offshore Townsends and Corson Inlets (Areas A1 and A2; Figure 1) had a relatively consistent longshore wave height distribution. Several areas of wave convergence and divergence (0.2 to 0.3 m) were caused by shoals surrounding Areas A1 and A2. These shoals focused wave energy at various locations along the coast depending on wave approach direction. Offshore Little Egg Inlet (Areas G1, G2, and G3), wave transformation again was influenced by numerous linear ridges. Areas of wave height convergence and divergence (0.3 m) and changing wave direction appear most frequently near Brigantine Inlet. The area south of Barnegat Inlet (Area C1) experienced minor changes in wave height distribution along the coast and mild shoreline retreat. Shoals and swales south of Area C1, as well as offshore linear ridges to the north, produced wave height changes ranging from 0.1 to 0.3 m within the modeling grid. Wave energy focused by offshore ridges most often influenced beach changes along the northern 5 km of Long Beach Island.

The region seaward of northern Barnegat Bay (Area F2) also experienced wave height changes (0.2 to 0.3 m) produced by offshore shoals and swales. Consistent wave focusing was observed for the shoal within Area F2, as well as shoals to the south and southeast of F2. Wave energy focused by these features may impact regions seaward of northern Barnegat Bay depending on approach direction.

Storm wave propagation patterns were similar to those documented for directional approach trends. As with all storm wave simulations, wave convergence and divergence patterns were less pronounced because changes caused by bathymetric features were small when compared with large input wave heights. An increase in wave height relative to adjacent areas was documented where wave convergence occurred (BYRNES *et al.,* 2000). For example, the shoal in Area F2 produced wave convergence resulting in 6.0 m wave heights during a typical 50-yr northeast storm. In most cases, storm wave heights exceed 3.0 to 4.0 m along the coast.

Existing Versus Post-Dredging Conditions. Differences in wave heights between existing and post-dredging conditions offshore southern New Jersey (Areas A1 and A2) indicated maximum wave height increases of 0.3 m for wave approaching from the east-southeast (about 20% increase relative to existing conditions) at the borrow sites. By the time waves reach the coast, wave height increases at the borrow site dissipated to an average of about 0.1 m (8%) relative to existing conditions. For most directional cases, wave height modifications caused by sand mining dissipated before reaching the coast (*e.g.,* Figure 4). The magnitude of modifications increased as the magnitude of waves increased or when the orientation of borrow sites aligned with waves to produce maximum impact.

For sand borrow sites in Areas G1, G2, and G3 (Grid B2), maximum wave height changes ranged from 0.16 to 0.6 m. Similar to Areas A1 and A2, most modifications caused by sand mining dissipate relatively quickly as waves advance toward the coast and break (Figure 5). Wave height increases relative to existing conditions at the coast ranged from 0.25 m (16%) south of Brigantine Inlet for a southeast wave approach to 0.05 m (4%) south of Little Egg Inlet for waves from the south-southeast. The average increase in wave height for all wave approach directions that resulted from simulated offshore sand mining in Grid B2 was 0.13 m (10%).

For borrow sites in Areas C1 and F2 (northernmost borrow sites; Grids B1 and C), maximum changes in wave height ranged from 0.06 to 0.2 m, smaller than that estimated for offshore southern New Jersey. However, changes in wave height caused by sand mining do not dissipate much before reaching the coast (Figure 6). A steeper shoreface profile offshore northern beaches allowed more wave energy to reach the coast than gently sloping nearshore areas to the south. Maximum increases in wave height at the coast resulting from simulated sand mining in Area C1 was 0.12 m (8%) for southeast wave approach. For all wave approach simulations in Grid B1, average wave height increase was 0.09 m (5%). For the northernmost borrow site in Grid C, maximum wave height increase at the coast was 0.15 m (9%) for waves from the northeast. Average wave height increase for all approach directions in Grid C was 0.09 m (5%).

During extreme wave conditions (*e.g.,* a 50-yr storm), wave heights increased from 0.4 to 1.4 m adjacent to offshore borrow sites, suggesting a rather significant change. However, this represented a change of less than 20% relative to existing conditions. Due to shoreline and borrow site orientations, hurricane waves produced greater changes at Areas A1, A2, G1, G2, and G3, and northeast storm waves had greater influence on Areas C1 and F2. Most wave energy increases resulting from simulated dredging at offshore borrow sites were dissipated before waves reached the coast, especially along southern New Jersey beaches. As such, wave height increases were less than 0.4 m (10%) along most of the coast.

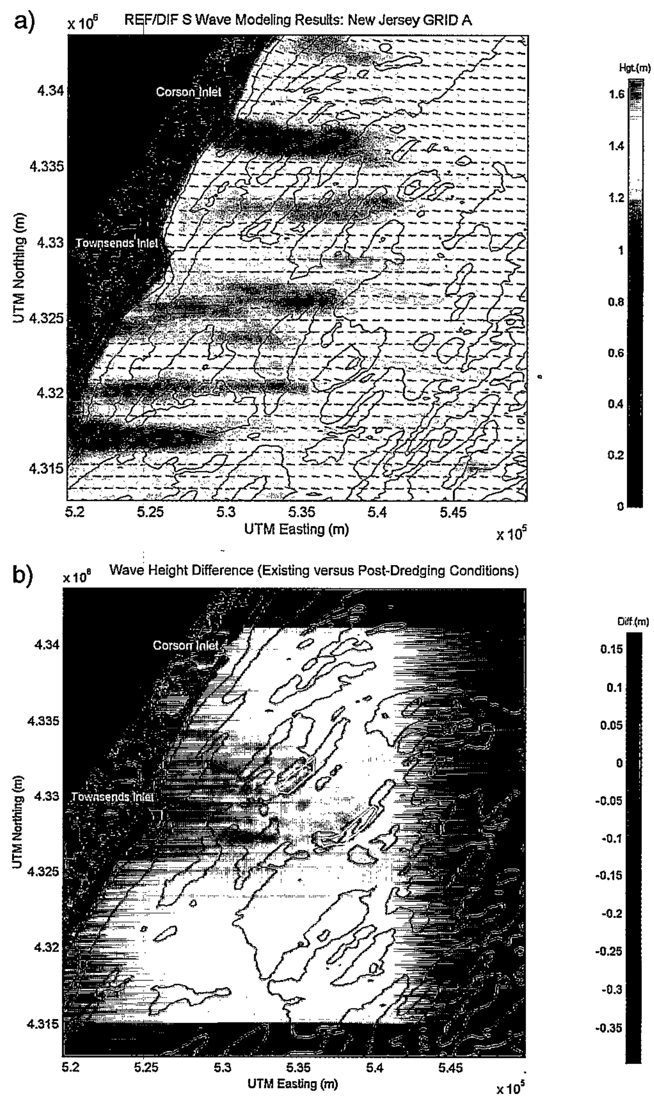


Figure 4. Spectral wave modeling results for Grid A. a) Existing conditions for an eastern approach direction. b) Wave height modifications resulting from offshore mining at Sand Resource Areas A1 and A2 for the eastern approach simulation (most common approach direction for non-storm waves). Green shades identify areas of increased wave height, and blue shades identify areas of decreased wave height.

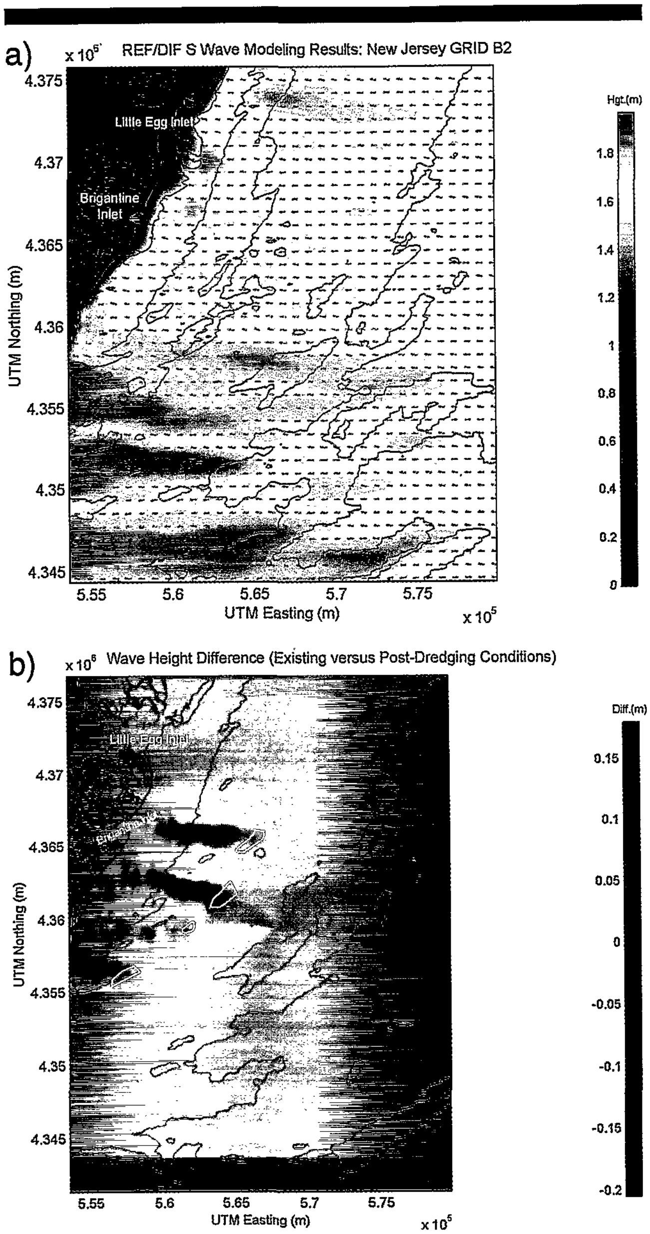


Figure 5. Spectral wave modeling results for Grid B2. a) Existing conditions for an eastern approach direction (0 degree bin). b) Wave height modifications resulting from offshore mining at Sand Resource Areas G1, G2, and G3 for the eastern approach simulation.

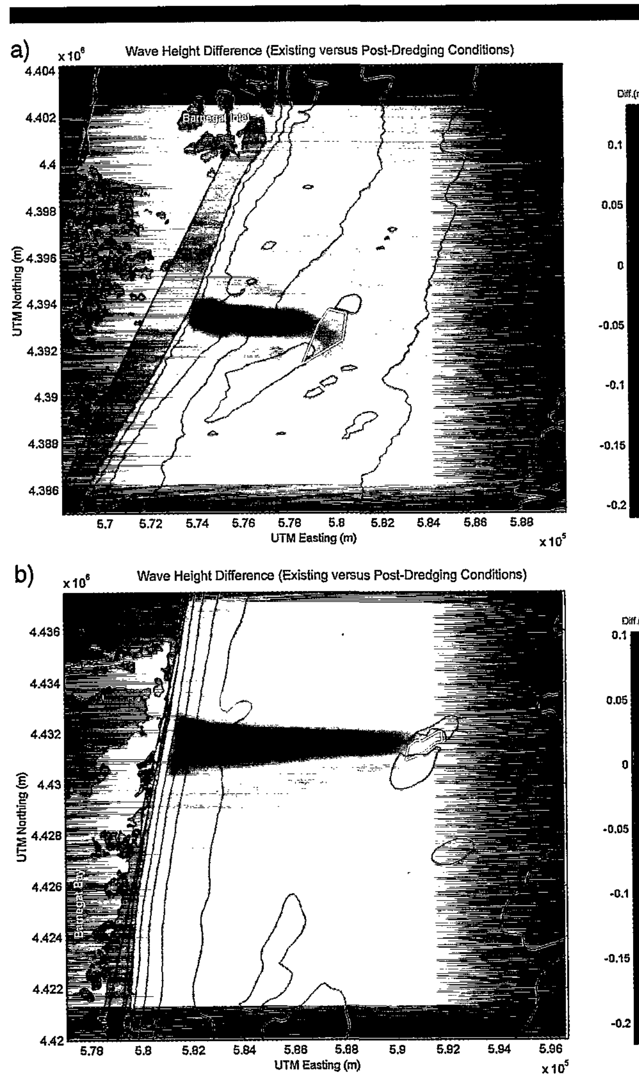


Figure 6. Wave height modifications resulting from simulated offshore sand mining at Grid B1 (a) and Grid C (b) for an eastern wave approach.

Currents

Bottom current data for offshore New Jersey (seaward of Little Egg Inlet) revealed considerable variability in flow speed and direction. Mean flow was to the southwest along inner shelf bathymetric contours. Strongest flow was observed in the along-shelf direction, with peak velocities of nearly 50 cm/sec (1 knot) to the south; maximum northward currents reached 37 cm/sec. Frequent flow reversals were noted.

Along-shelf currents were dominated by wind-driven processes, accounting for about 70% of total current energy. Wind-driven processes were greatest in winter; however, wind-driven flows appeared strongly biased by singular events, such as local responses to storm winds or non-locally generated free waves that influenced the magnitude of wind-driven current energy (NOBLE *et al.*, 1983). This suggests that singular events, with corresponding higher currents, have greatest potential to transport sand. If so, regional sediment transport patterns are predominately in the along-shelf direction, with a net transport oriented in the direction of mean southerly flow.

In the cross-shelf direction, mean flow was oriented onshore, consistent with upwelling processes that push bottom waters onto the shelf. Maximum cross-shelf flow was 31 cm/sec (directed onshore); minimum flow was 13 cm/sec (directed offshore). Cross-shelf bottom currents were influenced most significantly by semi-diurnal tides, with a mean onshore flow. Wind-driven currents were found to be less significant in the cross-shelf direction. Seasonal variability was most significant for wind-driven currents. Winter and autumn data records were most energetic, with summer and spring data sets having smaller energy values.

Sediment Transport

Wave transformation modeling and current measurements provided baseline coastal processes information for the study area. However, the most important data sets for documenting physical processes impacts from offshore sand mining were quantified changes in sediment transport dynamics.

Historical Trends. Regional geomorphic changes for the period 1843/91 to 1934/77 were analyzed to assess long-term, net coastal sediment dynamics using shoreline and bathymetric surveys (composite bathymetric surfaces included data sets for the periods 1843 to 1891 and 1934 to 1977; see BYRNES *et al.*, 2000). Shoreline position and nearshore bathymetric change documented four important sediment transport trends. First, the predominant direction of transport throughout the New Jersey coastal zone was north to south. Southern Long Beach Island (north of Little Egg Inlet) and southern Island Beach (north of Barnegat Inlet) have migrated at a rate of about 14 m/yr to the south since 1839/42. Ebb-tidal shoals at all inlets in the study area are oriented to the south, and channels are aligned northwest-southeast.

Second, the most dynamic geomorphic features within the study area are ebb-tidal shoals associated with inlets along the southern barrier island chain. Areas of significant erosion and accretion were documented for the period 1843/91 to 1934/77, reflecting wave and current dynamics at entrances, the influence of engineering structures on morphologic change, and the contribution of littoral sand transport from the north to sediment bypassing and shoal migration (Figure 7).

Third, alternating bands of erosion and accretion on the continental shelf east of the Federal-State boundary illustrated relatively slow but steady reworking of the upper shelf surface as sand ridges migrate from north to south. The process by which this was occurring at Areas G1, G2, and G3 suggested that a borrow site in this region would fill with shelf sediment transported from an adjacent site at a rate of about 62,000 to 125,000 m^3/yr. At Areas A1 and A2, the potential transport rate increased to 160,000 to 200,000 m^3/yr.

Finally, net alongshore changes in erosion and accretion, determined from seafloor changes in the littoral zone between Little Egg Inlet and the beach south of Hereford Inlet, indicated an increasing transport rate to the south from about 70,000 m^3/yr south of Little Egg Inlet to 190,000 to 230,000 m^3/yr at Townsends and Hereford Inlets. Variations in longshore transport are evident in patterns of change recorded on Figure 7 (alternating zones of erosion and deposition along the shoreline). Areas of largest net transport exist just south of entrances as a result of natural sediment bypassing from updrift to downdrift barrier beaches. These net transport rate estimates compare well with numerical model simulations of longshore transport rates and provide a measured level of confidence in wave and sediment transport modeling capabilities relative to impacts associated with sand dredging from selected borrow sites.

Borrow Site Infilling. Predicted sediment infilling rates at borrow sites ranged from a minimum of 28 m^3/day (about 10,000 m^3/yr; Area F2) to a high of 450 m^3/day (164,000 m^3/yr; Area A1); infilling times varied from 54 (Area A1) to 303 years (Area C1). Sediment that replaces sand mined from a borrow site will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. However, infilling rates and sediment types are expected to reflect natural variations that currently exist within sand resource areas. The range of infilling times was based on the volume of sand numerically dredged from a borrow site, as well as the estimated sediment transport rate. Predicted sediment infilling rates were slightly lower than net transport estimates derived from historical data sets, but the two estimates are within the same order of magnitude (10,000 to 160,000 m^3/yr versus 62,000 to 200,000 m^3/yr, respectively). Simulated infilling rates would be larger if the impact of storm events were incorporated in the analysis.

Nearshore Sediment Transport Modeling. Sand mining impacts on net littoral transport east of Areas A1 and A2 illustrated a defined but minor change. Due to the relatively shallow and wide continental shelf along the southern portion of the New Jersey coast, the percent difference in net longshore sand transport associated with offshore mining was small (approximately 7% of the existing value) relative to resource areas to the north.

Wave shadow zones are indicated by a reduction in south-directed wave energy. Shadow zones landward of Areas A1 and A2 are located approximately 5 km and 1 km north of Townsends Inlet, respectively (Figure 8a). The largest increase in net annual south-directed transport occurs between shadow zones (3 km north of Townsends Inlet), where borrow sites in Areas A1 and A2 have wave energy refracted to the south and north, respectively. An increase in wave energy at the shoreline is responsible for increased south-directed transport between shadow zones.

Because the distance from shore to Areas G2 and G3 is relatively small (approximately 5 km), the potential shoreline impact region is more confined than for Area A2. For borrow sites in Areas G2 and G3, the maximum variation in net annual longshore sand transport was approximately 9% of the existing value (Figure 8b). Only a single shadow zone landward of Areas G2 and G3 existed approximately 1 km south of Brigantine Inlet. This shadow zone was associated with a significant reduction in south-directed wave energy. The largest increase in net annual longshore transport occurred south of the shadow zone (approximately 2 km south of Brigantine Inlet). However, it is unclear whether the shadow zone or the region of increased south-directed wave energy was a result of dredging in Areas G2 (one borrow site), G3 (two borrow sites), or a combination of the three borrow sites.

For Area C1, southeast and east wave conditions dominated the wave record. However, a series of shadow zones landward of Area C1 occurred as a result of wave refraction generated by all modeled wave conditions. The largest shadow zone was generated by waves propagating from the east. In addition, waves propagating from the east-southeast caused

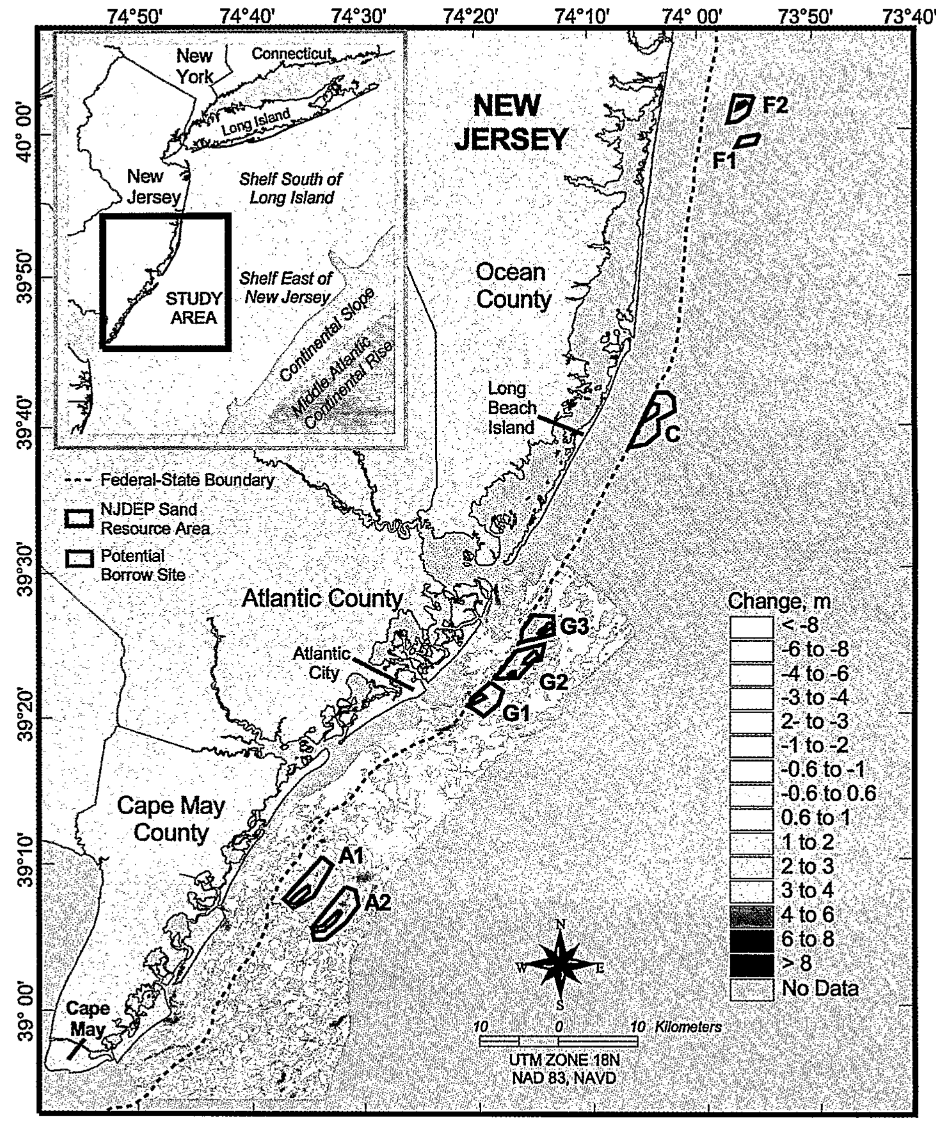


Figure 7. Nearshore bathymetric change (1843/91 to 1934/77) for the southeastern New Jersey continental shelf.

a reduction in south-directed transport. The maximum variation in net annual longshore sediment transport was about 20% of the existing annual transport rate.

For the borrow site in Area F2, maximum variation in net annual longshore sand transport was approximately 17% of existing conditions. Similar to Area C1, a relatively low net longshore sand transport rate resulted in a high percentage impact to the annual transport rate; however, the maximum change of approximately 12,700 m^3/yr was similar to modeled change for Areas A1, A2, C1, G1, G2, and G3. A shadow zone landward of Area F2 is located approximately 6 km south of Manasquan Inlet. Likewise, the largest increase in north-directed transport occurred on either side of the shadow zone (approximately 4 and 8 km south of Manasquan Inlet, respectively; see BYRNES *et al.,* 2000).

For average annual conditions, net longshore sand transport rates were approximately equal landward of borrow sites along the New Jersey coast. The absolute value of the mean difference between existing and post-dredging conditions was relatively consistent, ranging between 9,000 (20%) and 14,900 m^3/yr (7%).

Benthic Environment

Water Column

During May, bottom temperatures ranged from 8.2°C at Area F2 to 11.2°C in Area A1, salinity values ranged from 28.5 ppt in Area C1 to 33.8 ppt at Area F2, and dissolved oxygen measurements ranged from 6.41 mg/L in Area G2 to 9.60 mg/L at Area F2. During September, bottom tempera-

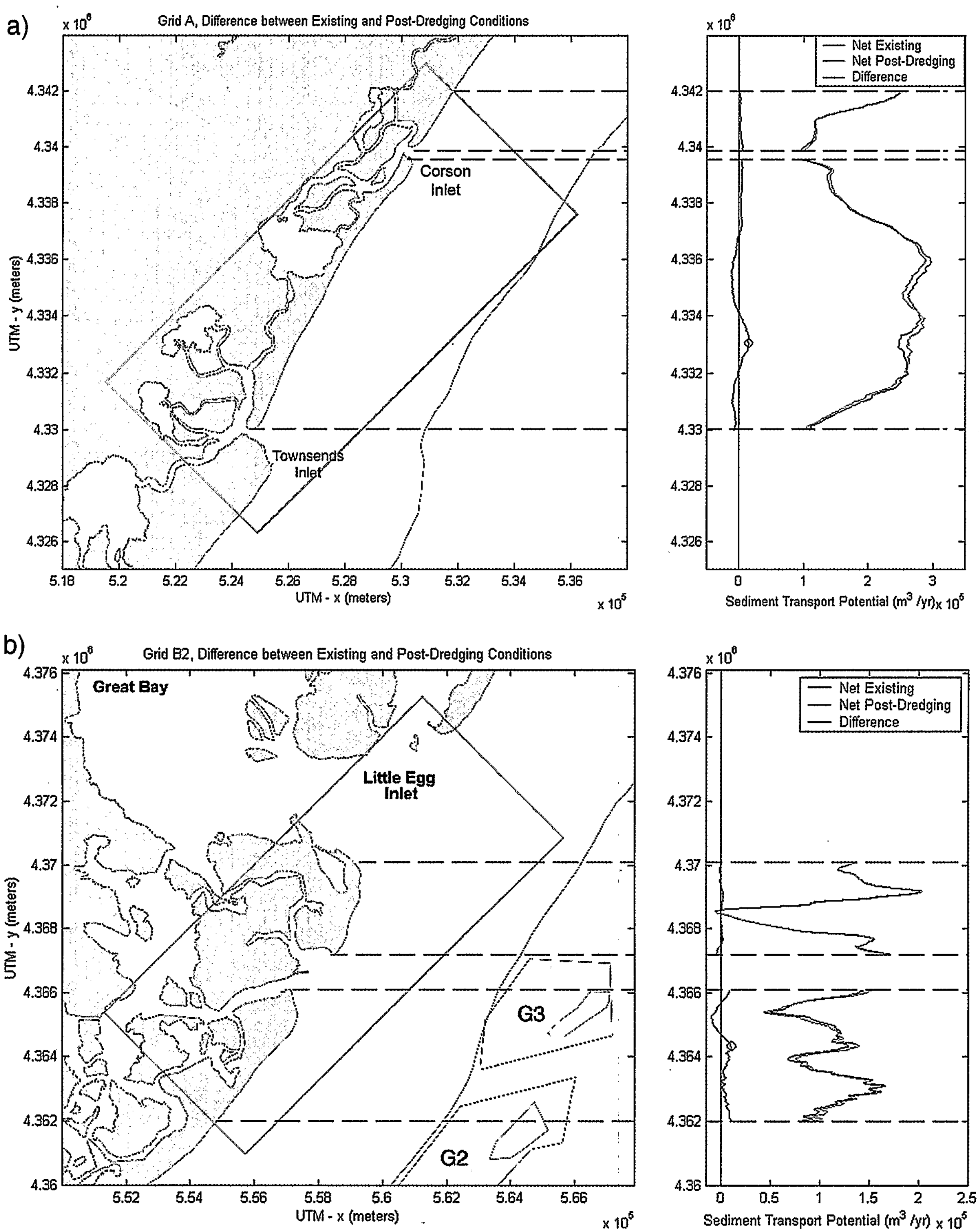


Figure 8. Difference in average annual transport rates associated with simulated dredging at sand borrow sites in a) Grid A and b) Grid B2.

Table 2. *Mean percentage (standard deviation) of sediment types in grab samples collected in the sand resource areas during May and September 1998.*

Resource Area (n)	Mean % Gravel (SD)	Mean % Sand (SD)	Mean % Fines (SD)
A1 (22)	10.78 (20.11)	88.62 (20.01)	0.19 (0.76)
A2 (26)	12.74 (14.71)	85.57 (15.70)	0.03 (0.10)
C1 (27)	19.97 (28.21)	78.09 (28.09)	1.42 (7.25)
F1 (7)	15.95 (12.48)	83.68 (12.46)	0.00 (0.00)
F2 (11)	22.45 (22.59)	77.15 (22.52)	0.00 (0.00)
G1 (14)	6.62 (12.71)	90.71 (16.24)	1.44 (4.76)
G2 (20)	0.55 (0.86)	93.47 (18.17)	4.20 (17.86)
G3 (16)	1.36 (3.61)	97.87 (3.58)	0.00 (0.00)

tures ranged from 12.5°C for Area F2 to 22.2°C in Area G1, bottom salinity values ranged from 27.6 ppt in Areas G1 and G2 to 33.4 in Area A2, and bottom dissolved oxygen values ranged from 2.94 mg/L in Area G3 to 6.48 mg/L in Area G2. Hypoxic and anoxic conditions were not found during May or September.

Sediment Grain Size

Proportions of gravel, sand, and fines (silt + clay) varied within and among resource areas (Table 2). Areas A1 and A2 included sand stations and a few gravel stations. C1 stations generally had varied amounts of gravel and a few sand stations. F1 and F2 samples contained varied amounts of gravel. Samples from G1, G2, and G3 were mostly sand with only minor amounts of gravel at a few stations. There were little or no fines in the sediment samples.

Infauna

The archiannelid *Polygordius* (LPIL) was numerically dominant in the grabs, comprising 18% of all infauna collected. Other than *Polygordius* (LPIL), taxa that were among the top 10 numerical dominants during both surveys included nut clam (*Nucula proxima*) and non-identified oligochaetous annelids and rhynchocoels. Mean taxa evenness (J') varied little between surveys but was variable between resource areas (Table 3). J' ranged from 0.51 (Area F1) to 0.73 (Area A2) in May and 0.60 (Area F1) to 0.71 (Area G2) in September. Mean taxa diversity (H') and richness (D) were higher in September compared to May for all resource areas except Area F2 diversity. Mean values of H' ranged from 1.64 (G1) to 2.37 (A1) in May and from 2.08 (F2) to 2.48 (G2) in September. Mean values of D ranged from 3.71 (G1) to 5.67 (A1) in May and from 4.30 (F2) to 6.68 (G1) in September.

Cluster analysis and MDS ordination identified seven station (sample) groups (Groups A through G) that were similar with respect to species composition and relative abundance (Figure 9). Ten of the 90 stations did not cluster with other stations, were generally depauperate, and were assigned to outlier groups (X and Y). Dispersion patterns were strong only for some of the clustered stations (Figure 9a), and no patterns emerged with respect to survey (Figure 9b). Lack of well-defined patterns in the MDS ordination was reflected by the high (0.22) stress value. Table 4 presents the distribution of stations by survey and resource area. Group D included stations sampled exclusively in May, whereas Groups B, E, and G included only September samples. Three groups (A, C, and F) included samples collected during both surveys. Groups B (21 stations) and F (31 stations) together contained most of the project samples (Table 4). Except for F1 and F2, resource areas were represented by multiple station groups. Groups with consistent sediment size across clustered stations were Groups B and D (sand) and Groups A and E (gravel) (Table 5). Samples in Groups C and F had variable sediment regimes.

Taxa typifying station groups, determined with SIMPER, are presented in Table 6. *Polygordius* (LPIL) contributed to station similarities in six of the seven station groups, an indication of the ubiquity of this taxon during the surveys. Station Groups C and F had lower average levels of similarity

Table 3. *Summary of infaunal community statistics by survey and resource area.*

Area (n)	Mean No. Taxa (SD)	Mean No. of Individuals (SD)	Mean Density (individuals/m²) (SD)	Mean Diversity (H') (SD)	Mean Evenness (J') (SD)	Mean Richness (D) (SD)
			May			
A1 (4)	37 (20)	898 (846)	8,975 (8,463)	2.37 (0.61)	0.67 (0.16)	5.67 (2.28)
A2 (4)	21 (7)	217 (181)	2,173 (1,814)	2.20 (0.69)	0.73 (0.20)	3.85 (1.01)
C1 (5)	28 (9)	625 (616)	6,254 (6,158)	2.01 (0.52)	0.63 (0.20)	4.49 (0.72)
F1 (2)	31 (1)	609 (441)	6,090 (4,412)	1.74 (0.46)	0.51 (0.14)	4.75 (0.49)
F2 (2)	26 (13)	351 (343)	3,505 (3,429)	2.25 (0.24)	0.72 (0.05)	4.26 (1.50)
G1 (3)	21 (5)	565 (612)	5,647 (6,124)	1.64 (1.10)	0.54 (0.37)	3.71 (0.90)
G2 (4)	27 (8)	757 (866)	7,570 (8,658)	1.91 (0.76)	0.59 (0.26)	4.26 (0.77)
G3 (3)	33 (18)	878 (1,296)	8,783 (12,960)	2.10 (0.80)	0.64 (0.30)	5.35 (1.41)
			September			
A1 (9)	41 (11)	734 (625)	7,339 (6,245)	2.41 (0.37)	0.66 (0.11)	6.24 (1.26)
A2 (8)	33 (8)	447 (366)	4,468 (3,660)	2.40 (0.31)	0.69 (0.08)	5.53 (1.19)
C1 (11)	28 (6)	384 (447)	3,842 (4,473)	2.15 (0.76)	0.65 (0.23)	5.10 (1.15)
F1 (3)	36 (4)	507 (393)	5,073 (3,933)	2.14 (0.39)	0.60 (0.13)	5.85 (0.12)
F2 (5)	26 (5)	339 (109)	3,392 (1,092)	2.08 (0.34)	0.64 (0.11)	4.30 (0.83)
G1 (6)	43 (10)	644 (351)	6,438 (3,512)	2.33 (0.51)	0.62 (0.13)	6.68 (1.52)
G2 (8)	35 (7)	800 (1,207)	8,000 (12,067)	2.48 (0.41)	0.71 (0.12)	5.70 (1.14)
G3 (7)	40 (7)	547 (392)	5,470 (3,920)	2.42 (0.52)	0.66 (0.16)	6.44 (0.93)

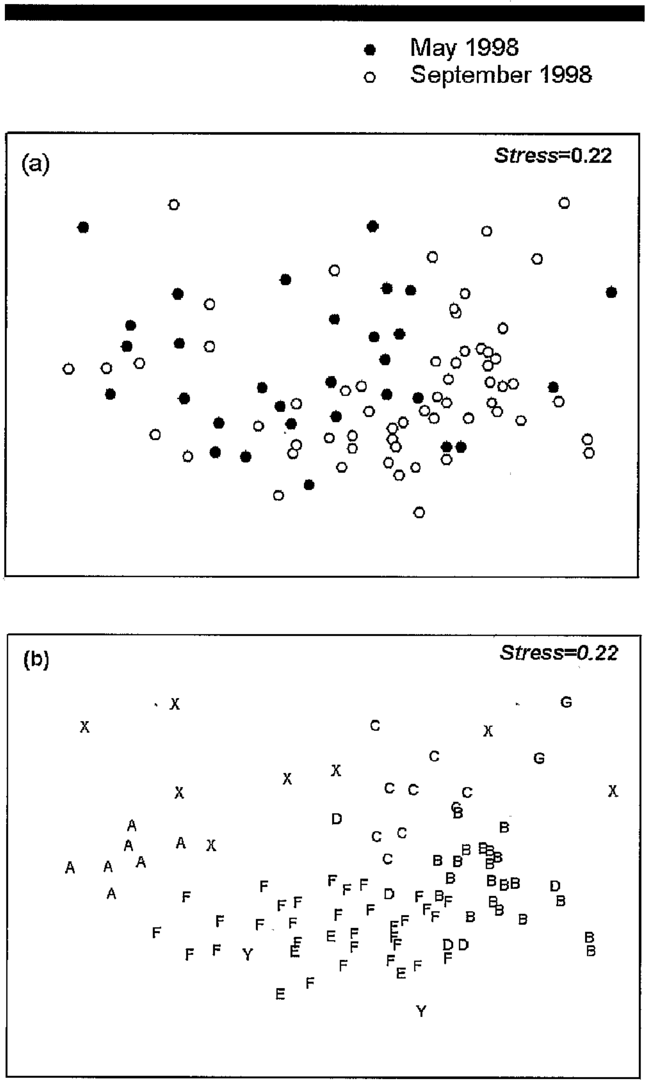


Figure 9. Multidimensional scaling plots of infaunal samples collected during May and September 1998 at eight offshore New Jersey sand resource areas labeled by (a) survey and (b) station groups determined from cluster analysis.

than other groups, indicating more assemblage variability between stations. Inverse cluster analysis resulted in five groups of taxa (Groups 1 through 5) that reflected their cooccurrence in sand resource area samples (Table 7).

Station groups defined by normal cluster analysis were analyzed using canonical discriminant analysis (CDA) to determine which environmental factors correlated best with the variability in infaunal assemblages. The first CDA axis correlated best with percent gravel (0.6978) and percent sand (−0.6814). The second CDA axis correlated best with latitude (Northing [0.8371]) and longitude (Easting [0.7659]). Mean scores of canonical variables were plotted on the first two CDA axes for Station Groups A through G (Figure 10). The first two CDA axes accounted for 77% of the variance explained by the environmental factors.

Table 4. *Distribution by survey and resource area for station groups resolved from multidimensional scaling ordination and normal cluster analysis.*

Station	Resource Area										
Group	A1	A2	C1	F1	F2	G1	G2	G3	Adj. 1	Adj. 2	Adj. 3
					May						
A	1		2							1	
B											
C	1						2	2	1		
D	1	1	1				1	1			
E											
F	1	1	1	2	2	1	1				1
G											
X/Y		2	1			2					
					September						
A			2							1	
B	6	3				5	4	3			
C	1					1			1		
D											
E		3					1				
F		1	6	3	5		2	3			1
G							1	1			
X/Y	2		3								

DISCUSSION

Physical Processes

Extraction of sediment from offshore borrow sites may result in modifications to physical processes at and adjacent to borrow sites and in the nearshore zone of New Jersey. Incident wave heights and angles experienced little variation seaward of the 20-m depth contour. However, landward of this depth to the shoreline, wave field changes were controlled by bathymetric variations. The region offshore Townsends and Corson Inlets (Grid A) illustrated several regions of wave convergence and divergence caused by shoals surrounding Areas A1 and A2. These features focused wave energy at various locations along the coast depending on wave approach direction. Seaward of Little Egg and Brigantine Inlets (Grid B2), wave transformation patterns again were controlled by numerous offshore sand ridges and swales. Increased wave heights appeared most frequently near Brigantine Inlet. The region south of Barnegat Inlet experienced a relatively consistent wave height distribution along the shoreline. However, wave energy focused by shoals and swales south of Area C1 most often impacted beaches along

Table 5. *Mean percentage (standard deviation) by sediment type for station groups resolved from multidimensional scaling ordination and normal cluster analysis.*

Station Group (n)	Mean % Gravel (SD)	Mean % Sand (SD)	Mean % Fines (SD)
A (7)	47.75 (30.48)	51.30 (29.73)	0.50 (1.23)
B (21)	0.69 (3.02)	98.63 (2.98)	0.00
C (9)	8.99 (16.46)	81.35 (27.60)	5.78 (25.99)
D (5)	2.77 (4.20)	96.82 (4.29)	0.00
E (4)	8.33 (3.85)	84.54 (15.08)	0.00
F (31)	12.13 (16.61)	87.22 (16.49)	0.04 (0.22)
G (2)	0.00 (0.00)	86.38 (12.41)	0.00

Table 6. *Average abundance of infaunal species accounting for at least 50% of the within group similarity in station (sample) groups A through G. Numbers in bold represent the average similarity for each group as a whole.*

Group	Taxa	Average Abundance	Average Similarity
A	*Hemipodus roseus*	55.57	11.15
	Pseudunciola obliquua	354.43	9.63
	Polygordius (LPIL)	32.00	9.02
			50.47
B	*Tanaissus psammophilus*	26.81	5.70
	Polygordius (LPIL)	150.24	5.43
	Acanthohaustorius millsi	23.52	5.19
	Astarte castanea	20.05	4.59
	Spiophanes bombyx	10.19	2.80
	Caulleriella sp. J	34.19	2.01
			49.98
C	*Tanaissus psammophilus*	415.33	6.21
	Polygordius (LPIL)	33.56	5.30
	Mytilus edulis	30.33	5.01
	Tellina agilis	104.56	4.28
	Chiridotea tuftsi	10.44	3.48
	Tanaissus psammophilus	415.33	6.21
			45.99
D	*Pisione remota*	14.40	13.82
	Acanthohaustorius millsi	11.60	12.95
	Polygordius (LPIL)	8.80	11.52
			56.36
E	*Polygordius* (LPIL)	27.75	8.11
	Spiophanes bombyx	61.25	8.09
	Aricidea catherinae	11.00	6.67
	Brania wellfleetensis	19.25	6.39
			54.23
F	*Polygordius* (LPIL)	171.32	12.15
	Spiophanes bombyx	59.74	9.24
	Caulleriella sp. J	26.68	3.74
			45.21
G	*Spisula solidissima*	799.00	14.82
	Unciola irrorata	51.00	9.13
	Dispio uncinata	29.00	7.64
	Ampelisca sp. X	20.00	6.02
			65.37

the northern end of Long Beach Island. The area seaward of northern Barnegat Bay also experienced wave height changes produced by offshore shoals and swales. Wave focusing by the shoal within Area F2 was common for all wave conditions. Similar wave propagation patterns at all sand resource areas were observed for the 50-yr hurricane and northeast storm.

Post-dredging model simulations were performed by numerically excavating selected borrow sites for each of the four modeling grids. Differences in wave height between existing and post-dredging conditions indicated maximum wave height increases for directional approach simulations of 0.3 m (about 17% of the initial wave height). The magnitude of modifications increased as the magnitude of waves increased, or when borrow site orientation was aligned with waves to produce maximum impact (*e.g.,* southeast approach at Areas A1 and A2). South of Brigantine Inlet, maximum wave height changes dissipated quickly as waves advanced toward the coast and broke. Landward of Areas C1 and F2, maximum changes did not dissipate as rapidly due to the relatively

Table 7. *Infaunal species groups resolved from inverse cluster analysis of all samples collected in the sand resource areas.*

GROUP 1

Polygordius (LPIL)
Tanaissus psammophilus
Pseudunciola obliquua
Spiophanes bombyx
Spisula solidissima
Tellina agilis
Caulleriella sp. J
Protohaustorius wigleyi
Rhepoxynius hudsoni
Acanthohaustorius millsi

GROUP 2

Pisione remota
Astarte castanea
Hemipodus roseus
Mytilus edulis
Crenella decussata
Lumbrinerides acuta
Aricidea cerrutii
Hesionura elongata
Protodorvillea kefersteini
Parougia caeca
Spio setosa

GROUP 3

Petricola pholadiformis
Nereis succinea
Anachis lafresnayi
Brania wellfleetensis
Cirriformia grandis
Chiridotea tuftsi
Sigalion arenicola
Politolana polita
Donax variabilis
Bathyporeia parkeri
Oxyurostylis smithi
Tectonatica pusilla
Echinarachnius parma
Exogone hebes
Parapionosyllis longicirrata
Streptosyllis arenae
Capitella capitata
Diastylis polita
Ampelisca abdita
Unciola irrorata
Aricidea catherinae
Ampelisca sp. X
Apoprionospio dayi
Mediomastus (LPIL)
Ampelisca macrocephala
Mercenaria mercenaria
Odostomia gibbosa

GROUP 4

Tharyx acutus
Asabellides oculata
Nucula proxima
Edotia triloba
Nephtys picta
Phyllodoce arenae
Ilyanassa trivittata
Apoprionospio pygmaea
Dispio uncinata
Spiochaetopterus oculatus
Magelona papillicornis
Euspira heros
Acanthohaustorius shoemakeri
Microprotopus raneyi
Turbonilla interrupta
Americamysis bigelowi

GROUP 5

Glycera dibranchiata
Mitrella lunata
Harmothoe imbricata

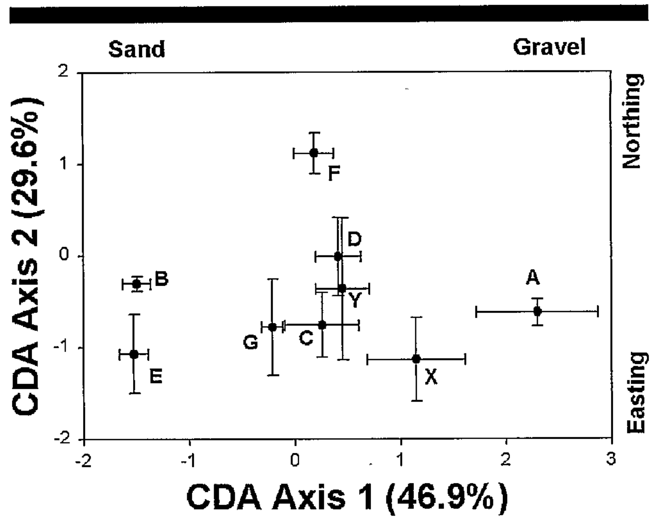


Figure 10. Means (± standard errors) of canonical variables for infaunal Station Groups A through G plotted on Canonical Discriminant Analysis (CDA) Axes 1 and 2.

steep shoreface profile along the northern New Jersey coast. During extreme wave conditions (*e.g.*, a 50-yr storm), wave height changes from borrow site excavation increased less than 10% relative to existing conditions. Hurricane simulations illustrated greater impacts along beaches south of Little Egg Inlet due to the orientation of borrow sites relative to the shoreline, whereas a northeast storm simulation generated greater impacts landward of Areas C1 and F2.

Overall, borrow sites within Areas A1 and A2, located offshore Townsends Inlet, had a greater impact on the wave field due to larger extraction volumes (8.8 and 8.6 MCM, respectively). In addition, regions with multiple borrow sites (Grids A and B2) indicated a greater potential for wave modifications with simultaneous dredging. However, the impact caused by potential offshore sand mining during normal and storm conditions was minimal.

Mean flow offshore New Jersey was to the southwest along inner shelf bathymetric contours. Strongest flow was observed in the along-shelf direction, and currents were dominated by wind-driven processes. Wind-driven processes were greatest in winter; however, flows appeared strongly biased by singular events, such as local storms. While no large-scale predictive circulation models were developed to quantify the effects of mining in sand resource areas, analysis of current patterns in the study area suggests sand mining will have negligible impact on large-scale shelf circulation. Sand mining locations are small relative to the entire shelf area, and it is anticipated that dredging will not remove enough material to significantly alter major bathymetric features in the region.

Borrow site infilling rates increased from north (Area F2) to south (Areas A1 and A2) and ranged from about 10,000 m^3/yr to 160,000 m^3/yr. This increase in potential transport rate reflects a more dynamic offshore environment seaward of the southern barrier island chain. For the water depths and proposed geometries at selected borrow sites, minimal impacts to waves and regional sediment transport are anticipated during infilling. Volume and type of sediment that replace excavated sand from borrow sites will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. However, infill sediment is expected to reflect surface sediment texture at adjacent ridge and swale deposits.

Potential effects of offshore sand mining on nearshore sediment transport patterns are of interest because dredged borrow sites can intensify wave energy at the shoreline and create erosional hot-spots. Comparisons of average annual longshore sediment transport potential were performed for existing and post-dredging conditions to indicate the relative impact of offshore sand mining on transport processes. For average annual conditions, the difference between existing and post-dredging conditions ranged from about 7% along southern New Jersey beaches to about 20% of the mean transport rate along Long Beach Island. Because the net longshore sediment transport rate predicted landward of Area C1 (Long Beach Island) was relatively low (approximately 45,000 m^3/year; similar to CALDWELL [1966]), the percentage difference between existing and post-dredging conditions was greatest for this site. Results from analyses of a 50-year event indicated similar trends.

KELLEY *et al.* (2004) developed an analytical approach for quantifying the significance of potential physical environmental impacts associated with offshore sand mining. The approach incorporates an analysis of nearshore wave transformation and wave-induced longshore sediment transport for existing and post-dredging conditions relative to temporal and spatial variations in local wave climate. Based on wave transformation results and the natural variability of normal wave climate for coastal New Jersey, predicted changes in longshore sediment transport rates resulting from offshore sand mining (up to 7 to 20% of existing conditions) are expected to have minimal impact along the shoreline for the selected borrow site characteristics. Alternative conditions are not expected to pose any greater effects unless borrow site geometries are substantially different and the quantity of sand mined from a site is larger than volumes selected for this study.

Benthic Infaunal Characterization Surveys

There was variability in infaunal assemblage composition within and between resource areas, but not uniformly across the study area. Multivariate analyses found that assemblage composition at stations in the northernmost areas (F1 and F2) was similar within and across surveys while southern areas (A1, A2, C1, G1, G2, and G3) had varied assemblages regardless of survey. Infaunal distribution and abundance correlated best with the relative percentages of gravel and sand in surficial sediments. Broad patterns of a homogeneous assemblage in northern areas and mixed assemblages in southern areas may have been due to sediment type distributions, which were mostly gravel stations in F1 and F2 and a mixture of gravel and sand stations in southern areas. Identified sand (Species Group 1) and gravel (Groups 2 and 5) taxa were common types in the region (STEIMLE and STONE, 1973; PEARCE *et al.*, 1981; STEIMLE, 1982; CHANG *et al.*, 1992). Furthermore, station groups with relatively consistent sand or gravel sediments had better defined assemblages than station groups that included both sand and gravel stations. After sediments, relative resource area location within the study area correlated best with assemblage composition, but this also may have been a reflection of sediment type distributions.

Univariate community statistics also revealed differences in assemblages comparing northern and southern areas. Taxa richness was similar across surveys in F2 but increased from May to September in other resource areas, particularly A1, A2, G1, G2, and G3. While several sand stations in G1, G2, and G3 clustered with the northern area stations in September, other southern sand stations (Group D) yielded a common assemblage that was not present in C1, F1, or F2.

Univariate and multivariate analyses of sand and gravel samples suggest that factors other than sediment characteristics also were influencing community patterns. Other possible factors include settlement and post-settlement mortality, and organic content (food supply) of sediments. It is unknown if larval settlement occurred unevenly across the study area prior to September or if settlement perhaps was spatially consistent but post-settlement survivorship or dispersal was variable. A review by ÓLAFSSON *et al.* (1994) concluded that recruitment limitation (*i.e.,* larval availability) is not the dominant determinant of infaunal community patterns in marine sediments. Instead, post-settlement processes resulting in early mortality play a more significant role in population regulation and community organization (ÓLAFSSON *et al.,* 1994; GOSSELIN and QIAN, 1997). A requisite precursor to post-settlement processes, such as competition, predation, and starvation, is faunal dispersal. It is not known at what spatial scales larval distribution may be limiting in the study area, but dispersal range probably varies between species. Studies of sessile marine invertebrate distributions have found evidence of the effects of settlement and early post-settlement mortality at small spatial scales, but mortality has less influence at larger scales (HUNT and SCHEIBLING, 1997).

Area C1 is more than 30 km and A1, A2, G1, G2, and G3 are more than 60 km south of Areas F1 and F2. GRAY (2002) suggested that climatic, latitudinal, or other prime forces regulate broad-scale patterns of infaunal species richness, but regional habitat characteristics (*e.g.,* sediment grain size) probably influence variability over smaller scales. Wave transformation modeling and analysis of sediment transport rates indicated differences between the northern and southern portions of the study area. Southern resource areas also are in proximity to several coastal inlets (*e.g.,* Little Egg Inlet) that are potential sources of organic material. Periodic nutrient inputs to inner shelf sediments can promote intermittent levels of secondary production that otherwise are non-sustainable (HANSON *et al.,* 1981; TENORE, 1985). Substantial additional evidence indicates that secondary production of soft-sediment benthos often is limited by food supply (ÓLAFSSON *et al.,* 1994). In addition to sediment regime, other physical environmental differences between northern and southern portions of the study area may have affected infaunal community patterns.

This study provides infaunal community characterization and does not include post-dredging monitoring. Reviews of prior studies are useful for deduction of general mechanisms of recolonization and recovery in offshore dredged sites (VAN DOLAH, 1996; NEWELL *et al.,* 1998). Frequent benthic disturbance favors opportunistic infaunal taxa (GRASSLE and GRASSLE, 1974; MCCALL, 1977). However, later successional stages of benthic recolonization tend to be more gradual, and involve taxa that generally are less opportunistic and longer-lived. In mined areas with prolonged effects to the infaunal community, transitional opportunists tend to persist (WILBER and STERN, 1992), and it is the later successional stages that may not fully recover for 2 to 3 years. Long-term consequences of sediment mining become more likely in relatively steep bathymetric depressions that sometimes are formed by dredging (NATIONAL RESEARCH COUNCIL, 1995). Such depression features often show increases in silt and clay following dredging (BURLAS *et al.,* 2001). In a borrow site located 3.6 km offshore Coney Island, New York, a prominent bathymetric depression was formed by dredging, and alteration of infaunal assemblage composition at the site has persisted for nearly a decade because of silt settling in the site (BARRY A. VITTOR & ASSOCIATES, INC. STAFF, 1999).

Assuming that smoothly graded features are created by dredging, recolonization by opportunistic taxa, and perhaps later successional stages, may occur in concert with recruitment processes in adjacent non-dredged areas. Strategically dredging portions of target shoals in resource areas could increase the likelihood that motile adults are available for migration into dredged areas from adjacent sediments (VAN DOLAH *et al.,* 1984; JUTTE *et al.,* 2002). GÜNTHER (1992) concluded that post-larval and adult migration into disturbed areas becomes less important, and larval settlement more important, as size of a disturbed area increases. Presumably this is due to currents or other physical forces that disperse pelagic larvae across greater distances than motile post-larvae or adults that crawl or burrow. Mining several small sites on a target ridge or shoal, or mining relatively small portions of several ridges or shoals, may help to ensure availability of nearby populations of potential colonizers. Variations in biological and physical processes along the New Jersey shelf may differentially influence larval settlement and adult immigration. If physical and biological differences between northern and southern portions of the New Jersey shelf are real, the nature and duration of benthic effects may differ with location of mined sites.

CONCLUSIONS

Nearshore sediment transport analyses performed and simulations conducted for potential sand mining operations on the New Jersey OCS have identified minor physical environmental impacts. However, under normal wave conditions, the average change in longshore sand transport was about 10% of existing conditions. Based on wave transformation results and natural variability of the normal wave climate for coastal New Jersey (see KELLEY *et al.,* 2004), predicted changes in longshore sediment transport resulting from offshore sand mining are expected to have minimal impact along the shoreline. Although changes during storm conditions illustrated greater variation, the relative impacts were similar to non-storm conditions. Furthermore, the ability of models to predict storm wave transformation and resultant sediment transport is less certain than for normal wave conditions.

Impacts to the benthic community are expected due to physical removal of borrow material and infauna. Based on previous studies, and assuming that dredged sites do not create a sink for very fine sediments or result in hypoxic or anoxic conditions, levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition may take longer. The nature and duration of benthic effects may differ with location of mined sites, due to physical and biological differences between northern and southern portions of the New Jersey shelf.

ACKNOWLEDGMENTS

The MMS funded this project under Contract No. 14-35-01-97-CT-30864. Authors are grateful for assistance and expertise of numerous individuals who participated in this project.

Contributors include J.S. Ramsey (Sediment Transport Modeling), J.D. Wood (Currents and Circulation), F. Li (Bathymetric Change), and E. Hunt (Report Preparation) from Applied Coastal Research and Engineering, Inc.; F.B. Ayer, III (Benthic Surveys Director), P.S. Fitzgerald (Benthic Survey 1 Chief Scientist and Survey 2 Scientist), A.D. Hart (Benthic Sampling Design and Statistical Analyses), and T. Quinney (Benthic Survey 1 Scientist) from Continental Shelf Associates, Inc.; B.A. Vittor (Benthic Manager) and J.D. Lee, J.M. Horn, L.W. Sierke, and F. Fernandez (Benthic Surveys Scientists) from Barry A. Vittor & Associates, Inc.; K.F. Bosma (Wave Transformation Modeling and Borrow Site Infilling Calculations) from Woods Hole Group; W.C. Isphording (Grain Size Analyses) from the University of South Alabama; and B.S. Drucker (Contracting Officer's Technical Representative) and J.M. Carlson (Contracting Officer) from the MMS. The manuscript was substantially improved by the thorough and insightful technical comments of two anonymous reviewers.

LITERATURE CITED

ASHLEY, G.M., 1987. *Recommendations for Inlet Dredge Channel Placement Based on Analysis of Historic Change: Townsends and Hereford Inlets, New Jersey.* New Brunswick, New Jersey: Final Report to New Jersey Department of Environmental Protection, Rutgers University, 64p.

ASHLEY, G.M.; HALSEY, S.D., and BUTEUX, C.B., 1986. New Jersey's longshore current pattern. *Journal of Coastal Research,* 2(4), 453–463.

BARRY A. VITTOR & ASSOCIATES, INC. STAFF, 1999. *Pre- and Post-dredging Monitoring, Macroinvertebrate Assemblages at a Borrow Area Located Offshore of Coney Island, New York: 1992–1998 Data Synthesis.* New York, New York: U.S. Corps of Engineers, New York District.

BOESCH, D.F., 1973. Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. *Marine Biology,* 21, 226–244.

BRAY, J.R. and CURTIS, J.T., 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs,* 27, 325–249.

BURLAS, M.; RAY, G.L., and CLARKE, D., 2001. *The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project.* New York, New York: U.S. Army Engineer District, New York and U.S. Army Engineer Research and Development Center, Waterways Experiment Station.

BYRNES, M.R. and BAKER, J.L., 2003. Chapter 3: Inlet and Nearshore Morphodynamics. *In:* KRAUS, N.C. and ARDEN, H.T. (Editors), *North Jetty Performance and Entrance Navigation Channel Maintenance, Grays Harbor, Washington, Volume I: Main Text.* Vicksburg, Mississippi: *ERDC/CHL TR-03-12,* Coastal and Hydraulics Laboratory, U.S. Army Engineer Research and Development Center, pp. 67–136.

BYRNES, M.R. and HILAND, M.W., 1995. Large-scale sediment transport patterns on the continental shelf and influence on shoreline response: St. Andrew Sound, Georgia to Nassau Sound, Florida, U.S.A. *In:* LIST, J.H. and TERWINDT, J.H.J. (eds.), *Large-Scale Coastal Behavior. Marine Geology,* 126, 19–43.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; RAMSEY, J.S.; SNYDER, D.B.; WOOD, J.D.; BOSMA, K.F.; THIBAUT, T.D., and PHILLIPS, N.W., 2000. *Environmental Survey of Potential Sand Resource Sites: Offshore New Jersey.* Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), *OCS Report MMS 2000-052, Volume I*: Main Text 380p. + Volume II: Appendices 291p. Online version at http://www.oceanscience.net/mms_nj_ny/related_nj.htm

CALDWELL, J.M., 1966. Coastal processes and beach erosion. *Journal of the Society of Civil Engineers,* 53(2), 142–157.

CHANG, S.; STEIMLE, JR., F.W.; REID, R.N.; FROMM, S.A.; ZDANOWICZ, V.S., and PIKANOWSKI, R.A., 1992. Association of benthic macrofauna with habitat types and quality in the New York Bight. *Marine Ecology Progress Series,* 89, 237–251.

CLARKE, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology,* 18, 117–143.

CLARKE, K.R. and GORLEY, R.N., 2001. Primer v5: User Manual/Tutorial PRIMER-E. Plymouth, United Kingdom.

FIELD, J.G.; CLARKE, K.R., and WARWICK, R.M., 1982. A practical strategy for analysing multispecies distribution patterns. *Marine Ecology Progress Series,* 8, 37–52.

GILBERT, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring.* New York: Van Nostrand Reinhold, 320p.

GOSSELIN, L.A. and QIAN, P.Y., 1997. Juvenile mortality in benthic marine invertebrates. *Marine Ecological Progress Series,* 146, 265–282.

GRASSLE, J.F. and GRASSLE, J.P., 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. *Journal of Marine Research,* 32, 253–284.

GRAVENS, M.B.; SCHEFFNER, N.W., and HUBERTZ, J.M., 1989. *Coastal Processes from Asbury Park to Manasquan, New Jersey.* Vicksburg, Mississippi: *Miscellaneous Paper CERC-89-11,* U.S. Army Corps of Engineers, Waterways Experiment Station, Coastal Engineering Research Center, 197p.

GRAY, J.S., 2002. Species richness of marine soft sediments. *Marine Ecological Progress Series,* 244, 285–297.

GÜNTHER, C.P., 1992. Dispersal of intertidal invertebrates: A strategy to react to disturbances of different scales? *Netherlands Journal of Sea Research,* 30, 45–56.

HANSON, R.B.; TENORE, K.R.; BISHOP, S.; CHAMBERLAIN, C.; PAMATMAT, M.M., and TIETJEN, J., 1981. Benthic enrichment in the Georgia Bight related to Gulf Stream intrusions and estuarine outwelling. *Journal of Marine Research,* 39, 417–441.

HUNT, H.L. and SCHEIBLING, R.E., 1997. Role of early post-settlement mortality in the recruitment of benthic marine invertebrates. *Marine Ecological Progress Series,* 155, 269–301.

JUTTE, P.C.; VAN DOLAH, R.F., and GAYES, P.T., 2002. Recovery of benthic communities following offshore dredging, Myrtle Beach, South Carolina. *Shore & Beach,* 70, 25–30.

KELLEY, S.W.; RAMSEY, J.S., and BYRNES, M.R., 2004. Evaluating the physical effects of offshore sand mining for beach nourishment. *Journal of Coastal Research,* 20(1), 89–100.

KIRBY, J.T. and ÖZKAN, H.T., 1994. *Combined Refraction/Diffraction Model for Spectral Wave Conditions, REF/DIF S. v. 1.1.* Newark, Delaware: University of Delaware, Center for Applied Coastal Research, No. CACR-94-04.

KLITGORD, K.D.; HUTCHINSON, D.R., and SCHOUTEN, H., 1988. U.S. Atlantic continental margin: structural and tectonic framework. *In:* SHERIDAN, R.E. and GROW, J.A. (eds.), *The Atlantic Continental Margin: U.S., Volume I-2, The Geology of North America.* Boulder, Colorado: Geological Society of America, pp. 19–55.

KRAUS, N.C.; SCHEFFNER, N.W.; HANSON, H.; CHOU, L.W.; CIALONE, M.A.; SMITH, J.M., and HARDY, T.A., 1988. *Coastal Processes at Sea Bright to Ocean Township, New Jersey. Miscellaneous Paper CERC-88-2.* Vicksburg, Mississippi: U.S. Army Corps of Engineers, Waterways Experiment Station, Coastal Engineering Research Center, 142p.

MADSEN, O.S. and GRANT, W.D., 1976. *Sediment Transport in the Coastal Environment.* Massachusetts Institute of Technology, Department of Civil Engineering, *Report No. 209,* 105p.

MARGALEF, R., 1958. Information theory in ecology. *General Systematics,* 3, 36–71.

MAURIELLO, M.N., 1991. Beach nourishment and dredging: New Jersey's policies. *Shore & Beach,* 59(3), 25–28.

MCCALL, P.L., 1977. Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. *Journal of Marine Research,* 35(2), 221–266.

NATIONAL RESEARCH COUNCIL, 1995. *Beach Nourishment and Protection.* National Academy Press, 344p.

NEWELL, R.C.; SEIDERER, L.J., and HITCHCOCK, D.R., 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology: An Annual Review,* 36, 127–178.

NOBLE, M.; BUTMAN, B., and WILLIAMS, E., 1983. On the longshelf structure and dynamics of subtidal currents on the eastern United States continental shelf. *Journal of Physical Oceanography,* 13(12), 2125–2147.

ÓLAFSSON, E.B; PETERSON, C.H., and AMBROSE, W.G., JR., 1994. Does recruitment limitation structure populations and communities of macro-invertebrates in soft sediments: The relative significance of pre- and post-settlement processes. *Oceanography and Marine Biology: An Annual Review,* 32, 65–109.

PIELOU, E.C., 1966. Species-diversity and pattern-diversity in the study of ecological succession. *Journal of Theoretical Biology,* 10, 370–383.

PEARCE, J.B.; RADOSH, D.J.; CARACCIOLO, J.V., and STEIMLE, JR., F.W., 1981. *Benthic Fauna: Marine EcoSystems Analysis (MESA) Program, MESA New York Bight Project.* Albany, New York: New York Sea Grant Institute, *MESA New York Bight Atlas Monograph 14,* 79p.

QUINN, M.L., 1977. *The History of the Beach Erosion Board.* Vicksburg, Mississippi: U.S. Army Corps of Engineers, Coastal Engineering Research Center, *Miscellaneous Report 77-9,* 181p.

RAMSEY, J.S., 1991. *A Study of Wave-Induced Currents Behind Shore Parallel Breakwaters.* Newark, Delaware: M.C.E. Thesis, Department of Civil Engineering, University of Delaware, 101p.

SAS INSTITUTE, INC. STAFF, 1989. *SAS/STAT ®User's Guide,* Version 6, Fourth Edition, Volume 1. Cary, North Carolina: SAS Institute, Inc., 943p.

SMITH, P.C., 1996. *Nearshore Ridges and Underlying Upper Pleistocene Sediments on the Inner Continental Shelf of New Jersey.* New Brunswick, New Jersey: Masters Thesis, Rutgers University, Geological Sciences, 157p.

STEIMLE, F.W., JR., 1982. The benthic invertebrates of the Block Island Sound. *Estuarine, Coastal and Shelf Science,* 15, 1–16.

STEIMLE, F.W., JR. and STONE, R.B., 1973. *Abundance and Distribution of Inshore Benthic Fauna off Southwestern Long Island, N.Y.* Seattle, Washington: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *NOAA Technical Report SSRF-673.*

TENORE, K.R., 1985. Seasonal changes in soft bottom macrofauna of the U.S. South Atlantic Bight. *In:* ATKINSON, L.P.; MENZEL, D.W., and BUSH, K.A. (eds.), *Oceanography of the southeastern U.S. continental shelf.* Washington, DC: American Geophysical Union, pp. 130–140.

UPTEGROVE, J.; MULLIKEN, L.G.; WALDNER, J.S.; ASHLEY, G.M.; SHERIDAN, R.E.; HALL, D.W.; GILLROY, J., and FARRELL, S., 1995. *Characterization of Offshore Sediments in Federal Waters as Potential Sources of Beach Replenishment Sand—Phase I.* Trenton, New Jersey: Open File Report OFR 95-1, New Jersey Geological Survey, 148p.

USACE, 1997. *Townsends Inlet to Cape May Inlet Feasibility Study.* Philadelphia, Pennsylvania: U.S. Army Corps of Engineers New Jersey Shore Protection Study, Philadelphia District.

VAN DOLAH, R.F., 1996. Impacts of beach nourishment on the benthos: What have we learned? *Proceedings of the Twenty-fourth Annual Benthic Ecology Meeting* (Columbia, South Carolina), p. 82.

VAN DOLAH, R.F.; CALDER, D.R., and KNOTT, D.M., 1984. Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary. *Estuaries,* 7, 28–37.

WICKER, C.F., 1951. *History of the New Jersey Coastline.* Long Beach, California: Proceeding of the 1st Conference on Coastal Engineering, pp. 299–319.

WILBER, P. and STERN, M., 1992. A re-examination of infaunal studies that accompany beach nourishment projects. *Proceedings of the 5th Annual National Conference on Beach Preservation Technology, New Directions in Beach Management,* Florida Shore and Beach Preservation Association (Tallahassee, Florida), pp. 242–257.

WINER, H., 1988. *Numerical Modeling of Wave-Induced Currents Using a Parabolic Wave Equation.* Gainesville, Florida: Department of Coastal and Oceanographic Engineering, University of Florida, Technical Report No. 80.

TITLE: Effects of Sand Mining on Physical Processes and Biological Communities Offshore New Jersey, U.S.A.
SOURCE: J Coast Res 20 no1 Wint 2004
WN: 0436007132003

Journal of Coastal Research	20	1	61–69	West Palm Beach, Florida	Winter 2004

Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 2—Biological Considerations

R. J. Diaz†, G. R. Cutter, Jr.‡ and C. H. Hobbs, III†

†Virginia Institute of Marine Science
College of William & Mary
Gloucester Point, VA 23062, USA

‡University of New Hampshire
Center for Coastal and Ocean Mapping
24 Colovos Rd.
Durham, NH 03824, USA

ABSTRACT

DIAZ, R.J.; CUTTER, JR., G.R., and HOBBS, III, C.H., 2004. Potential impacts of sand mining offshore of Maryland and Delaware: Part 2—biological considerations. *Journal of Coastal Research,* 20(1), 61–69. West Palm Beach (Florida), ISSN 0749-0208.

The mining of sand resources from the inner continental shelf for beach nourishment may lead to impacts or increase stress on commercial and noncommercial living resources that utilize these areas. The objective of our work was to characterize benthos present in areas likely to be mined and to predict impacts of sand mining. In 1998 and 1999 we used a combination of methods (grab samples, sediment profile cameras, video sled, and trawl) to collect data on the benthos, both fishes and invertebrates, which utilized several potential sand mining areas. We found benthic communities and fish assemblages to be typical of middle Atlantic sandy inner continental shelf habitats. A sand mining scenario that removed the top meter of sand from Fenwick Shoal would disturb approximately 7.7 km^2 with the potential acute impact on noncommercial sessile species being the loss of about 150×10^6 individuals representing 300 kg of wet weight biomass that could have functioned as trophic support to fishes. In addition, mobile species would be displaced and have to search for replacement habitat. To minimize impacts and promote recolonization of mined areas the total removal of substrate should be avoided. Small areas with a project area should be left to serve as refuge patches that would promote recolonization and serve as habitat for mobile species. Predicted impacts on demersal fishes would be lessened by a rapid recolonization, particularly the recovery of mobile epifaunal crustacean that serve as the primary trophic support species. Project timing and engineering could also be used to lessen impacts on fishes by reducing stress on crustaceans. For example, mining activities that ended in time for Spring/Summer recruitment would favor crustaceans while a Fall/Winter end would favor annelids.

ADDITIONAL INDEX WORDS: *Recolonization, benthos, juvenile fishes, EFH, sand mining, trophic transfer, secondary production, demersal fishes, sand shoals, continental shelf.*

INTRODUCTION

The demand for sand to nourish eroding beaches has risen to the point that sand resources on the inner continental shelf are being mined. This demand for continental shelf sand is expected to increase with time considering the amount of erosional shoreline in the middle Atlantic Bight (GALGANO *et al.*, 2003). The impacts of sand mining activities on benthic living resources on the shelf are of concern because of the scale (potential for removal of millions of cubic yards of sand) and potential for cumulative impacts of mining activities as either the area mined expands or the same area is mined again. From a biological perspective, mining sand from the continental shelf would directly disturb benthic communities and indirectly disturb trophically dependent pelagic species.

The potential disturbances resulting from sand mining are important because of the highly interactive and dynamic biological and physical conditions on the continental shelf. By altering the submarine topography, mining will influence the dynamics of the water movement, which would directly impact sediment dynamics and indirectly benthic organisms. These direct and indirect responses occur on differing time and spatial scales (CUTTER and DIAZ, 2000). A companion paper (MAA *et al.*, this volume) presents a consideration of the physical oceanographic impacts associated with the same study.

The impacts of acute disturbances related to sand mining, which are primarily removal of resident organisms and exposure of subsurface sediments, are modulated by the physical dynamics on the shelf. Dredging will directly alter topographic features with subsequent impacts on water column dynamics, thence the substrate and recovery rates of the benthos. Impacts to the biological resources include removal of infauna, epifauna, and some benthic fishes and alteration of the available substrate. Prediction of the short-term responses of the benthos is considerably more difficult that of the long-term because of asynchronous and naturally variable short-term population fluctuations (MAURER *et al.*, 1976). Contrastingly, long-term responses can be considered in terms of a spatial problem in that the community structure

5 received and accepted in revision 6 June 2003.

eventually should respond to the components of the substrate and primary alterations of the substrate should be limited to the vicinity of the mining site.

This portion of the mid-Atlantic coast is also an important foraging and spawning ground for a wide variety of benthic and pelagic fishes with most species being transients or seasonal residents and few year-round residents. This predominantly transient pattern of use by fishes is related primarily to the extreme range of sea temperature, one of the largest for our world oceans (MUSICK, 1999). The suite of mobile or transitory species that pass through the area annually includes boreal, temperate, and sub-tropical species (MUSICK *et al.,* 1986). OLNEY and BILKOVIC (1998) list and discuss many of the fishes that occur within the study area. Late spring and summer months are the periods when the greatest number of species spawn or pass egg and larval life-history stages in the area. The fewest are present in January, February, and March.

The pre- and post-mining benthic resources occur over several scales of spatial and temporal variation. Water depth or topography, the substrate's sedimentalogical characteristics, and benthic community attributes vary at small (cm) to regional (km) scales. This great range in scales requires that attention be given to sample design for detecting impacts from sand mining. Similarly, there is wide variation in temporal scales with differing levels of importance. Diurnal use of habitat occurs relative to protection from predators and foraging for prey (DIAZ *et al.*, 2003) and seasonal changes in recruitment and species turnover (MUSICK *et al.,* 1986; OLNEY and BILKOVIC, 1998). Strom events are also important in structuring the benthos and while individual storms are less predictable the rough seasonality and approximate number of events has a relatively narrow interannual range.

This paper reports upon some of the biological consequences that are likely to occur should large quantities of sand be mined from beneath the waters offshore of Maryland and Delaware along the mid-Atlantic coast of the United States (Figure 1). The work reported upon herein is a summary of studies conducted from 1998 to 1999 (HOBBS, 2000; HOBBS, 2002; DIAZ *et al.,* 2003).

METHODS

The states of Delaware and Maryland with the Minerals Management Service (MMS) identified five regions of interest (ROI) in the study area. Two, Indian River and North Bethany Beach, were offshore of the Indian River Inlet and three were on major shoals of Fenwick, Weaver, and Isle of Wight offshore of Ocean City Inlet. Most the focus in this paper will be on the shoals off of Ocean City inlet. We conducted two extensive sampling cruises to collect data from these areas. Scientific operations were conducted 24 hours a day to collect data on day/night differences in habitat use by mobile species.

The first cruise, May 1998, encompassed the five ROI and some surrounding areas whereas the June 1999 cruise concentrated on the three shoals ROI. During the 1998 cruise data were acquired from fixed stations on a regular lattice with sediment profile cameras to characterize both physical and biological aspects of the benthic habitat. Grab samples for grain-size and benthos were collected at random picked stations within the lattice. A towed camera sled, with both video and still cameras, was used on transects within and across the lattice. During the 1999 cruise grab samples were collected at a subset of the stations sampled in 1998. See CUTTER and DIAZ (2000) for details on the sampling design.

A Young grab having a surface area of 0.044 m^2 was used for benthos and sediment samples. Grab samples were washed through a 500-um sieve, sorted, and all organisms identified to the lowest practical taxonomic level (LPTL), usually species. Individuals were grouped by LPTL and placed in two percent Formalin until wet weight measurements were completed. Sediment profile images (SPI) were obtained on Fujichrome 100 ASA color slide film with a Hulcher model Minnie Sediment Profile Camera. The VIMS Bottom Imaging Sled was deployed with video cameras and water quality sensors and towed at speeds $<$1 knot when possible. On the 1999 cruise, we deployed an eight-foot (2.4 m) beam-trawl to collect juvenile fish, epibenthos, and megabenthos. Trawl locations were selected based on benthic habitat data collected in 1998. Two physically dominated sandy and gravelly-shelly habitats with little evidence of biogenic structure along the northeastern and northwestern sides of Fenwick Shoal and two more biologically accommodated *Diopatra*- and *Asabellides*-tube-field habitats on the southeastern and southwestern sides were sampled with the trawl. Each location was trawled during the day and night to assess diurnal differences and the trawl was equipped with a meter wheel to enable estimation of fish abundance per unit area (DIAZ *et al.,* In press). See CUTTER and DIAZ (2000) for details on sample processing and data reduction methods.

RESULTS

Transitions in the local environments occur over different scales near the shoals at rates that appear related to the topographic slope. The southeast faces of the three major shoals off Ocean City Inlet were the steepest. The bathymetric change between Fenwick and Weaver Shoals was the greatest. The area between these shoals also had the greatest range of habitats with the most abrupt changes between habitat types. Within a few tens of meters, the substrate changed from medium to coarse sand to clayey-silty mud.

Sediments from Indian River ROI were coarser than those from the Ocean City shoal ROI based on grain-size from the grab samples. When assessing only the sand-fraction, mean grain size at Indian River ROI stations was 0.52 mm (1.06 phi) compared to 0.42 mm (0.86 phi) for the Ocean City shoals ROI stations. Standard deviations were 0.17 and 0.19mm (0.39 and 0.41 phi) respectively. Sediment profile images (SPI) yielded additional data on sedimentary habitat characteristics such as biogeochemical features, sediment-water interface properties, and counts of organisms and biogenic features. At the Ocean City shoals ROI, the depth of the redox potential discontinuity layer, RPD, averaged 7.8 cm in 1998 and 6.1 cm in 1999. At the Indian River ROI, sampled only in 1998, RPD depth averaged 7.4 cm. The RPD layer indicates the depth to which oxygen penetrates into the sed-

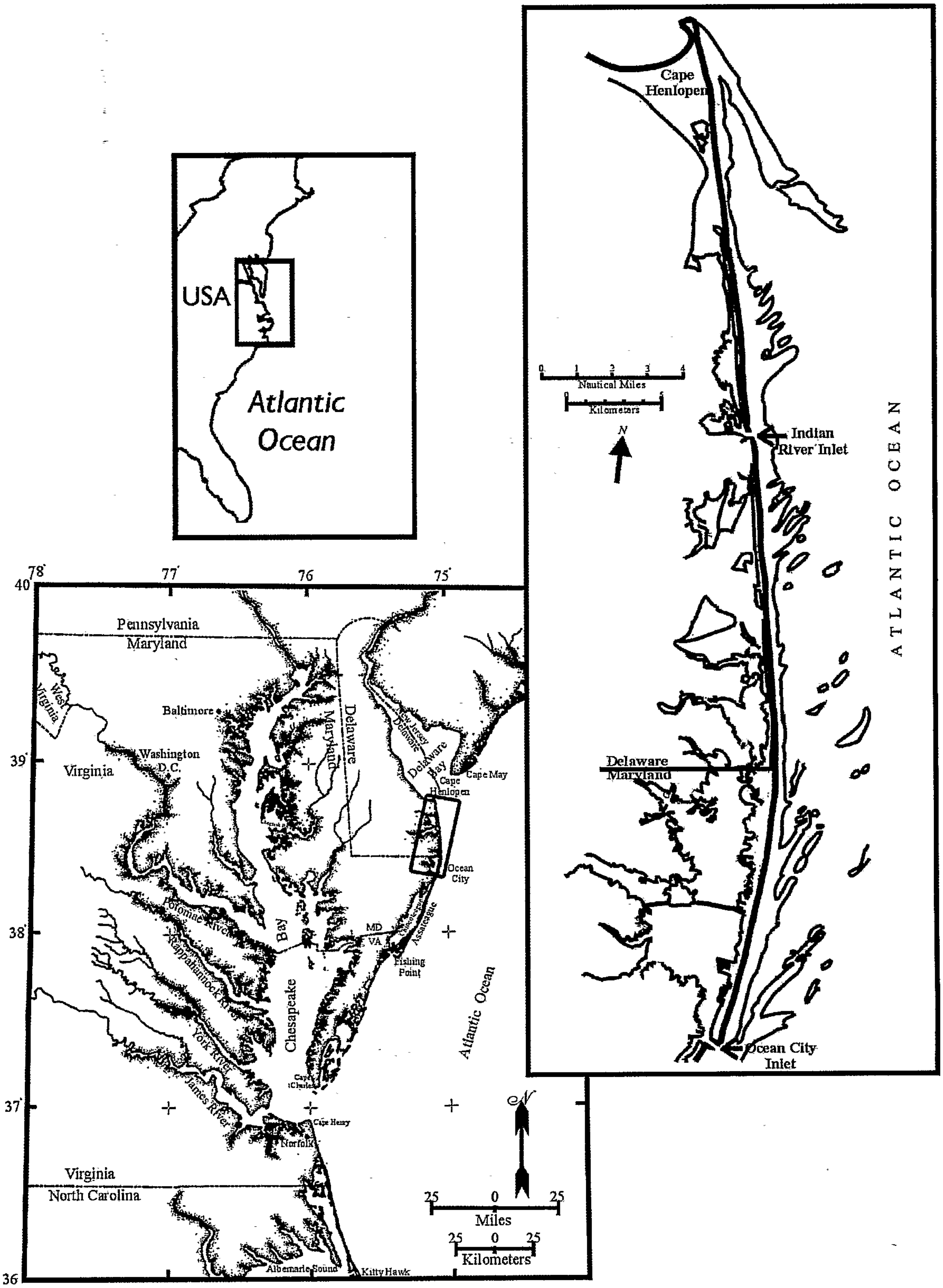


Figure 1. General location of Indian River Inlet and Ocean City Inlet ROI.

Table 1. *Abundance of benthic dominants from all ROI in 1998 and Ocean City shoal ROI in 1999. Includes all taxa that were at least one percent of the total abundance in either May 1998 (52 grab samples) or September 1999 (20 grab samples).*

		Total Occurrences			Taxa Abundance (individuals/m²)		
Major Taxa	Taxa	98&99	98	99	Ave. 98&99	98	99
Annelida	*Spiophanes bombyx*	39	29	10	5800	9710	1889
Annelida	Oligochaeta	58	43	15	1615	2789	445
Bivalvia	*Tellina* spp.	47	29	18	640	889	391
Annelida	*Spio setosa*	16	8	8	490	167	813
Annelida	*Aricidea (Acmira) cerrutii*	37	32	5	465	889	43
Nemertinea	Nemertinea	55	37	18	410	689	128
Annelida	*Asabellides oculata*	20	13	7	335	554	114
Annelida	*Brania wellfleetensis*	23	18	5	235	442	33
Crustacea	*Unciola irrorata*	30	17	13	230	286	175
Annelida	*Aricidea (Acmira) catherinae*	32	25	7	225	341	108
Annelida	*Aphelochaeta* sp.	25	20	5	175	314	32
Crustacea	*Pseudunciola obliquua*	17	11	6	175	167	180
Bivalvia	*Astarte* spp.	21	14	7	165	279	50
Crustacea	*Byblis serrata*	17	9	8	150	34	267
Bivalvia	*Mytilus edulis*	17	13	4	145	277	10
Annelida	*Hesionura elongata*	21	14	7	125	229	17
Annelida	*Parapionosyllis longicirrata*	30	25	5	120	227	11
Bivalvia	*Crenella glandula*	23	12	11	120	181	56
Crustacea	*Protohaustorius wigleyi*	29	22	7	115	202	25
Crustacea	*Tanaissus psammophilus*	22	16	6	100	165	33
Annelida	*Caulleriella* sp. B	16	16	0	95	192	0
Annelida	*Hemipodus roseus*	21	15	6	55	94	15
Annelida	*Nephtys* spp.	20	16	4	55	98	11
Annelida	*Streptosyllis pettiboneae*	15	11	4	55	92	16
Crustacea	*Chiridotea coeca*	17	12	5	55	89	20
Cnidaria	Anthozoa	15	9	6	50	82	19
Bivalvia	*Spisula solidissima*	15	12	3	30	53	5
Bivalvia	*Lyonsia hyalina*	15	9	6	25	37	13
Crustacea	*Pseudoleptocuma minor*	16	13	3	25	48	5
Cephalochordata	*Branchiostoma caribaeum*	18	8	10	20	23	17

iments, which is a key factor in determining benthic habitat quality (RHOADS and GERMANO, 1986). Thus any sand mining operation removing more than 10 cm of sand would expose anaerobic sediments that would affect recolonization by benthos (DIAZ and SCHAFFNER, 1990).

During the May 1998 cruise, a total of 10,634 individuals representing 152 taxa identified to LPTL were collected from 52 grab samples. Benthos abundance varied from 90 to 70,600 individuals/m² with the mean and median abundance being 5,100/m² and 1,950/m² respectively. Annelid worms were the most abundant followed by molluscs and crustaceans. At a finer taxonomic scale, 15 percent of the annelids were oligochaetes and 85 percent polychaetes, 97 percent of the molluscs were bivalves and 3 percent gastropods, and 60 percent of the crustaceans were amphipods. The number of taxa (LPTL) per sample varied from three to 35. Wet weight biomass varied 6,000 fold from 0.3 to 2,000 g/m². The lowest biomass occurred at a station on the crest of the shoals and the highest on the Indian River flats. The large difference in biomass was a due to the occurrence of a few large individuals, usually molluscs. Molluscs accounted for about 87 percent of the biomass followed by polychaetes, gastropods, and amphipods with about 6, 3, and 1 percent, respectively.

A total of 6,145 individuals representing 108 taxa were obtained from 20 samples collected in June 1999. Infaunal abundance varied from 230 to 30,400 individuals/m² with the mean and median being 7,680 and 2,187/m². Again, annelid worms were the most abundant followed by about equal numbers of crustaceans and molluscs. Polycheates accounted for about 92 percent and oligochaetes for about 8 percent of the annelids, 92 percent of the molluscs were bivalves and 8 percent gastropods and 92 percent of the crustaceans were amphipods. The number of species per sample varied from 6 to 40 with a mean of 20.4. Wet biomass varied from 0.3 to 2,000/m² with the lowest on the shoals and the greatest in the Indian River area.

While 166 taxa were collected during the course of the two cruises, 31 occurred in at least 15 samples and were considered the dominants (Table 1). Of these 31 dominant taxa, oligochaete worms were the most widely distributed, occurring at 58 stations. The surf clam, *Spisula solidissima,* occurred at 15 stations but was 66 percent of the total biomass on both cruises and dominated wet weight biomass. The other 30 dominant taxa made up 30 percent of the total biomass and the remaining 135 taxa 4 percent. The basic patterns in the distribution of the benthos were driven by species-habitat or species-sediment preferences. For the dominant taxa patterns were primarily related to sediment grain size with Nemertina, *Astarte* spp., *Crenella glandula, Mytilus edulis,* and *Byblis serrata* characteristic of coarser sediments and with *Asabellides oculata, Spio setosa, Spiophanes bombyx, Tellina* spp., and *Unciola irrorata* associated with the finer, in some cases silty, sediments.

The dominant taxa have a broad range of life history traits.

Table 2. *Life history traits summary for dominant taxa from the Ocean City shoals ROI. See CUTTER and DIAZ (2000) for sources.*

Species Name	Preferred Substrate	Feeding Mode	Mobility	Spawns/Year	Larval Mode	Spawning Times	Lifespan
Ampelisca spp.	Medium to Coarse Sand	Suspension	Tube Builder	Twice	Brooding	Spring/Summer	Annual
Byblis serrata	Medium to Coarse Sand	Suspension	Tube Builder	Multiple Events	Brooding	Late Spring/Summer	Annual
Protohaustorius wigleyi	Fine Sand	Suspension	Burrower	Multiple Events	Brooding	Late Spring/Summer	Annual
Pseudounciola obliquua	Medium to Coarse Sand	Suspension	Tube Builder	Multiple Events	Brooding	Late Spring/Summer	Annual
Unciola irrorata	Coarse to medium Sand	Deposit/Suspension	Lives in tubes of other organisms	Once	Brooding	Spring/Early Summer	Annual
Astarte spp.	Muddy Fine Sand	Deposit/Suspension	Limited Mobility	Once	Lecithotrophic eggs on substratum	Fall	20 years
Ensis directus	Medium to Fine Sand, Muddy Sand	Suspension	Limited Mobility	Multiple Events	Planktonic	?	>1
Mytilus edulis	Hard Substrates, Coarse Sand, Gravel	Suspension	Sessile	Once or Twice	Planktonic	Late Fall/Winter	7 years
Nucula proxima	Muddy	Deposit	Limited Mobility	?	Planktonic	Late Summer/Early Fall	>1
Spisula solidissima	Coarse Sand	Suspension	Limited Mobility	Twice	Planktonic	Late Summer/Fall	20 to 35 Years
Tellina agilis	Medium to Fine Sand, Muddy Sand	Surface Deposit	Limited Mobility	Twice	Planktonic	Spring/Fall	2 Years
Branchiostoma caribaeum	Coarse to Fine Silty Sand	Suspension	Mobile	?	Planktonic	?	?
Anthozoa	Coarse to Fine Sand	Carnivore/Suspension	Sessile	?	Asexual/Planktonic	?	Annual?
Oxyurostylis smithi	Fine Sand	Suspension	Burrower/Limited Mobility	Continuous	Brooding	Early Winter	Annual
Pseudoleptocuma minor	Fine Sand	Suspension	Burrower/Limited Mobility	Continuous	Brooding	?	Annual
Busycon canaliculata	Coarse to Muddy Fine Sand	Carnivore	Mobile	Once	Direct Development	?	>5 years
Nassarius trivittatus	Coarse to Fine Sand	Scavenger	Mobile	?	Direct Development	?	>1
Politolana concharum	?	?	Limited Mobility	?	Brooding	Winter/Early Spring	?
Nemertinea	Coarse sand to Muds	Carnivore	Burrower	?	Direct Development or Planktonic	?	Annual?
Oligochaeta	Coarse to Fine Sand, Muds	Deposit	Burrower/Interstitial	Continuous	Direct Development	Spring/Summer/Fall	Annual
Aphelochaeta sp.	?	Surface Deposit	Tube Builder	Multiple Events	Lecithotrophic eggs	Spring/Summer	?
Aricidea spp.	Muddy, Silty-Fine Sand	Subsurface Deposit	Burrower	?	Brooding	?	?
Asabellides oculata	Sand, Silty Sand	Surface Deposit	Tube Builder	Once	Brooding	Winter, Early Spring	Annual
Brania wellfleetensis	Muddy, Muddy Sandy	Deposit	Burrower	Once	Brooding	Fall	?
Hemipodus roseus	Coarse Sand	Carnivore	Burrower	Once	Planktonic	?	?
Hesionura elongata	Medium to Coarse Sand	Carnivore	Burrower	Once	Planktonic	?	?
Mediomastus ambiseta	Muddy Fine Sand	Deposit	Tube Builder	Once	Planktonic, Non-Feeding	Late summer/fall	Annual
Nephtys spp.	Coarse to Very Fine Sand	Carnivore/Omnivore	Burrower	Twice	Planktonic	Spring/Fall	4 Years
Parapionosyllis longicirrata	Muddy Sand, Shells	?	Burrower	?	Brooding	Fall	?
Protodorvillea kefersteini	Coarse to Fine Sand	Carnivore	Burrower	Once	Direct Development	Summer/Late Fall	?
Spio Setosa	Muddy Fine Sand	Deposit/Suspension	Tube Builder	Twice	Broods Spring Planktonic Fall	Spring/Fall	Annual
Spiophanes bombyx	Fine Sand, Muddy	Deposit/Suspension	Tube Builder	Once	Planktonic	Late Summer	Annual
Streptosyllis pettiboneae	Medium Fine Sand	Carnivore	?	Once	Brooding	Spring/Early Summer	Annual

Table 3. *Predicted recruitment potential of dominant benthos found at the Ocean City shoal ROI.*

Major Group	Species Name	Recruitment Potential		
		Year Round	Spring/Summer	Fall/Winter
Cnidaria	Anthozoa	Poor	Poor	Poor
Nemertinea	Nemertinea	Good	Good	Good
Oligochaeta	Oligochaeta	Good	Good	Good
Polychaeta	*Aricidea* spp.	Poor	?	?
	Hemipodus roseus	Poor	?	?
	Hesionura elongata	Poor	?	?
	Brania wellfleetensis	Poor	Poor	Good
	Mediomastus ambiseta	Poor	Poor	Good
	Parapionosyllis longicirrata	Poor	Poor	Good
	Aphelochaeta sp.	Poor	Good	Poor
	Spiophanes bombyx	Poor	Good	Poor
	Streptosyllis pettiboneae	Poor	Good	Poor
	Asabellides oculata	Good	Good	Good
	Nephtys spp.	Good	Good	Good
	Protodorvillea kefersteini	Good	Good	Good
	Spio Setosa	Good	Good	Good
Gastropoda	*Busycon canaliculata*	Good	Good	Good
	Nassarius trivittatus	Good	Good	Good
Bivalvia	*Astarte* spp.	Poor	Poor	Good
	Mytilus edulis	Poor	Poor	Good
	Nucula proxima	Poor	Poor	Good
	Ensis directus	Good	Good	Good
	Spisula solidissima	Good	Good	Good
	Tellina agilis	Good	Good	Good
Cumacean	*Oxyurostylis smithi*	Good	Good	Good
	Pseudoleptocuma minor	Good	Good	Good
Isopoda	*Politolana concharum*	Good	Good	Good
Amphipoda	*Ampelisca* spp.	Poor	Good	Poor
	Byblis serrata	Poor	Good	Poor
	Protohaustorius wigleyi	Poor	Good	Poor
	Pseudounciola obliquua	Poor	Good	Poor
	Unciola irrorata	Poor	Good	Poor
Cephalochordata	*Branchiostoma caribaeum*	Good	Good	Good

According to the literature, shallow continental shelf macrobenthic communities are primarily controlled by sediment grain size and bottom topography. Many life history traits reflect an accommodation to the influence of physical processes and cycles. For example, some taxa are restricted to either coarse or fine sands. The majority of the dominants were either suspension feeders, common to high energy and high particulate habitats, or carnivores (Table 2). Many had combinations of life history traits that would give them a good ability to recruit into sand mine disturbed areas (Table 3).

The potential of a species to recruit or recolonize a mined area is a function its life history traits. Three categories of recolonization potential were considered: Year Round, Spring/Summer, and Fall/Winter. A species was considered to be a Year Round colonizer if it had a broad range of sediment preferences, spawned more than once a year over multiple seasons, and had a life span of a year or less. Species with good dispersal or mobility were considered good colonizers (Table 3). For example, oligocheates can recolonize a habitat at any time of the year by being transported with the (sediment) bed transport. Good Spring/Summer or Fall/Winter colonizers were those species that recruited during the appropriate time period and had good mobility. Of the species considered, 15 were rated as good and 18 as poor Year Round colonizers, eight were good Spring/Summer and seven were good Fall/Winter colonizers. There was insufficient information to categorize four of the dominant taxa.

Twenty species of fish were collected from the four previously determined habitats. The most abundant fish was the hake, *Urophycis regia,* followed by *Etropus microstomus,* together accounting for about 70 percent of the fish caught. All the fishes caught were the common members of the shallow continental shelf fish assemblage (ABLE and FAHAY, 1998). Cluster analysis indicated that there were day/night differences in the fish assemblage in the south west *Asabellides* tube and the north west sand habitats. Overall, the association between fishes and habitats appeared to be related to sediment grain-size, bed roughness, and the presence (or absence) of biogenic structures.

DISCUSSION

Sand mining activities will physically alter the local habitat and impact benthos. Assuming substantial excavation and removal of all benthic organisms the mining area, it is possible to predict the potential nature of recolonization communities based primarily on the occurrences and proximity of the other community groups in the vicinity. Predictions are based upon three elements: First, that neighboring commu-

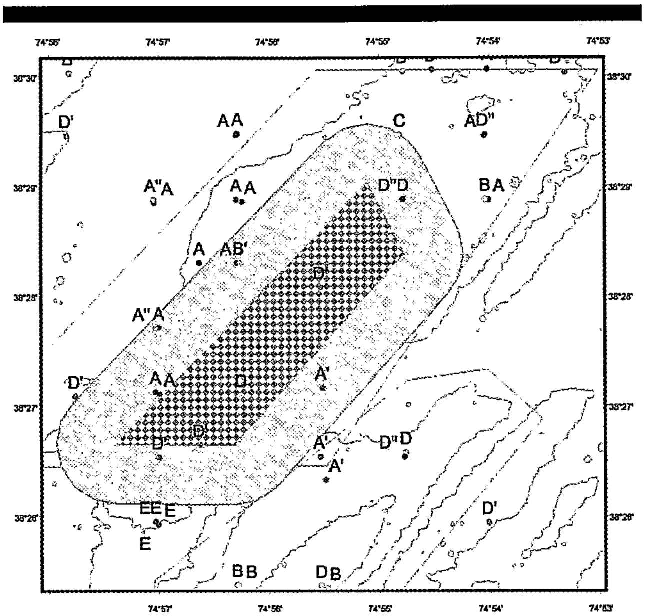


Figure 2. Sand mining scenario for the Fenwick Shoal ROI, off Ocean City Inlet, Maryland. Benthic recolonization of the mined area (coarse stippling) would proceed from community groups in the buffer zone (fine stippling) and from outside the mined area. Letters refer to cluster groups based on benthic grab data.

nity groups, species compositions and abundances of major taxa that surround the mined area are the primary source of recruits. Second, incorporation of available data on the likely nature of the newly exposed substrate. Third, the effect of season on recolonization would have to be assessed with consideration of the life histories of the species available for recolonization. Several of the dominants, oligochaetes, nemerteans, *Protodorvillea, Tellina,* and *Asabellides,* likely would recruit in any season while the amphipods (*Bybilus, Pseudunciola,* and *Parahaustorius*) likely would recruit better in spring/summer than in fall/winter. The polychaete *Brania* and the bivalve *Nucula* would do better in fall/winter. Overall it is probably that larval and juvenile recruitment would be better after a spring/summer dredging than after a fall/winter disruption. Recruitment by adults during any season is more apt to be regulated by factors such as storms that affect passive transport. While the active transport of mobile species such as epifaunal mysids or *Crangon septemspinosa* might be more rapid during the warm months when the species are more active, it would also take place during the winter but at a reduced rate.

As an example of potential recolonization considers the scenario of removing at least the top meter of sand from Fenwick Shoal and that the grain-size characteristics of the new substrate are the same as the original. The disturbed area would be approximately 7.7 km^2 (Figure 2). The average density of the infauna of the dominant and subdominant species would be approximately 1900 individuals/m^2 and the average (wet) biomass about 3.8 g/m^2. Thus the acute impacts would be a loss of approximately 150×10^6 individuals with a combined wet biomass of about 300 kg. A mining operation with a subsequent recruitment in the spring/summer would favor crustaceans while a fall/winter recruitment would favor annelids (Table 4). After a single spring/summer recruitment it is likely that the level of benthic resources would be sufficient for a return of demersal fishes. Indeed the recruitment potential of the crustaceans is such that the habitat might be slightly enhanced. However, following a fall/winter recruitment the benthic resource value might not be as great as annelids might not be utilized by demersal fishes to the same extent as crustaceans. Should the post-exploitation substrate have a finer grain size than the original, it might favor annelids and bivalves that might in the long-term reduce the resource value for demersal fishes.

Table 4. *Scenarios depicting the effect of season and climatology on infaunal recolonization trajectory. Habitat and faunal characteristics for the combination of season and climate are listed in each cell.*

Climate Immediately After Mining:	Season When Sand Mining Conducted:	
	Spring/Summer	Fall/Winter
Stormy/Energetic	Transport of small to large individuals into and out of mined area Dispersal of organic matter and fine sediments Dispersal of individuals form mass recruitment events Lower potential for shift in community structure Recolonization rate intermediate Production lowered	Transport of small to large individuals into and out of mined area Dispersal of organic matter and fine sediments Physical and physiological stress highest, sensitive life history stages eliminated Recolonization slowed to lowest rate High potential for delay of community structure recovery Production at lowest point
Calm/Quiescent	Deposition of water column primary production Fine sediments accumulate in mined area Recruitment of warm water larval forms favored Surface and subsurface deposit feeders favored Species that queue on fine sediments favored Recolonization proceeds at highest rate Highest potential for shift in community structure Extended quiescence may lead to hypoxia, regionally or within mined area Highest production	Fines accumulate in mined area Recruitment of cold water larval forms favored Recolonization rate intermediate High potential for shift in community structure Pulse of high production

JUTTE and VANDOLAH (1999) found that a year after sand mining in two areas offshore of Hilton Head, SC that the silt-clay content of the surface sediments increased by 13 percent and that the benthic resources had changed from the original and hand not recovered to the original community structure. However they also found that in an area offshore of Myrtle Beach, SC that the surface sediments had not fined and that the infaunal community recovered in about two years.

In order to ensure that the biological assemblages that recolonize a mined area resemble that prior to the disturbance, it would be beneficial to avoid total removal of the substrate. Leaving selected small, untouched areas to serve as refuges (refuge patches) within the disturbed zone should minimize the potential alteration of community structure and function and, therefore, reduce potential effects upon trophically dependent species. Refuge patches from mining should be of higher priority in areas where the tops or ridges of shoals are to be mined for two main reasons: 1) the shoal-ridge communities are different from the mid-shoal and trough communities and 2) potential recruits from adjacent shoals, if any, likely would suffer high mortality from exposure to predators during the open water transit and, thus, would have limited chance for successful recolonization. By contrast, if local refuge patches are retained, travel distances and exposure times for transiting organisms would be minimized with a concomitant increase in success. Marine refuge patches should promote similarity between the pre- and post-mining benthic communities and related or dependent nekton.

The impacts of sand mining on mobile fisheries resources also are connected to the rate and success of benthic recolonization. Many fishes use the shallow continental shelf as a nursery ground (ABLE and FAHEY, 1998; OLNEY and BILKOVIC, 1998; MUSICK, 1999) and, depending on when their demersal life history stages utilize a particular area, any impacts could be minimized by insuring that their cover or food source not be disrupted. For the most part this would mean minimizing impacts to crustaceans. Conversely, any aspect of sand mining that would enhance production of crustaceans likely would improve habitat quality for demersal fishes.

CONCLUSIONS

Sand mining activities should be designed to minimize impacts to biological resources and to ensure the biological assemblages that recolonize a mined area functions in a similar manner to that present prior to mining; the primary function being trophic support of fishes. Avoiding total removal of surficial substrates and retaining small patches within the mined area could do this, in part. These patches would serve as refuges for established benthic species and facilitate recolonization by providing a local source of potential recruits. Facilitating rapid recolonization of a mined site by established community members would minimize alteration of community structure and function and reduce potential effects upon trophically dependent fishes. Impacts to demersal fishes would be connected to the rate and success of benthic recolonization, as many fishes utilize the shallow continental shelf as a nursery ground, which would be connected to the seasonal timing of sand mining (Table 4). We found juvenile demersal fishes to overwhelmingly feed on epifaunal and infaunal crustaceans, thus any aspect of sand mining that would enhance the production of crustaceans would likely also improve habitat quality for demersal fishes.

ACKNOWLEDGMENTS

The Minerals Management Service of the U.S. Department of the Interior funded the work. We thank Barry Drucker, the contract manager, for his support and encouragement. C. C. Spaur and an anonymous reviewer for their insightful comments. We also thank the crews of the *R/V Atlantic Surveyor* and the *R/V Cape Henlopen* for contributing to the success of the data collection and our co-workers at VIMS for assistance in fieldwork and laboratory processing and for discussion ideas and support. K. W. Able of Rutgers University did the fisheries trawl work. This is contribution 2549 of the Virginia Institute of Marine Science.

LITERATURE CITED

ABLE, K.W. and FAHEY, M.O., 1998. *The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight.* Rutgers University Press, New Brunswick, NJ, 324p.

ALLER, R.C. and ALLER, J.Y., 1998. The effect of biogenic irrigation intensity and solute exchange on diagenetic reaction rates in marine sediments. *Journal of Marine Research,* 56:905–936.

CUTTER, G.R., JR. and DIAZ, R.J., 2000. Benthic habitat mapping and resource evaluation of potential sand mining areas, 1998–1999. *In:* Hobbs, C. H., III, (Project Manager), *Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland,* Final Project Report to the Minerals Management Service, OCS Study 2000-055, Virginia Institute of Marine Science, Gloucester Point, VA. (http://www.mms.gov/intermar/DL&%20MDEnviron%20study2000.PDF)

DIAZ, R.J. and SCHAFFNER, L.C., 1990. The functional role of estuarine benthos. *In:* HAIRE, M. and KROME, E.C. (eds.) *Perspectives in the Chesapeake Bay,* 1990; Advances in Chesapeake Bay Research. Chesapeake Research Consortium Publication 129, CBP/TRS 24/88.

DIAZ, R.J.; CUTTER, G.R., JR., and ABLE, K.W., 2003. The importance of physical and biogenic structure to juvenile fishes on the shallow inner continental shelf. *Estuaries,* 26(1):12–20.

GALGANO, F.A.; LEATHERMAN, S.P., and DOUGLAS, B.C., 2003. Inlets dominate U.S. east coast shoreline change. *Journal of Coastal Research,* in press.

HOBBS, C. H., III (Project Manager), 2000. *Environmental Studies Relative to Potential Sand Mining in the Vicinity of the City of Virginia Beach, Virginia.* Final Project Report to the Minerals Management Service, OCS Study 2000-055, Virginia Institute of Marine Science, Gloucester Point, VA. Also available at on the MMS website at http://www.mms.gov/intermar/DL&%20MDEnviron%20study2000.PDF

HOBBS, C.H., III, 2002. An investigation of potential consequences of marine mining in shallow water: an example from the mid-Atlantic coast of the United States. *Journal of Coastal Research,* 18(1):94–101.

JUTTE, P.C. and VANDOLAH, R.F., 1999. *An assessment of benthic infaunal assemblages and sediments in the Joiner Bank and Gaskin Banks borrow sites, Phase I—Cherry Grove borrow area.* Final Report to the U.S. Army Corps of Engineers, Charleston District, Charleston, SC, 105p.

MAA, J. P-Y.; HOBBS, C.H., III, KIM, S.C., and WEI, E., 2003. Possible impacts by cumulative sand mining offshore of Maryland and Delaware: Part 1—on physical oceanographic processes. *Journal of Coastal Research,* **this volume.**

MAURER, D.; KINNER, P.; LEATHER, W., and WATLLING, L., 1976. Benthic faunal assemblages off the Delmarva peninsula.. *Estuarine and Coastal Marine Science,* 4:163–177.

MUSICK, J.A., 1999. Transitory Species (vertebrate nekton). Part 2 of Hobbs, C. H., III, (Project Manager) 2000, *Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland,* Final Project Report to the Minerals Management Service, OCS Study 2000-055, Virginia Institute of Marine Science, Gloucester Point, VA.

MUSICK, J.A.; COLVOCORESSES, J.A., and FOELL, E.J., 1986. Seasonality and distribution, availability and composition of fish assemblages in Chesapeake Bight. Chapter 21 *In*: A. YANEZ y. ARANCIABIA (ed.), Fish community Ecology in Estuaries and Coastal Lagoons: Towards an Ecosystem Integration. Univ. Mexico Press. Mexico City.

OLNEY, J., SR. and BILKOVIC, D.M., 1998. Literature survey of reproductive finfish and icthyoplankton present in the proposed sand mining locations within the middle Atlantic bight. *In:* HOBBS, C. H., III, (Project Manager) 2000, *Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland,* Final Project Report to the Minerals Management Service, OCS Study 2000-055, Virginia Institute of Marine Science, Gloucester Point, VA.

RHOADS, D.C. and GERMANO, J.D., 1986. Interpreting long-term changes in benthic community structure: a new protocol. *Hydrobiologia,* 142:291–308.

Journal of Coastal Research | 20 | 1 | 1–5 | West Palm Beach, Florida | Winter 2004

THEMATIC SECTION

The U.S. Minerals Management Service Outer Continental Shelf Sand and Gravel Program: Environmental Studies to Assess the Potential Effects of Offshore Dredging Operations in Federal Waters

Barry S. Drucker,† William Waskes,† and Mark R. Byrnes‡

†U.S. Minerals Management Service
Leasing Division—Sand and Gravel Unit
381 Elden Street, Mail Stop 4010
Herndon, VA 20170, USA

‡Applied Coastal Research and Engineering, Inc.
766 Falmouth Road, Suite A-1
Mashpee, MA 02649, USA

ABSTRACT

DRUCKER, B.S.; WASKES, W., and BYRNES, M.R., 2004. The U.S. Minerals Management Service outer continental shelf sand and gravel program: environmental studies to assess the potential effects of offshore dredging operations in federal waters. *Journal of Coastal Research,* 20(1), 1–5. West Palm Beach (Florida), ISSN 0749-0208.

The U.S. Department of the Interior, Minerals Management Service, provides policy direction relative to the development of all marine mineral resources located beneath Federal waters of the United States. Over the last ten years or so, geological studies encompassing the collection and analysis of seismic, vibracore, and grain size data have been conducted in partnership with coastal States in the Atlantic and Gulf of Mexico to locate suitable sources of compatible sand for beach and coastal restoration. Environmental studies have been initiated to provide biological, physical, and other pertinent information for decisions regarding leasing and use of this resource. Aggregate dredging studies also have been conducted in the event that an offshore aggregate mining operation is proposed in the future. A symposium was held in New Orleans in January 2002 to report results from several studies completed over the past 2 years. The papers prepared for this Special Issue summarize the findings of recently completed environmental studies.

ADDITIONAL INDEX WORDS: *Beach nourishment, coastal restoration, sand shoals, aggregate mining, wave modeling.*

INTRODUCTION

The Federal Outer Continental Shelf (OCS) represents a viable source of industrial minerals and materials, such as titanium and phosphate, as well as sand and gravel for beach restoration and construction aggregate. These resources are under the jurisdiction of the Minerals Management Service (MMS), a bureau within the U.S. Department of the Interior. The OCS is defined as the submerged lands, subsoil, and seabed, lying between the seaward extent of State jurisdiction and the seaward extent of Federal jurisdiction. For most States, offshore Federal lands begin 3 nautical miles (approximately 3.3 statute miles) seaward of the baseline from which the breadth of the territorial sea is measured. Offshore Texas and the Gulf coast of Florida, the boundary is at the 3 marine leagues (9 nautical miles) mark. The seaward limit of Federal jurisdiction is defined as the farthest of 200 nautical miles seaward of the baseline from which the breadth of the territorial sea is measured or, if the continental shelf can be shown to exceed 200 nautical miles, a distance not greater than a line 100 nautical miles from the 2,500-meter isobath or a line 350 nautical miles from the baseline.

Initially, the MMS marine minerals program focused on offshore material that could serve as a source of commercially important raw materials and minerals (manganese nodules, polymetallic sulfides, titanium resources, *etc.*) As far back as 1989, however, MMS detected a trend toward greater interest in offshore sand resources. In 1993, Congress recognized the potential benefits of using Federal offshore sand for coastal restoration projects and crafted legislation to remedy what was considered an impediment to State and local government access to Federal sand resources. The impediment was the competitive leasing provision of the Outer Continental Shelf

1 received and accepted in revision 6 June 2003.

Figure 1. Location of MMS State/Federal Cooperative Efforts.

Lands Act (OCSLA). Under this provision, State and local governments expressed little interest in pursuing rights to Federal sand through a lengthy competitive process that could ultimately award the resource to another (higher) bidder. They viewed this uncertainty as an unacceptable risk. Congress remedied the situation by passing Public Law 103-426 in October 1994 which amended the OCSLA by providing the Secretary of the Interior with new authority to negotiate agreements for use of Federal sand, gravel, or shell resources under certain circumstances. The passage of this law has greatly accelerated the demand for Federal offshore sand, specifically for public works related projects.

All studies presented in this JCR Special Issue were funded through the MMS Environmental Studies Program (ESP). The ESP was initiated in 1973 as a means to gather and synthesize environmental, social, and economic science information to support decision-making concerning the MMS offshore oil and gas and marine minerals programs. Section 20 of the Outer Continental Shelf Lands Act authorizes the ESP and establishes the general goal for the program: *establish the information needed for assessment and management of environmental impacts on the human, marine, and coastal environments of the OCS and the potentially affected coastal areas.*

STATE/FEDERAL COOPERATIVE PROGRAMS

A key strategy to ensure environmental protection, safe operations, and issue resolution for decisions regarding access to OCS sand and gravel material has been the closely coordinated partnerships between the Federal Government, coastal States, and local communities. The MMS has developed cooperative agreements with Alabama, Delaware, Florida, Louisiana, Maryland, New Jersey, North Carolina, South Carolina, Texas, and Virginia. Discussions are currently underway with the states of Maine, Massachusetts, and California regarding new Federal/State partnerships to investigate potential sand sources for beach nourishment offshore their respective coasts. These partnerships rely primarily on State Geological Surveys, in cooperation with other State and Federal agencies, to identify State needs and propose suitable offshore areas for study.

The State/Federal partnerships have focused primarily on isolated, relict submerged shoals and surficial sand sheets which represent viable sources of sand borrow material for coastal erosion management. In the near future, sand investigations will broaden to include such promising deposits as buried paleochannels and shoreface-attached sand ridges. The use of sand in Federal waters is becoming more important and more viable due to the general diminishing supply of onshore and nearshore sand, the renourishment cycles for beaches or coastal areas requiring quantities of sand not currently available from State sources, and the need for sand for immediate and/or emergency repair of beach and coastal damage from severe coastal storms.

The first phase of each cooperative program involves compiling and inventorying beach erosion along the entire coast of each State and identifying areas where sand for future nourishment would be needed most. Geological studies, which encompasses the collection of shallow seismic and vibracore data, are initiated to document potential sand sources and estimate volumes of usable and compatible sand available for beach nourishment. Figure 1 shows the location of State/Federal sand investigations to date.

OCS SAND AND GRAVEL ACTIVITIES

The sand and gravel program has been steadily moving to an operational phase from what was once purely a research

Table 1. *Cubic yards of Federal OCS sand conveyed as of June 1, 2003.*

State	Locality	Cubic Yards Conveyed
Florida	Jacksonville (Duval County)	1,240,000
South Carolina	Myrtle Beach (Surfside)	150,000
Virginia	Dam Neck Naval Facility	808,600
Virginia	Sandbridge Beach	1,098,191
Maryland	Assateague National Seashore	134,000
Florida	Brevard County	7,300,000
Florida	Patrick Air Force Base	600,000
Louisiana	Holly Beach	4,200,000
Louisiana	Ship Shoal Dredge Test	3,000
Virginia	Sandbridge Beach	2,000,000
Maryland	Assateague Island	1,800,000

phase. Since Public Law 103-426 was enacted, MMS, as of mid-April 2002, had conveyed over 19 million cubic yards of sand to State, local, and Federal entities (Table 1). A number of negotiated leases also are pending or are a possibility in the near-term (Table 2).

ENVIRONMENTAL STUDIES

OCS sand and gravel resources must be managed effectively to ensure that environmental damage to marine and coastal environments will not occur. MMS has focused on integrating resource data provided through State/Federal cooperative efforts to identify suitable OCS sand deposits, and provide needed environmental information to make decisions regarding the use of Federal sand for future beach nourishment activities.

Since 1992, MMS has expended over $8.2 million for marine mineral environmental studies. Site-specific, interdisciplinary studies have been conducted in identified sand borrow areas to provide basic information on the biological characterization of resident benthic communities, as well as the evaluation of potential dredging effects on the local wave and current regime.

The primary purpose of MMS funded biological studies is to address biological concerns raised by the potential for adverse environmental impacts on marine life as a consequence of dredging sand on the OCS. In order to provide an initial characterization of benthic ecological conditions at offshore borrow sites prior to any dredging activity, the MMS has funded numerous site-specific studies. These studies have focused on the compilation and synthesis of existing oceanographic literature and available data sets which exist within identified offshore borrow areas, as well as biological field sampling surveys. Biological sampling surveys have included collecting traditional benthic grab samples, sediment profile camera images, and video sled footage. As a result, the MMS has been able to characterize and evaluate present benthic and pelagic communities within offshore borrow sites and address the potential effects of offshore sand dredging, including interpretations as to the potential rate and success of recolonization following cessation of dredging. In addition, the development of a time schedule of environmental windows that best protects benthic and pelagic species from adverse environmental effects has been examined.

Prior to dredging activity at an offshore borrow site, the potential for adverse changes in local wave and current patterns created by alterations in local bathymetry resulting from dredging operations must be assessed. Increased wave action after dredging offshore shoal areas may result in localized changes in erosional patterns and longshore coastal transport. A thorough evaluation of physical process changes must take into account the local current regime and the historical wind and wave climate.

Numerical wave modeling studies were initiated to examine potential alterations in the local wave field following dredging and the excavation of sand within identified borrow sites. In addition, modeling studies explored the potential for increased wave action after dredging and any resultant adverse localized changes in erosional patterns and longshore transport which might result in significant losses of beach sand after nourishment. These efforts have provided information to further explore the potential for changes in local sediment transport rates, as well as the cumulative physical effects of multiple dredging events.

Recognizing that the environmental effects of dredging op-

Table 2. *Possible conveyances of federal sand within the next 3 to 5 years.*

State	Locality	Cubic Yards Which Might Be Conveyed
Louisiana	Terrebonne and Barataria Basin barrier island restoration projects, including Whiskey Island west flank project and New Cut project (from Ship Shoal and other OCS sources)	10,000,000–20,000,000
Louisiana/Texas	Holly Beach, LA/Texas Beaches (from Sabine Bank)	4,000,000–6,000,000
Louisiana	Houma levee project (from Ship Shoal)	10,000,000
Virginia	Virginia Beach resort strip	1,000,000
Virginia	Dam Neck Naval Facility	1,000,000–2,000,000
New Jersey	Corsons Inlet	1,200,000
New Jersey	Harvey Cedars	7,400,000
New Jersey	Avalon-Stone Harbor	?
New Jersey	Monmouth-Sea Bright	?
New Jersey	Brigantine Beach	?
New Jersey	Manasquan-Barnegat Inlet	?
North Carolina	Dare County	?
Florida	East Coast (Jacksonville and counties south)/West Coast (Fort Myers area)	?

erations in many instances are similar for most areas, generic-type studies have been initiated to examine the effects of particular types of dredging operations on various aspects of the physical, chemical, and biological environments, and to develop or recommend appropriate mitigation, computer modeling, or monitoring techniques to alleviate or prevent adverse environmental impacts.

Because the OCS represents a future source of coarse sand and gravel for use as construction aggregate, MMS also has funded work in the United Kingdom to assess the potential for environmental damage associated with offshore aggregate mining in the event that such an endeavor is proposed for the U.S. OCS. These efforts have focused upon the extent and potential impacts associated with surface and benthic plumes generated during the aggregate operation, and the possible effects of these plumes on benthic organisms residing in the vicinity of dredging operations. .

Environmental studies information is used by MMS analysts to evaluate the effects of specific proposed dredging operations, as required under current environmental laws and legislation. The results also are incorporated, as appropriate, in lease requirements and stipulations for the dredging of OCS sand.

FUTURE ENVIRONMENTAL STUDIES DIRECTION

Several overriding environmental issues will serve to steer the course of the MMS sand and gravel environmental program over the next several years. Site-specific studies in newly identified sand resource areas will continue to be conducted. One of the greatest challenges when determining the impact benthic communities face from dredging is the lack of baseline data and overall context in which benthic communities can be compared. Compilation and analysis of historical benthic data sets for various regions would provide baseline information for use in future biological studies and NEPA documentation. Biological data generated from site-specific benthic studies of potential sand resource areas would be more readily validated and useful in assessing variations in taxonomic assemblages resulting from offshore dredging operations (*i.e.* recolonization). Furthermore, the determination of regional assemblages, leading to a better understanding of the ecological relationship between the unique habitats of ridge and shoal features and resident benthic communities that live in those habitats, would provide a more complete analysis when evaluating the consequences associated with dredging for preparing environmental assessments. It is expected the information would provide a context in which environmental factors can be assessed qualitatively and described in detail.

Some identified sand borrow areas represent long-term sources of material that may be used on a continual basis. Sand sources that are used repeatedly may require ongoing biological and physical monitoring to alleviate adverse impacts to the surrounding marine and coastal environment. In particular, the continued, long-term use of submerged sand shoals on the OCS raises concerns relative to possible negative impacts to local biology and the physical environment. Sand shoals tend to be focal points for various fisheries, both recreational and commercial. Altering the physical characteristics of these areas (*e.g.*, grain size, morphology, wave and current regime) could be detrimental for various fish species. With the passing of legislation such as the Magnuson-Stevens Act, agencies such as the MMS are mandated to consider the effects of offshore dredging operations on fisheries. Areas on the OCS that are often selected as potential sand resource sites are in many cases used by fish as migration corridors, habitat for juvenile development, and spawning grounds. Migratory corridors are essential for many fish species as they play a distinctive role in their reproductive cycle. Activities that adversely influence these uses, through disturbances in migration patterns and changes in substrate, water quality, or acoustic parameters, can directly result in a decrease in fisheries. Potential adverse effects from offshore dredging activities should be evaluated for developing appropriate mitigation measures. Numerical wave modeling has, in some cases, shown that long-term excavation of shoals can cause adverse impacts to the wave climate and sediment transport regime, particularly during high-energy events. MMS must focus on engineering alternative for mining OCS sand borrow areas for avoiding or mitigating potential adverse effects on the biological and physical environment.

New advances in offshore dredging technology are leading to more environmentally sensitive offshore operations. Researchers are advancing our basic understanding of dredging procedures relative to physical and biological environmental impacts. Numerical modeling and measurement of physical processes, with the aim to predict behavior and minimize negative environmental effects associated with offshore excavation of sand, is ongoing. Research results provide the dredging industry advanced information to more effectively control the impacts of operations. In addition, environmentally-friendly engineering technologies currently used overseas are being contemplated for use in U.S. waters. To effectively manage the development of sand resources, the MMS must obtain detailed knowledge of the most current dredging technologies available for use.

SCOPE OF THE SPECIAL MARINE MINERALS ISSUE

In January 2002, MMS convened a symposium at the MMS Information Transfer Meeting in New Orleans, Louisiana to present the results of several recently completed studies. Those presentations form the basis for the technical papers included in this Special Issue. The papers describe site-specific and generic studies that provide information for lease decisions, including recommendations to protect marine and coastal environments as offshore dredging activities take place.

MMS operates under a mandate to ensure that OCS sand and gravel mining, proposed or conducted under Agency jurisdiction, does not result in adverse environmental impacts to the marine, coastal, or human environment. The combination of site-specific and generic studies provides a foundation on which the MMS can make sound environmental decisions relative to OCS marine mineral development.

Copies of all final reports for MMS sand and gravel environmental studies, plus supporting information on the MMS sand and gravel program can be accessed via the sand and gravel page on the MMS Offshore Program website.

ACKNOWLEDGEMENTS

Considerable effort was put forth to ensure a high quality, state-of-knowledge summary of MMS marine mineral studies. This could not have been accomplished without the assistance and cooperation of all technical reviewers and authors. In addition, we acknowledge the financial support of the MMS ESP, in particular, Dr. James Kendall, for providing the necessary funds to make publication of these papers possible.

Journal of Coastal Research | 20 | 1 | 138–148 | West Palm Beach, Florida | Winter 2004

Natural Maintenance of Sand Ridges and Linear Shoals on the U.S. Gulf and Atlantic Continental Shelves and the Potential Impacts of Dredging

Miles O. Hayes† and Robert B. Nairn‡

†Research Planning, Inc.
1121 Park Street
Columbia, SC 29201, U.S.A.

‡W.F. Baird & Associates Ltd.
627 Lyons Lane
Oakville, Ontario L6J 5Z7,
Canada

ABSTRACT

HAYES, M.O. and NAIRN, R.B., 2004. Natural maintenance of sand ridges and linear shoals on the U.S. gulf and Atlantic continental shelves and the potential impacts of dredging. *Journal of Coastal Research,* 20(1), 138–148. West Palm Beach (Florida), ISSN 0749-0208.

Ridge and swale topography is exceptionally well developed on the continental shelves of the Mid-Atlantic Bight and the northeastern Gulf of Mexico. In both cases, these linear ridges are oriented parallel to the predominant wave approach direction, suggesting a common process for both their origin and maintenance. Most researchers have concluded that ridges were derived from shorefaces of barrier islands as they retreated across the shelf in response to rising sea level and tides or storm-driven currents maintain them.

The widely cited ridge formation theory of HUTHNANCE (1982) requires a sufficient sand source, currents to move the sand, and an irregularity on the sea floor around which the ridges are initiated. MCBRIDE and MOSLOW (1991) postulated that one of the initial irregularities is a segment of an ebb-tidal delta abandoned by inlet migration. However, the search for other precursors continues. These theories of origin provide little information on how these features maintain their form once they are detached from the shore yet remain in a zone of active wave attack (*i.e.* in depths less than 20 m). SNEDDEN *et al.* (1999) indicate that shoals in water depths less than approximately 20 m are migrating shoreward through the influence of Stokes Drift under fair-weather waves based on the work of MCHONE (1973). However, this model does not explain the maintenance of the form of linear shoal and ridge features.

To assess the impacts of dredging on these features it is essential that a better understanding of the processes that maintain these features be developed. A new conceptual model presented in this paper demonstrates how waves shoaling and refracting up either side of a ridge off the coast of Maryland and Delaware result in convergence of sand transport over the crest of the ridge, thus maintaining the ridge even after it is detached from shoreface processes.

The possibility that these ridges might deflate or disappear as a consequence of dredging, resulting in dramatic changes in wave conditions along the shore, is a major concern. The application of a spectral or phase-resolving wave model combined with two-dimensional hydrodynamic and sand transport models as applied in this paper represents a method to evaluate this potential impact of dredging.

ADDITIONAL INDEX WORDS: *Wave refraction, sand transport, non-linear wave orbital velocity, shoal evolution, shoal persistence.*

INTRODUCTION

A growing demand exists for good quality sand to support beach nourishment projects along the Gulf and Atlantic coasts of the United States. As a result of dwindling supply of suitable quality sand in State waters that can be extracted without significant physical and biological impacts, Outer Continental Shelf (OCS) deposits, under the federal jurisdiction of the Minerals Management Service (MMS), are now being dredged and widely considered as a primary source of sand. In response to this demand, the MMS has completed a range of investigations including several environmental studies of individual deposits on the OCS. In addition, the MMS commissioned a study to design a long-term monitoring program that would evaluate the physical and biological changes that might occur as a result of Federal OCS sand mining (NAIRN *et al.,* this volume). The outcome of this project was the development of monitoring protocols for dredging OCS sand. A component of these protocols will address the long-term response of shoal morphology. Any significant changes to the shoal form that are triggered by removal of sand could result in a range of indirect physical and biological impacts.

During development of the monitoring protocols, the types of OCS sand deposits that have been dredged or targeted for dredging were reviewed and classified. Many of these features had the form of ridge and swale complexes or similarly shaped shoals and were found in water depths of 5 to 15 m in a zone of active wave action. A concern exists that repeated dredging of these shoals may eventually result in the "deflation" of the features by permanently altering natural processes that maintain shoal form. Recognizing that the potential for these shoal-type features to be altered in form may result in significant biological and physical impacts, a review of the characteristics, origin and maintenance of these features was undertaken. A new conceptual model for mainte-

11 received and accepted in revision 6 June 2003.

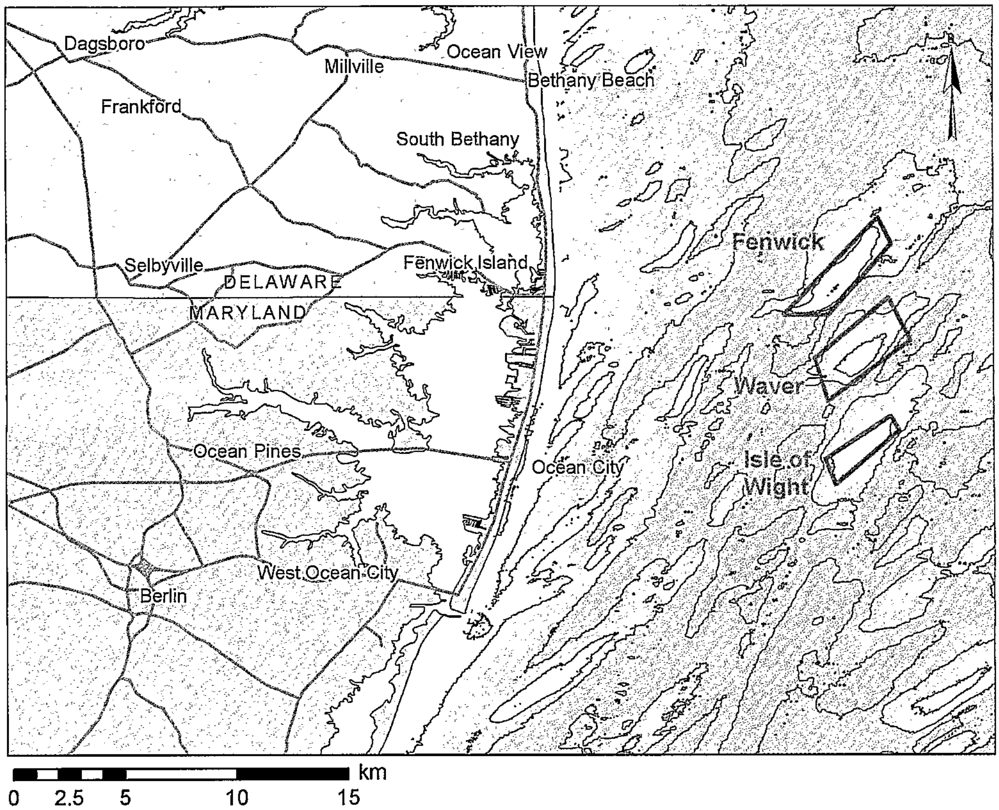


Figure 1. Example of ridge and swale topography typical of the Mid-Atlantic Bight region. Note detailed bathymetry (VIMS, 2000).

nance of continental shelf shoal features by wave action is presented. Finally, the potential physical and biological impacts of dredging these features are summarized.

The specific objective of this paper is to determine how ridge and linear shoal features are maintained in order to develop a method to assess the impact of dredging on shoal "maintaining" processes. The definition, occurrence, and origin of these features are reviewed for the purpose of deriving an understanding of processes that maintain these features in their observed form within the active wave zone. Much more comprehensive literature reviews are presented by McBride and Moslow (1991) and Snedden *et al.* (1999). The primary focus is on a review of the processes that maintain these features and ultimately the development of a new conceptual model to explain how these features are maintained.

DEFINITION AND OCCURRENCE

Several kinds of sand bodies exist on the continental shelves of the USA, but this discussion will focus primarily on sand ridges and swales that are located on the inner/upper continental shelf and oriented parallel to the predominant or prevailing wave approach direction (*i.e.*, ridges that are oriented shore-oblique). One of the first comprehensive descriptions of these occurrences on the continental shelf off the east coast of the USA was by Uchupi (1968). These features, which he termed sand swells, were described as follows: radiating clusters near the mouths of estuaries; arcuate, seaward convex ridge systems near cuspate forelands; shoreface ridge and swale systems; and broadly spaced ridges and swales on the open shelf. Ridges and swales will be emphasized in this discussion.

Other varieties of sand bodies preserved on the shelf that could provide sand for beach renourishment include: (1) overstepped barrier islands (*e.g.*, Ship Shoal off the Mississippi Delta); (2) active and inactive estuarine entrance shoals (*e.g.*, off St. Helena Sound, South Carolina); (3) large ebb-tidal deltas off major tidal inlets (*e.g.*, Mobile Bay); (4) delta lobes deposited at lower stands in sea level (*e.g.*, Santee Delta, South Carolina); (5) features associated with low-stand river valleys (*e.g.*, shelf off Texas and North Carolina); and (6) tidal sand ridges (*e.g.*, offshore New England and Alaska); and possibly others (see Table 3 in McBride and Moslow, 1991).

The best examples of ridge and swale topography on the North American continental shelf occur in the mid-Atlantic Bight (Figure 1), northeastern Gulf of Mexico (offshore Alabama and northwest Florida; Figure 2) and Sable Island Bank in eastern Canada (Figure 3).

In every case, the long axes of ridges are oriented directly into the predominant or prevailing storm wave approach direction. Waves approach from the northeast in the mid-Atlantic Bight (during "nor'easters"), from the southeast off Al-

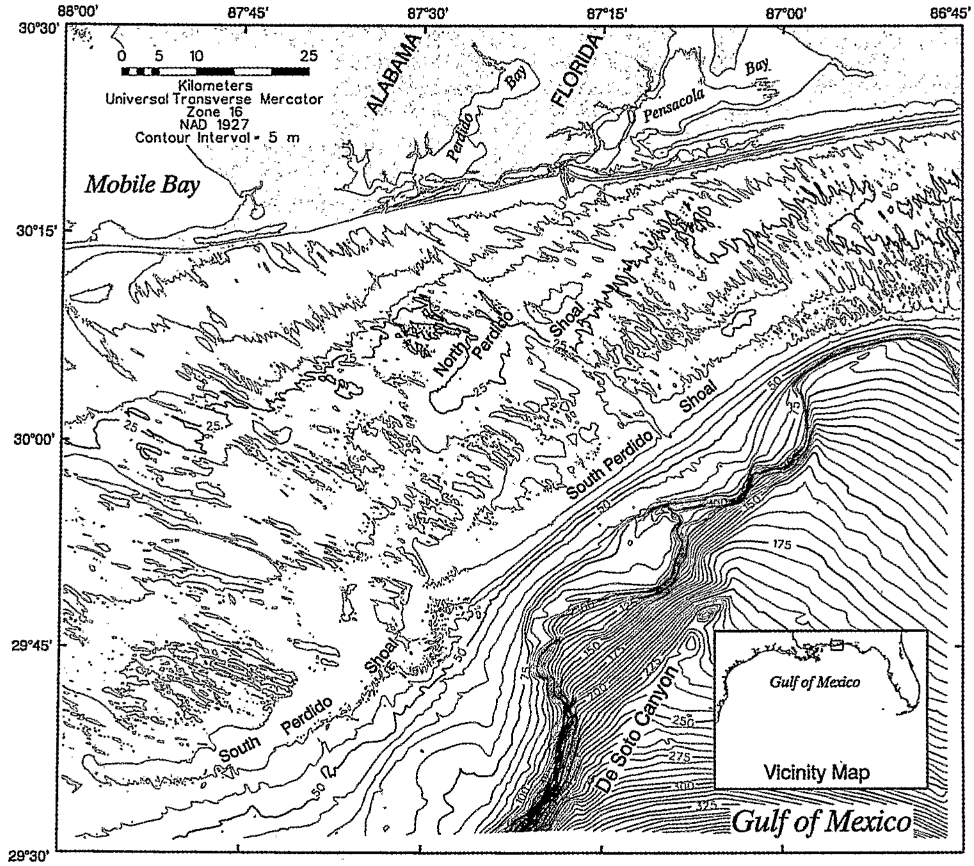


Figure 2. Continental shelf in the northeastern Gulf of Mexico showing detailed bathymetry at 5 m contour intervals. Thicker contours are at 25 m intervals. From McBRIDE *et al.* (1999).

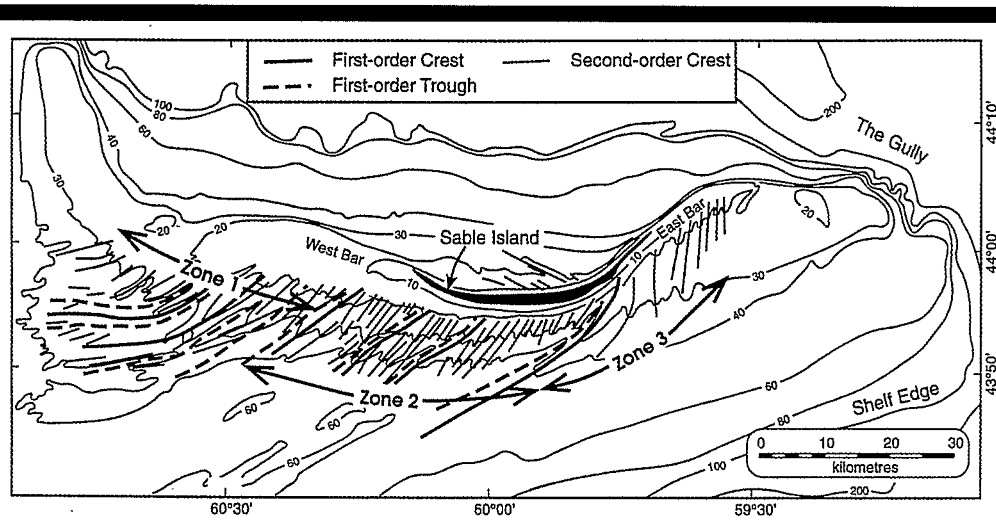


Figure 3. Bathymetry (in meters) of the area surrounding Sable Island, with crestline positions of the shoreface-attached ridges. From HOOGONDOORN and DALRYMPLE (1986).

Table 1. *General characteristics of sand ridges summarized from the data for the Maryland shelf (slightly modified from SWIFT and FIELD, 1981) and for global sand ridges, including tidal sand ridges (from SNEDDEN and DALRYMPLE, 1999).*

Criteria	Maryland	Global
orientation	perpendicular to wave approach	flow-oblique
symmetry	asymmetrical near shore	asymmetrical
relief	3–12 m	5–40 m
horizontal width	0.9–2.8 km	0.7–8 km
spacing	1.5–11.1 km	—
maximum side slopes	0.2–7 degrees	<1–7 degrees
grain size	fine to coarse sand	fine to coarse sand
lateral trends (grain size)	stoss* side coarser than lee side	stoss side coarser
superimposed bedforms	ripples to sand waves	ripples to sand waves

* Stoss side faces the dominant current direction (or in the case of waves faces the dominant wave approach direction).

abama, and from the southwest on Sable Bank. This fact seems to suggest a common process, likely related to wave forces either directly or indirectly, for both the origin and maintenance of these features.

Table 1 lists the general characteristics of sand ridges. Grain size trends commonly observed on sand ridges off Sable Island and New Jersey show that coarsest sediments occur in the swales and on the shoreward flank of ridges (*i.e.,* northwest side of New Jersey ridges and west side of Sable Island ridges). This pattern appears to be typical for ridges in water depths of less than 20 m.

Based on the numerous studies conducted within the last two decades, it seems clear that, once formed, most ridges in depths of less than 20 m are maintained and even enlarged by present-day hydrodynamics (SNEDDEN and DALRYMPLE, 1999). It also seems clear that an evolutionary progression occurs in an offshore direction as the influence of waves diminishes. The contrast of storm and fair-weather conditions on ridges, in both nearshore and offshore areas, as envisioned by SNEDDEN *et al.* (1999), is given in Figure 4. The fair-weather onshore transport mechanism due to Stokes Drift was originally proposed by MCHONE (1973). Measurements of currents taken during a storm showed that storm-generated flows ran obliquely offshore and across the crest of a shoreface-attached ridge in New Jersey (Figure 5; from SNEDDEN *et al.,* 1994). It is noted that this ridge is much closer to shore than the ridges under consideration on the OCS.

GOFF *et al.* (1999) stated "in depths greater than 20 m, ridges have not continued to grow since transgression has brought them into the offshore hydrodynamic regime". Many studies have concluded that reworking occurs at the tops of the ridges located further offshore, but few imply that the ridges have been completely reformed.

THEORIES FOR ORIGIN AND MAINTENANCE

PENLAND *et al.* (1988) studied the evolution of Ship Shoal, a large transgressive sand body off the coast of Louisiana using vibracores, age dates, seismic profiles, and fossil assemblages. The shoal, located in water depths of 3 to 10 m, has a 5 m thick core that was interpreted as a barrier island

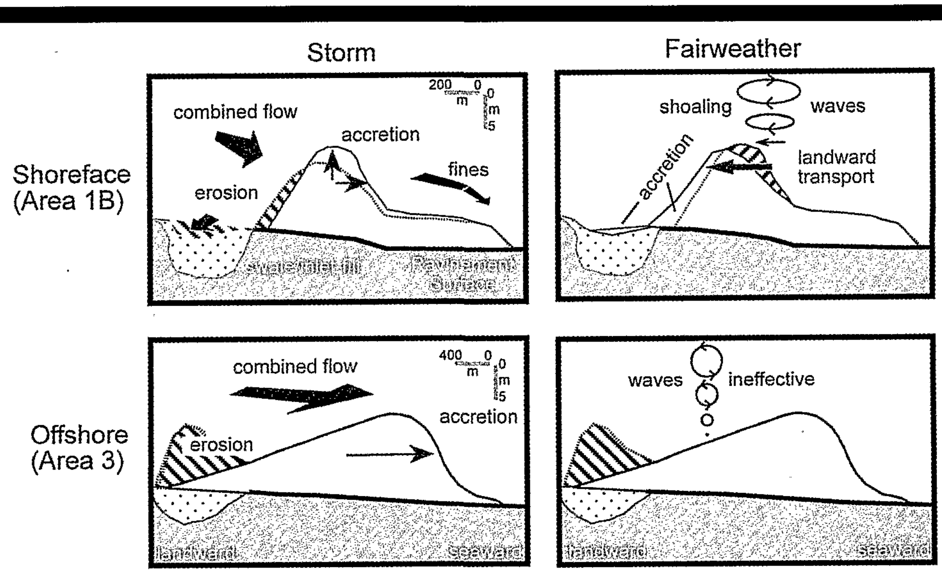


Figure 4. Storm and fair-weather dynamics and ridge migration in nearshore and offshore areas. Based on current meter data reported in SNEDDEN *et al.* (1994) and MCCLELLAND (1973) and bathymetric surveys of MCHONE (1973). From SNEDDEN *et al.* (1999).

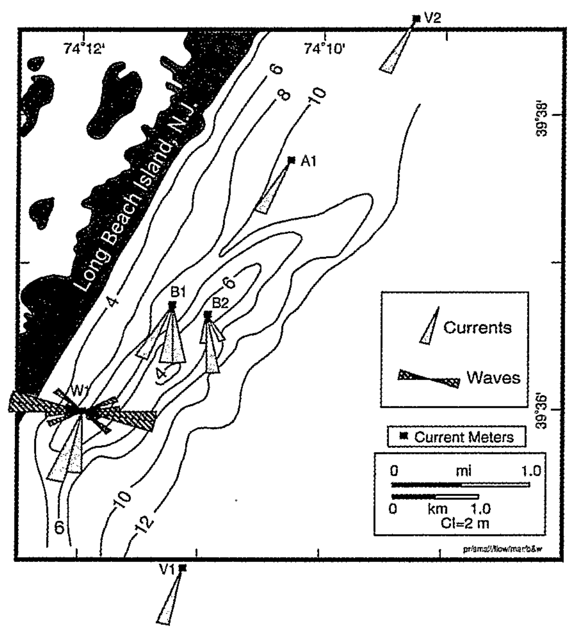


Figure 5. Orientation of near-bottom, peak storm current and wave motion 30–31 March 1985. Current meters V1 and V2, which are located outside map area, are shown for reference. From SNEDDEN *et al.* (1994).

deposit. Furthermore, the shoal is asymmetric landward, implying some modification and reworking by waves. Preservation of a relict barrier island of this magnitude can only occur on shorelines that are subsiding rapidly, which is the case for the abandoned Mississippi River delta lobe with which that barrier island was associated. On tectonically stable shelves, such as Maryland and Alabama, any such lowstand barrier islands that may have been present, owing to a stabilization of sea level for some period of time, would have been eroded away during the slow rise of sea level that followed formation of the islands. Some authors, such as STUBBLEFIELD *et al.* (1984), have concluded that remnants of relict barrier islands are still preserved on the middle continental shelf of the Mid-Atlantic Bight, but none have been proposed for depths as shallow as Ship Shoal, at least not in the more recent literature.

The development of ridge and swale topography of the type under discussion here appears to be favored by: a wide, sandy continental shelf with a moderately abundant sand supply, either from riverine sources, erosion of the shoreline as the sea level rises, or from sediment brought to the shelf during periods of glaciation and/or ice melt; rising sea level over a widening shelf; and bathymetric irregularities that act as nuclei for the ridges.

Ridges and swales do not occur on prograding delta fronts or other intensely prograding areas, especially those with high rates of mud deposition. Based on a literature search, ridges and swales do not occur on macrotidal coasts, but apparently some occur off the mesotidal coast of the North Sea (HUTHNANCE, 1982). The center of the Georgia Bight, which has the largest tides along the east coast of the USA south of Maine, as well as a source for abundant muddy sediments, does not have near the number of ridges that occur in the Mid-Atlantic Bight area.

Early researchers of the Mid-Atlantic Bight recognized a need to explain the puzzling fact that ridges are parallel to each other, seeming to mimic earlier ridges in deeper water, and that their long axes are oriented directly into the dominant northeasterly wave approach direction. SWIFT *et al.* (1973) and later authors concluded that ridges were derived from the shoreface of barrier islands as they retreated across the continental shelf in response to rising sea level. Over time, these new shoals became disconnected from the barrier islands and retreated to the southeast as the barrier island continued to migrate landward. To explain how the ridges were maintained, these authors relied on storm-generated helical secondary flow structure and storm wave surge, which resulted in converging bottom currents that aggraded the ridge crests.

Numerous other formation theories have been proposed, none of which dispute the importance of rising sea level and an abundant sand supply. One of the more controversial theories was proposed by BOCZAR-KARAKIEWICZ and BONA (1986). It states that a mechanism that may account for systems of sand ridges on wave-dominated shelves is associated with the development of infragravity waves. These waves have periods ranging from 30 seconds to 5 minutes. This theory does seem to account for the number and parallelism of the ridges. However, even the authors admit that mechanisms leading to the development and form of ridges are not explained by this concept.

One of the more widely cited theories of origin and maintenance of these features is that of HUTHNANCE (1982). Based on observations of tidal currents and sand transport for linear sand banks offshore Norfolk, UK on the North Sea, CASTON (1972) found that the direction of the tidal currents progressively turned towards the crest of the shoal feature in shallower water, thereby maintaining the feature. HUTHNANCE (1982) developed his model to provide a theoretical explanation for the observations of CASTON (1972) and ultimately for the formation, growth, maintenance, and equilibrium of tidal sand ridges.

The HUTHNANCE (1982) model is based on the solution of continuity of mass and momentum equations for depth-averaged flow. This hydrodynamic model was coupled with the sediment transport formulation of BAGNOLD (1956) to predict sediment transport patterns in the two horizontal dimensions. When a perturbation or irregularity is introduced to the seafloor, tidal flows moving over the feature will tend to turn toward the crest of the feature as a result of the influence of increased friction slowing currents in shallow water. The influence of wave action was introduced to the model to suppress growth above a certain crest elevation (*i.e.*, above a certain depth wave action acts to suspend sediment and prevent additional deposition). The influence of non-linearity of the oscillatory wave motion was not considered. The asymmetry of ridges along the major axis was explained by tidal asymmetry that is prevalent along much of the Norfolk coast of the UK for which the model was originally developed.

Three major constraints exist that must be met in order

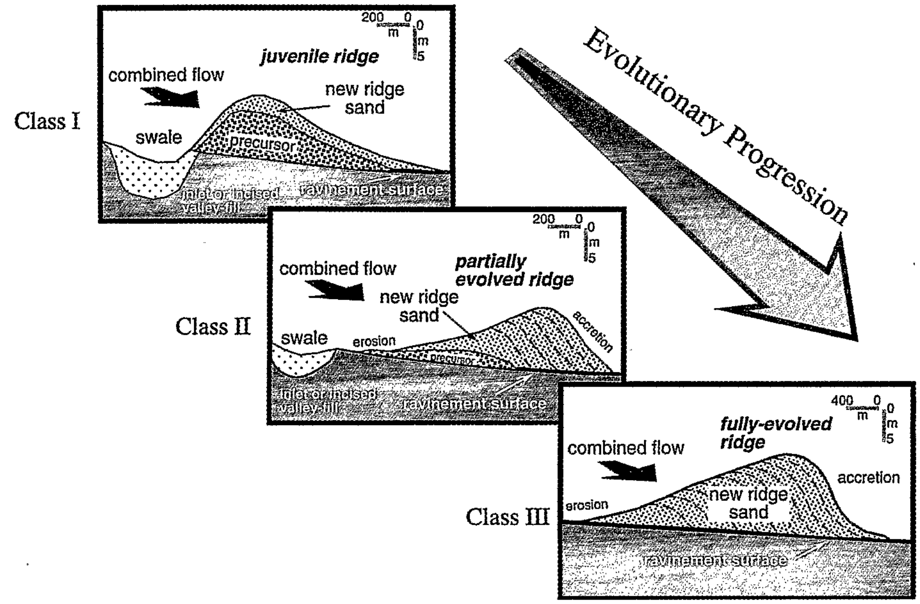


Figure 6. Schematic diagram of ridge classes. From SNEDDEN and DALRYMPLE (1999). The precursor in the case of the Class I and II ridges is a pre-existing bathymetric feature, sometimes associated with a shoreline or inlet, which provides the nucleation point for the ridge via the Huthnance process. Subsequently, this precursor may be removed or reduced in size through current erosion and ridge migration. Accretion on the landward side of the juvenile ridge (Class I) is largely induced by fair-weather wave transport from the ridge crest and is not expected to occur in ridges developed in deeper water, as with Classes II and III. New ridge sand is primarily deposited in shelf waters by combined flows associated with storm passage.

for the Huthnance theory for the genesis of ridges to work: (1) a sufficient quantity of loose sand; (2) currents capable of moving the sand; and (3) a pre-existing irregularity.

In order to take issue three into account, many of the recent workers favor an idea presented by MCBRIDE and MOSLOW (1991). Under this theory, the pre-existing irregularity is the ebb-tidal delta of an inlet through an adjacent barrier island. The inlet migrates downdrift, leaving a piece of its ebb-tidal delta behind that becomes the core of the new sand ridge formed by the process outlined by HUTHNANCE. The inlet continues to migrate until it eventually closes and a new inlet forms and the process starts all over again. SNEDDEN and DALRYMPLE (1999), in an excellent summary paper on sand ridges, are strong proponents of this idea and indicate that the migrating inlet is responsible for the swale on the landward side of the new ridge.

Another theory of preservation postulated by TROWBRIDGE (1995), who also discussed the ridges on the Mid-Atlantic Bight shelf, proposed that storm-driven southerly currents veer offshore over the ridge crests, as the data of SNEDDEN *et al.* (1994; see Figure 5) clearly show. Trowbridge also stated that the "exponential growth of shore-oblique features is a result of offshore deflection of storm-driven alongshore flows at ridge crests, which leads to convergence of sediment flux because the effective carrying capacity decreases with increasing distance offshore." The Trowbridge model effectively replaces the asymmetric tidal currents of the HUTHNANCE (1982) model with currents having a dominant southerly direction generated by the prevailing northeasterly storm waves.

Limitations and outstanding questions remain with all of these theories, thus the search for the different precursors (initial irregularity) required to fulfill the Huthnance theory continues. A number of possible initial irregularities exist, as discussed by MCBRIDE and MOSLOW (1991, Table 3, *e.g.,* submerged pieces of relict barrier islands). In the evolutionary progression for the sand ridges proposed by SNEDDEN and DALRYMPLE (1999), the precursor element may eventually be preserved, reworked, or eroded as the migrating ridge migrates offshore across the shelf (illustrated in Figure 6).

SNEDDEN *et al.* (1999) proposed a model for the evolution of sand ridges from the inner shelf (depths less than 20 m) through to the outer shelf (depths greater than 20 m). For the inner shelf shoals and ridges the onshore migration of these features is attributed to Stokes Drift (*i.e.,* the Lagrangian component of mass transport) based on the work of MCHONE (1973). In deeper water (approximately greater than 20 m), the role of waves diminishes and is overwhelmed by offshore-directed ocean currents that cause these features to migrate offshore.

Another formation process or explanation of origin of ridge and shoal features relates to stratigraphically controlled features. These features consist of sand deposited over Pleistocene sediment units and are particularly prevalent along the North Carolina coast (RIGGS *et al.,* 1995). The stratigraphy of such features has important implications regarding size of sand reserves and potential impacts of dredging. Also, the form and crest elevation of the Pleistocene core may provide valuable information on the extent of dredging that could take place on a ridge consisting entirely of sand without risk-ing natural deflation of the feature. Providing there was sufficient supply of sand available locally around the base of the shoal that is dredged, presumably it could rebuild with time from the remaining nucleus (just at the Pleistocene-cored shoal grew originally). However, there are several complications in transferring the Pleistocene-cored model for growth and maintenance to the present related to defining the sea level and wave climate at the time of original formation.

In conclusion, while significant effort has been invested in development of theories for origin and maintenance of these features in tide-dominated environments or nearshore wave-dominated environments, there has been surprisingly little research or explanation of how these features manage to maintain their form in an active wave environment located offshore on the OCS in water depths of less than 20 m.

A NEW CONCEPTUAL MODEL FOR THE MAINTENANCE OF RIDGE AND SWALE FEATURES

The direct influence of wave action has received little attention in the literature with regards to the maintenance (and migration) of shelf ridge and swale features. The fact that most features continue to have their major axis aligned with the dominant direction of wave approach even after being detached from the littoral zone points to the importance of wave action and the related sediment transport for maintaining these features. Other theories of origin and maintenance such as those of HUTHNANCE (1982) and TROWBRIDGE (1995) do not provide a complete explanation for the maintenance of these features in their form and orientation in areas where they are detached from the coast with little influence from wave- and tide-generated currents.

The part of the evolution model of SNEDDEN *et al.* (1991) that addresses migration of these features due to Stokes Drift under fair-weather waves (after MCHONE, 1973) in water depths less than 20 m does not explain the maintenance of these features. Also, NAIRN (1990) has shown that the Stokes Drift component has very little influence on onshore-directed (*i.e.*, in the direction of wave propagation) sand transport for depths in the range of 0 to 10 m corresponding to the depth of water over the crest of shoals located in water depths of 20 m or less.

A Boussinesq wave model (phase resolving) was applied to assess the influence of waves on the group of shoals offshore Maryland and Delaware (Fenwick, Weaver, and Isle of Wight Shoals) shown in Figure 1. The MIKE21 Boussinesq Wave Module (M21BW) is a two-dimensional finite difference model developed by the Danish Hydraulic Institute for the simulation of short-crested waves. The model has the ability to simulate irregular multi-directional waves and includes full and partial reflection, current interaction, and other features. A full technical description of the model may be found in MADSEN *et al.* (1991), MADSEN and SØRENSEN (1992) and MADSEN and SØRENSEN (1993). A phase-resolving model was selected for application here to be able to produce an animation of the wave surface to provide more realistic visual representation of the processes. This model helps in elucidating key processes that are explained below.

A M21BW model simulation was completed for a wave representative of northeasterly storm conditions with an incident direction of ENE, a significant wave height of 3 m, and a wave period of 16 seconds. Figure 7 provides a snapshot of an animation of the Boussinesq model simulation of waves approaching from the northeast and interacting with the shoals. Refraction causes waves to shoal and refract around either side of Fenwick Shoal and converge on the crest. This crossing pattern at the crest of the shoal may be the key factor to maintenance of shoal features aligned with the dominant wave direction. The existence of converging waves on the crest suggests that convergence of sand transport over the crest occurs.

To assess the influence of the waves on sand transport, the orbital velocity and steady currents generated by the Boussinesq model were used to predict sand transport rates and direction throughout the model domain. Depth-averaged fluxes in X and Y directions were divided by the total instantaneous water depth to get a depth-averaged velocity time history with a duration of 15 minutes and a time step of 0.5 seconds. Sediment transport rate vectors were calculated on a wave-by-wave basis using the formula of Dibajnia and Watanabe (DIBAJNIA *et al.,* 2001). The formula has been derived for sheet-flow transport under nonlinear irregular oscillations and superimposed steady currents. The results are presented in Figure 8, showing time-averaged (for the 15 minute simulation period) vectors of sand transport giving magnitude (*i.e.,* the size of the arrow head) and direction overlaid on the bathymetry of Fenwick Shoal. These results demonstrate how waves shoaling and refracting up either side of Fenwick Shoal result in convergence of sand transport along most of the crest of this shoal. Net sand transport direction in shallow water, where waves are rapidly shoaling and breaking, is determined by the balance of the two main components of transport consisting of the onshore-directed component driven by non-linear orbital velocities (with the stronger, shorter orbital motion in the direction of wave propagation) and a steady undertow velocity directed against the wave propagation direction (see NAIRN and SOUTHGATE, 1993). However, in the case of a shoal where there is no above-water beach, a strong undertow velocity will not be generated, leaving the non-linear orbital velocity component of sand transport as the primary force driving net sediment motion. There will be situations with smaller linear waves where ripples form and the direction of sand transport is far more difficult to determine. However under conditions of large waves, strong shoaling and some breaking (when most sand moves) sheet-flow and flat-bed conditions prevail and net onshore transport will exist as explained by NAIRN and SOUTHGATE (1993). This explains why the net sand transport will be in the direction of local wave propagation approaching the crest of a shoal feature.

Referring again to Figure 8, a mechanism also appears to exist to extend the shoal in the direction of the incident wave propagation at the tip of the southwest end of the shoal, explaining the presence of a wide shelf-like feature in this area. In addition to convergence over the crest, there is net sand transport towards the steep shoreward flank of the shoal (SW or bottom left corner in Figure 8). Several authors have reported on observed migration of ridges in the direction of the

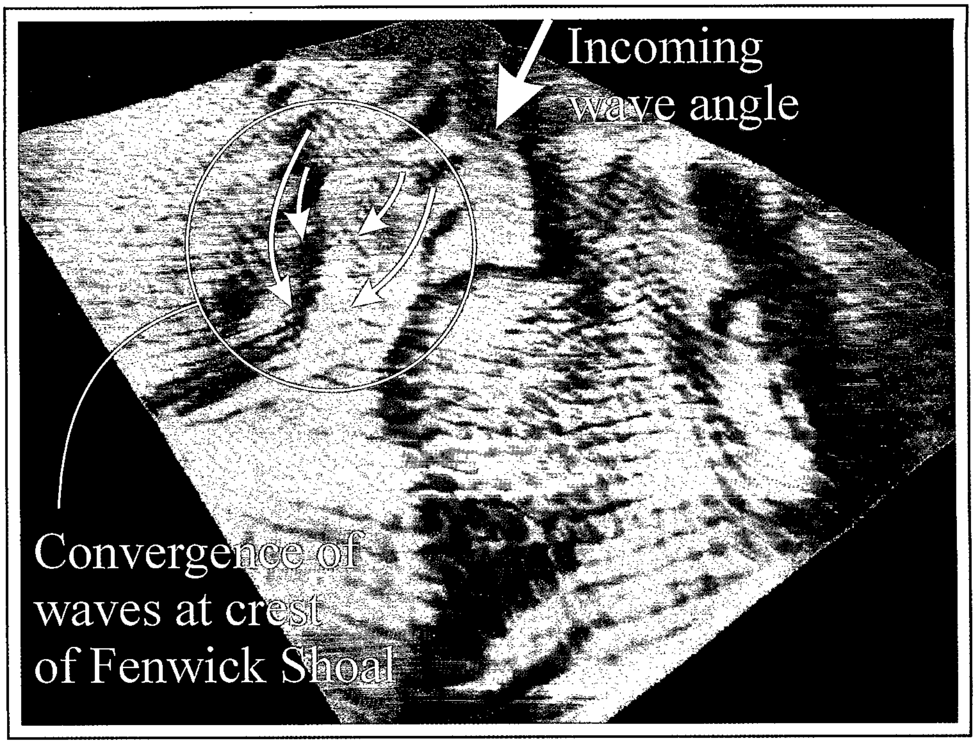


Figure 7. Snapshot of an animation of wave action predicted with a Boussinesq numerical model over the Fenwick and Weaver Shoals. The results are for a 3 m significant wave height, 16 second period and ENE direction. Waves wrap around and up the slopes on either side of the shoal, converging at the crest.

steep edge of the shoal. HOOGENDOORN and DALRYMPLE (1986) reported that ridges migrate 50 m per year off Sable Island. BYRNES *et al.* (1999) note evidence for migrating shoals offshore Alabama through comparison of bathymetry from historic and recent hydrographic surveys. DUANE *et al.* (1972) reported that a ridge moved 3,600 m in 53 years (off Virginia coast) and that one moved 76 m during the Ash Wednesday storm of 1962 (off Delaware). SNEDDEN *et al.* (1999) propose an evolutionary model illustrated in Figure 4 that explains the onshore migration of shoals over the inner shelf (Class I features in depths less than about 20 m) and offshore migration over the middle shelf (Class II and III features depths greater than 20 m).

This new explanation of convergence for wave-dominated environments only works for one direction of wave attack. For example, SE waves would not have resulted in the same strong convergence of sand transport as shown in Figure 8. Therefore, strongest convergence is associated with a linear shoal orientation aligned in the same direction as dominant wave attack (roughly from the NE along much of the Atlantic coast and to the SE along the Alabama coast).

The approach proposed here provides a description of the processes of maintenance for linear shoal features in wave-dominated continental shelf environments. HUTHNANCE (1982) presented a maintenance process for tide-dominated environments. The HUTHNANCE approach relied on asymmetric tidal currents for the explanation of converging sand transport and asymmetric shoal cross-sections along the major axis. Most targeted sand mining areas on the OCS of the Atlantic and Gulf coasts of the US (see MICHEL *et al.,* 2001) are wave-dominated and the tides in these areas are mostly symmetric or only weakly asymmetric. The model of TROWBRIDGE (1995) applies to nearshore wave-dominated environments where currents generated by wave radiation stresses are strong and the presence of a shoreline promotes the transfer of momentum from waves to longshore currents. The fair-weather wave influence through Stokes Drift proposed by MCHONE (1973) and adopted by SNEDDEN *et al.* (1999) to explain the onshore migration of shoal features is replaced by this new approach. The new approach presented here relies on the non-linearity (asymmetry) of refracting and converging waves to maintain these features and does not require either a tidal or storm-generated current. This process occurs under both fair-weather and storm waves (contrary to the model of SNEDDEN *et al.,* 1999 and MCHONE, 1973) and therefore better explains why these features are aligned parallel to the direction of storm wave attack. It is likely that both steady currents (generated by tides, waves, or other influences) and non-linear orbital motion of waves have some degree of influence at all locations where sand ridges and linear shoals exist, as proposed by SNEDDEN *et al.* (1999), with the influence of waves diminishing with increasing water depth.

In summary, the action of waves converging over the crest

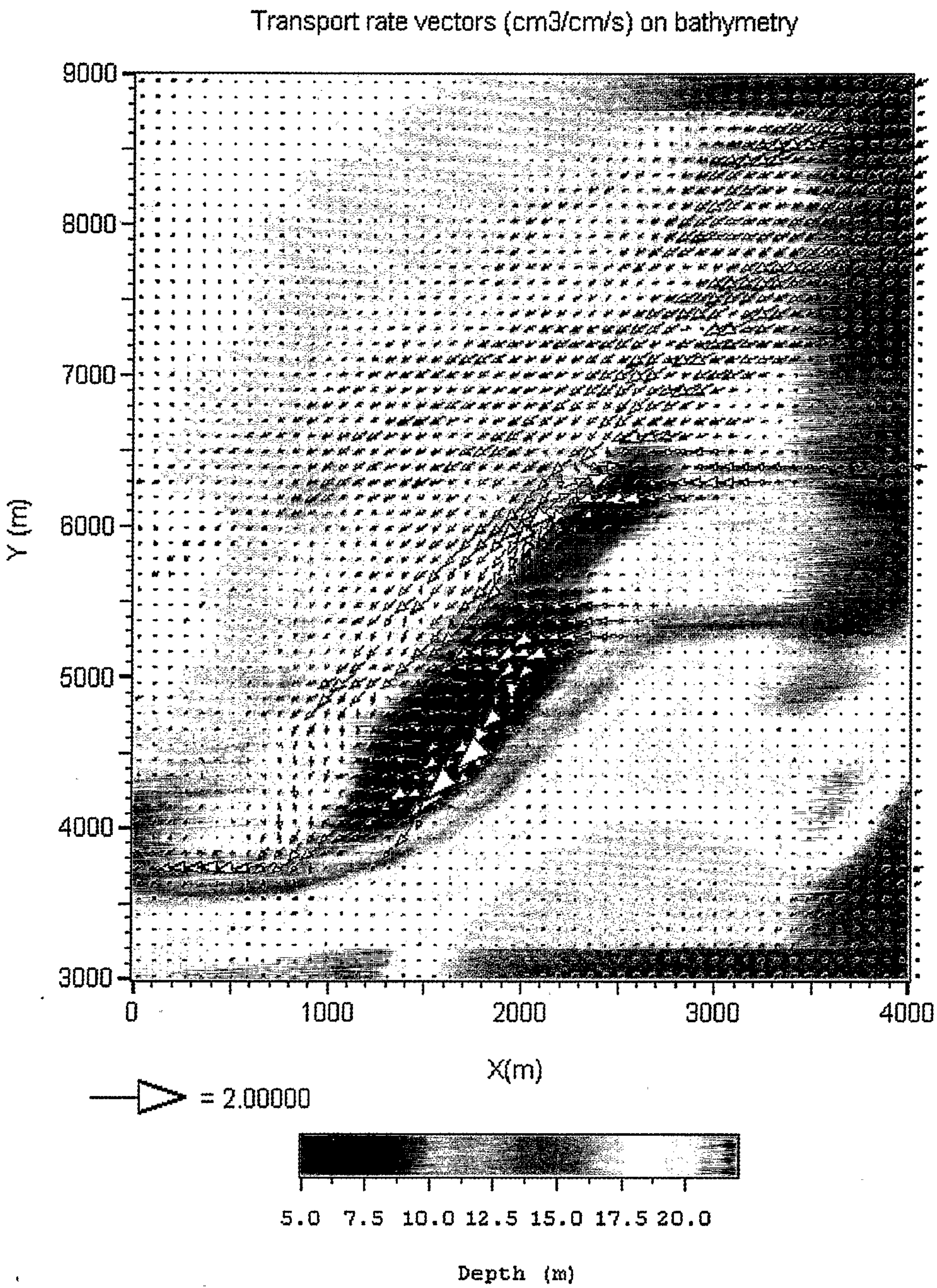


Figure 8. Time-averaged sand transport predictions for the steady and unsteady flows generated by the Boussinesq model over Fenwick Shoal for a significant wave height of 3 m, a wave period of 16 seconds, and ENE direction. A convergence of sand transport occurs along most of the crest of the shoal and there is net shoreward sand transport towards the steep flank of the shoal.

of the shoal leads to convergence of sand transport over the crest of the shoal. This process is driven by non-linear orbital velocities that feature a stronger, shorter shoreward flow under the crest of each wave. This process preferentially transports larger, heavier grains and may explain the presence of coarser sand on the crest and shoreward side of these features noted by STUBBLEFIELD *et al.* (1984) and others.

IMPACT OF DREDGING

One of the concerns during development of the monitoring protocols was the ability to determine whether there might be a limit beyond which the removal of sand from a ridge and swale feature would lead to the deflation or eventual disappearance of the bathymetric feature. For example, this may occur if the converging wave pattern is reduced in strength and importance, or if the depths are increased to the extent that the non-linear orbital velocities that generate the converging sand transport pattern are diminished or eliminated.

From a physical impact perspective, the disappearance or deflation of a shoal feature could have serious consequences. This outcome could result in dramatic change to wave patterns between the shoal and the shoreline. In turn, this could lead to a change in longshore and cross-shore sand transport patterns and changes in shoreline erosion and accretion rates. MICHEL *et al.* (2001) noted that important and unique biological characteristics were associated with the form and related texture of the shoals. These characteristics appear to provide a unique assembly of micro-habitats around the shoals. The literature review conducted into the ecological utilization of ridge and shoal features by fish species indicated that little is known or has been published on the subject.

Therefore, a better understanding is needed of the importance of the shoal form as habitat and the potential for these features to deflate or disappear in response to repeated dredging. The physical and biological protocols suggested by MICHEL *et al.* (2001) have been designed to help develop additional information on the biophysical interactions associated with the shoal form and surface texture and to monitor for long-term change to the form of the feature.

The methodology proposed here for investigating the maintenance of linear shoal and ridge features in wave-dominated environments, consisting of the application of a phase-resolving wave and hydrodynamic model with a two-dimensional sand transport model, should be applied to assess the change to the convergence of sand transport before and after the shoal is dredged. A fully spectral model (*i.e.,* in frequency and direction) could be applied in place of the phase-resolving model, provided that the two peaks of the directional spectra that develop over the crest of the shoal are considered independently in hydrodynamic calculations for non-linear orbital velocities. If only the dominant wave direction is considered (which in fact would be an average of two very different crossing wave directions), the convergence will be significantly understated or missed altogether. Additional investigation may yield a simpler method to identify the critical depth below which the features should not be dredged by linking this threshold depth to a depth where non-linear wave orbital motion no longer occurs on a frequent basis. For both the modeling and simpler approaches, a key to simplifying an evaluation of the potential for dredging to result in the deflation of a shoal will be to define a single representative wave condition for the wave climate, if possible.

It is recommended that additional research be undertaken through a combination of field measurements, physical and numerical models to improve and confirm the proposed mechanism for maintenance of linear shoals and ridges in wave-dominated environments, and to determine the relative role of tidal currents at locations where tidal currents are significant.

SUMMARY

No apparent consensus exists on the processes that work to maintain the shape of the ridge and swale shoal structures that represent the form of many identified OCS borrow sites. Theories for the maintenance of linear shoals have been developed for nearshore zones and tide-dominated offshore environments. The direct role of wave action (*i.e.,* aside from currents generated by storm or fair-weather waves) appears to have been entirely neglected in the literature. Sand transport in the direction of wave propagation driven by the non-linearity of wave orbital velocities represents the most likely mechanism for maintenance of these features in wave-dominated environments on the OCS (*i.e.,* water depths less than 20 m). No direct references were found in the literature, however, the form of these sand body features may have an important influence on the structure and distribution of biological communities inhabiting them. Monitoring for changes to the form of the shoal, grain-size characteristics, and the related biological communities is essential. In addition, further development of the conceptual model for the maintenance of these features by wave-generated sand transport is recommended so that this can be applied before dredging projects are completed to assess how much sand can be removed from a shoal feature without disrupting the processes that maintain the feature.

LITERATURE CITED

BAGNOLD, R.A., 1956. The flow of cohesionless grains in fluids. *Philosophical Transactions of the Royal Society A,* 249, 235–297.

BOCZAR-KARAKIEWICZ, B. and BONA, J.L., 1986. Wave-dominated shelves: A model of sand ridge formation by progressive, infragravity waves. *In:* KNIGHT, R.J. and MCLEAN, J.R. (eds.), *Shelf Sands and Sandstones.* Calgary, Alberta: Canadian Society of Petroleum Geologists Memoir 11, pp. 163–179.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; RAMSEY, J.S.; SNYDER, D.B.; BOSMA, K.F.; WOOD, J.D.; THIBAUT, T.D., and PHILLIPS, N.W., 1999. *Environmental Survey of Identified Sand Resource Areas Offshore Alabama: Volume I: Main Text, Volume II: Appendices.* Herndon, Virginia: Minerals Management Service OCS Report MMS 99-0052, 326 pp. + 132 pp. appendices.

CASTON, V.N.D., 1972. Linear sand banks in the southern North Sea. *Sedimentology,* 18, 63–78.

DIBAJNIA, M.; MORIYA, T., and WATANABE, A., 2001. A representative wave model for estimation of nearshore local transport rate. *Coastal Engineering,* 43(1), 1–38.

DUANE, D.B.; FIELD, M.E.; MEISBURGER, E.P.; SWIFT, D.J.P., and WILLIAMS, S.J., 1972. Linear shoals on the Atlantic inner continental shelf, Florida to Long Island. *In:* SWIFT, D.J.P.; DUANE, D.B., and PILKEY, O.H. (eds.), *Shelf Sediment Transport: Process and Pattern.* Stroudsburg, Pennsylvania: Dowden, Hutchinson, and Ross, pp. 447–498.

GOFF, J.A.; SWIFT, D.J.P.; DUNCAN, C.S.; MAYA, L.A., and HUGHES-CLARKE, J.E., 1999. High-resolution swath sonar investigation of sand ridge, dune, and ribbon morphology in the offshore environment of the New Jersey margin. *Marine Geology,* 161, 307–337.

HOOGENDOORN, E.L. and DALRYMPLE, R.W., 1986. Morphology, lateral migration and internal structures of shoreface-connected sand ridges, Sable Island Bank, Nova Scotia, Canada. *Geology,* 14, 400–403.

HUTHNANCE, J.M., 1982. On one mechanism forming linear sand banks. *Estuarine and Marine Coastal Science,* 14, 79–99.

MCBRIDE, R.A.; ANDERSON, L.C.; TUDORAN, A., and ROBERTS, H.H., 1999. Holocene stratigraphic architecture of a sand-rich shelf and the origin of linear shoals: Northeastern Gulf of Mexico. *In:* BERGMAN, K.M. and SNEDDEN, J.W. (eds.), *Isolated Shallow Marine Sand Bodies: Sequence Stratigraphic Analysis and Sedimentologic Interpretation.* Tulsa, Oklahoma: SEPM (Society for Sedimentary Geologists) Special Publication No. 64, pp. 95–126.

MADSEN, P. A.; MURRAY, R., and SØRENSEN, O. R., 1991. A new form of the Boussinesq equations with improved linear dispersion characteristics (Part 1). *Coastal Engineering,* 15, 371–388.

MADSEN, P. A. and SØRENSEN, O. R., 1992. A new form of the Boussinesq equations with improved linear dispersion characteristics (Part 2): A slowly-varying bathymetry. *Coastal Engineering,* 18, 183–204.

MADSEN, P. A. and SØRENSEN, O. R., 1993. Bound Waves and Triad Interactions in Shallow Water. *Ocean Engineering,* 20 (4).

MCBRIDE, R.A. and MOSLOW, T.F., 1991. Origin, evolution, and distribution of shoreface sand ridges, Atlantic inner shelf, U.S.A. *Marine Geology,* 97, 57–85.

MCCLELLAND, C.E., 1973. New Jersey shelf near bottom current meter records and recent sediment activity. *Journal of Sedimentary Petrology,* 43 (2), 371–380.

MCHONE, J.F., JR. 1973. Morphologic time series from a submarine sand ridge on the southern Virginia coast. Norfolk, Virginia: Old Dominion University, M.S. thesis, 55 pp.

MICHEL, J.; NAIRN, J. R.; JOHNSON, J., and HARDIN, D., 2001. *Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-term Impacts of Offshore Dredging Operations on the Marine Environment.* Herndon, Virginia: Minerals Management Service OCS Report MMS 2001-089, 116 pp. + appendices.

NAIRN, R.B., 1990. Prediction of Cross-Shore Sediment Transport and Beach Profile Evolution. Ph.D. Thesis. London, UK: Imperial College of Science and Technology, University of London, 391 p.

NAIRN, R.B. and SOUTHGATE, H.N., 1993. Deterministic profile modeling of nearshore, processes. Part 2, Sediment transport and beach profile development. *Coastal Engineering,* 19, 57–96.

NAIRN, R.; JOHNSON, J.A.; HARDIN, D., and MICHEL, J., 2002. Development and design of a biological and physical monitoring program for the evaluation of long-term impacts to the marine environment from offshore sand dredging operations in the U.S. Outer Continental Shelf. This volume.

PENLAND, S.; BOYD, R., and SUTER, J.R., 1988. Transgressive depositional systems of the Mississippi delta plain: A model for barrier shoreline and shelf sand development. *Journal of Sedimentary Petrology,* 58, 932–949.

RIGGS, S. R.; CLEARY, W. J., and SNYDER, S.W., 1995. Influence of inherited geologic framework on barrier shoreface morphology and dynamics. *Marine Geology,* 126, 213–234.

SNEDDEN, J.H.; KREISA, R.P.; TILLMAN, R.K.; CULVER, S.J., and SCHWELLER, W.J., 1999. An expanded model for modern shelf sand ridge genesis and evolution on the New Jersey Atlantic shelf. *In*: BERGMAN, K.M., and SNEDDEN, J.W. (eds.), *Isolated Shallow Marine Sand Bodies: Sequence Stratigraphic Analysis and Sedimentologic Interpretation.* Tulsa, Oklahoma: SEPM (Society for Sedimentary Geologists) Special Publication No. 64, pp. 147–164.

SNEDDEN, J.W. and DALRYMPLE, R.W., 1999. Modern shelf sand ridges: From historical perspective to a unified hydrodynamic and evolutionary model. *In*: BERGMAN, K.M., and SNEDDEN, J.W. (eds.), *Isolated Shallow Marine Sand Bodies: Sequence Stratigraphic Analysis and Sedimentologic Interpretation.* Tulsa, Oklahoma: SEPM (Society for Sedimentary Geologists) Special Publication No. 64, pp. 13–28.

SNEDDEN, J.W.; KREISA, R.D.; TILLMAN, R.W.; SCHWELLER, W.J.; CULVER, S.J., and WINN, R. D., 1994. Stratigraphy and genesis of a modern shoreface-attached sand ridge, Peahala Ridge, New Jersey. *Journal of Sedimentary Research,* B (64), 560–581.

STUBBLEFIELD, W.L.; MCGRAIL, D.W., and KERSEY, D.G., 1984. Recognition of transgressive and post-transgressive sand ridges on the New Jersey continental shelf—a reply. *In*: TILLMAN, R.W. and SIEMERS, C.T. (eds.), *Siliciclasitic Shelf Sediments.* Tulsa, Oklahoma: Society of Economic Paleontologists and Mineralogists Special Publication No. 34, pp. 37–41.

SWIFT, D.J.P.; DUANE, D.B., and MCKINNEY, T.F., 1973. Ridge and swale topography of the middle Atlantic bight: Secular response to Holocene hydraulic regime. *Marine Geology,* 14, 1–43.

SWIFT, D.J.P. and FIELD, M.E., 1981. Evolution of a classic sand ridge field: Maryland Sector, North American inner shelf. *Sedimentology,* 28, 461–482.

TROWBRIDGE, J. H., 1995. A mechanism for the formation and maintenance of shore-oblique sand ridges on storm-dominated shelves. *Journal of Geophysical Research,* 15 August 1995, 16,071–16,086.

UCHUPI, E., 1968. *The Atlantic Continental Shelf and Slope of the United States (Physiography).* Washington, D.C.: U.S. Geological Survey Professional Paper 529-I, 30 p.

VIMS (VIRGINIA INSTITUTE OF MARINE SCIENCE), 2000. *Environmental Survey of Potential Resource Sites Offshore Delaware and Maryland.* Herndon, Virginia: Minerals Management Service OSC Study MMS 2000-055, 72 pp. + appendices.

Journal of Coastal Research	20	1	101–114	West Palm Beach, Florida	Winter 2004

Physical Impacts of Marine Aggregate Dredging on Seabed Resources in Coastal Deposits

David R. Hitchcock and Steve Bell

Coastline Surveys Limited
Bridgend Farmhouse
Downton Road
Bridgend
Gloucestershire GL10 2AX, U.K.

ABSTRACT

HITCHCOCK, D.R. and BELL, S., 2004. Physical impacts of marine aggregate dredging on seabed resources in coastal deposits. *Journal of Coastal Research,* 20(1), 101–114. West Palm Beach (Florida), ISSN 0749-0208.

A detailed study of the seabed surrounding dredge pits created during the mining of marine aggregate from a small licence off the south coast of the United Kingdom ("Licence Area 122/3") has been completed. Over 350 km of high-resolution sidescan sonar imagery and 177 sediment samples have been obtained over a study area extending 10 km either side of the dredge zone (representing one full tidal excursion) in order to identify far-field effects on both physical and biological resources of the seabed.

The physical results presented here for Area 122/3 clearly show that the physical impact of dredging (without screening) on the seabed is limited to a zone within approximately 300 m downtide of the dredge area. This will generally be within the dredge licence boundary due to operational procedures. There is no evidence of suspended sediments falling to the seabed beyond this zone and causing significant changes, which may be manifested as infilling of small pits by fine sediments, siltation within crevices or development of migratory sand ripples. However, there is some statistical evidence from grab sampling that surface sediments have a greater sand fraction within the excursion track of the plume, than those sediments either side. Despite this small change in seabed particle size distribution, the benthic communities do not exhibit a detectable impact, as reported in the accompanying paper by Newell *et al.* (2002).

Analysis of ADCP backscatter data supports recent evidence for development of a near bed benthic boundary plume some 2–4 metres thick and a few tens of metres wide which extends beyond the limits of the dredge activity. On an extraction licence undertaking cargo screening, this near bed plume may exceed 4.5 kilometres downtide. Such a phenomenon provides a potential mechanism for impacting physical and benthic resources well beyond the dredge licence boundary and requires further investigation.

ADDITIONAL INDEX WORDS: *Aggregates, dredging, marine mining, benthic resources, environmental impact, dredge plume, sand and gravel, screening.*

INTRODUCTION

Marine aggregate mining in the United Kingdom for construction and fill purposes has averaged 23–28 million tonnes per annum over the past decade or so. In 2000, 23.05 million tonnes of sand and gravel aggregate was mined from an area of seabed amounting to some 179 km^2, out of an available licensed seabed of 1506 km^2, representing just 0.12% of the U.K. national seabed jurisdiction. Notably, over 90% of the activity took place within a total area of just 11.89 km^2. The 72 current licences in the UK have a permitted total extraction of 38 million tonnes per annum, with 30 additional licences presently in various stages of application.

Such an intensive resource-based activity will unavoidably have impacts on the environment. It is important, therefore, that the industry is regulated appropriately and, better still, adopts *Best Practices* to minimise and mitigate the impacts wherever possible. The United Kingdom has in place a competent, workable and sustainable licensing system to formulate and regulate the exploration and exploitation of the resources. This system is administered by the Department of Transport Local Government and the Regions (DTLR). Notwithstanding this, the industry itself has responsibly developed effective Codes of Practice and Initiatives to improve integration of their operations with those of other sea users.

Studies of the physical impacts due to dredging can broadly be grouped into those reporting evidence of seabed disturbances, such as Dickson and Lee (1973) and Price *et al.* (1978), with little further work appearing until Davies and Hitchcock (1992); and those studies recently which have investigated the origins and fate of sediment plumes, a topic which has attracted considerable interest lately (see Hammer *et al.,* 1993; Land *et al.,* 1994; Bonetto, 1995; Hitchcock and Drucker, 1996; and Hitchcock *et al.,* 1998). The importance of sediment plumes cannot be underestimated as it is this phenomenon that has the capacity to extend the footprint of impact well beyond the limits of the dredging activity itself.

It is important to understand the operational modes of aggregate dredging. In its most simple form, sand and/or gravel mix is drawn by powerful pumps from the seabed to the

8 received and accepted in revision 6 June 2003.

dredge vessel along a suction pipe, the lower end of which is usually trailed slowly across the seabed. The dredged sand and gravel is retained 'all-in', regardless of cargo sediment size distribution, for discharge ashore. There is no 'processing' or 'beneficiation' of the materials dredged. A slight variation may be if the dredger is stationary or at anchor and the dredge pipe digs down in to the resource rather than trailing across. This is known as 'anchor' or 'static' dredging as opposed to 'trailer' dredging, and is commonly used for small, discrete resource areas or thick deposits.

More often, customers require a particular grade of aggregate, and it is economic to only load and transport the grade of aggregate required, rather than conduct grading operations at shore-side facilities. Most new dredgers therefore have the facility to 'screen out' unwanted fractions of the dredged mixture, returning the undersize (or oversize) sediments to the seabed. This process of screening can lead to many more times the actual cargo retained being dredged, with significant proportions returned immediately. NEWELL *et al.* (1998) notes 1.6–1.7 times the retained cargo is returned to the water column. This figure may be higher for particular cargoes, reaching 3–4 times the cargo load (HITCHCOCK and DRUCKER, 1996). Interestingly, the process can also foul the resource for the licence operator: continually screening and rejecting the finer sediments from the mixture, which are coarse enough to settle quickly under the vessel and therefore within the licence area, can lead to 'over-sanding' of the seabed, with subsequent coarse cargoes harder to load.

Within the dredged area, the persistence of physical impacts during and following dredging activities is a clear relationship between the nature of the substrate and the potential for natural disturbances that may infill the pits or scours formed by the activity. Shallower coastal deposits will be subject to greater natural disturbances than deeper offshore deposits. This has important implications for assessing the significance of likely impacts.

Pits within gravelly substrates have been observed variously to fill very slowly and persist after several years (DICKSON and LEE, 1973). VAN DER VEER *et al.* (1985) described recovery in the Dutch Wadden Sea. Pits in channels with high current velocities filled within one year, but those in intertidal watersheds took 5–10 years to fill.

Side-scan sonar records of dredge licences in coastal waters of the southern North Sea show that the seabed is crossed by a series of dredge tracks which are 2–3 metres wide and up to 0.5 metres deep (VAN MOORSEL and WAARDENBURG, 1990), although deeper troughs of up to 2 metres were recorded from where the dredge head had crossed the area several times. Similar results were observed in the English Channel and southern North Sea during detailed monitoring surveys (DAVIES and HITCHCOCK, 1992) and are discussed in more detail later. In high energy shallow water environments such as the dynamic sand banks of the Bristol Channel, dredge imprints are destroyed within a few tidal cycles.

Study Objectives

Our studies have examined the importance of the physical and biological impacts of marine aggregate dredging operations in the coastal waters of the United Kingdom. The results of the biological assessment are reported in NEWELL *et al.* (2002). Several key questions must be addressed:

(1) Does the use of ADCP techniques supported by traditional water sample characterisation still provide a best value approach to defining the gross morphology of the dispersing plume and any sub-divisions attributable to different sources and processes?

(2) Is there a detectable impact on the sedimentary provinces that may be caused by marine aggregate mining and is this significant?

(3) Can high resolution sidescan sonar mosaic imagery provide broadscale mapping at sufficient resolution to identify any impacts due to mining operations either due to changing sedimentary province and/or biological community?

(4) How far beyond the immediate limits of the dredged area do impacts extend?

(5) Can any impact on community structure beyond the boundaries of the dredged area be related to 'far-field' deposition of material in the outwash?

Study Site

Choice of a suitable study site presented some difficulties because the effects of the dredging process itself, important for the U.S. industry case, needed to be distinguished from secondary impacts through discharge of overboard screened material (which is not common in the U.S. at present). A complicating factor is that in many dredged sites, trailer dredging occurs over a relatively wide area and impacts may be dissipated in space and time and thus harder to detect.

A small intensively-exploited aggregate area to the east of the Isle of Wight, off the south coast of the U.K., known as the North Nab Production Licence Area 122/3 (Figure 1) is licensed to, and managed by, United Marine Dredging Ltd. This was selected as study site for a number of logical reasons:

(1) Although the amount of aggregates removed from the area is quite low, up to 150,000 tonnes per annum, material is extracted from very localised 'sweet spots', each of the order of a few hundred metres in diameter. This makes the operation one of the most intensively dredged sites per unit area in the U.K.

(2) The area was licensed in 1989 and has a good historical record of dredging activities, locations and volumes. Any impacts that may be created by the operations could reasonably be expected to be established by the time of the investigation.

(3) Although material is not screened (common in many U.K. operations, especially in the North Sea), 'all-in' loading is a feature of ¾ of south coast licences (A. BELLAMY, *pers. comm.*). It is also the predominant technique of loading cargoes in the U.S., although recent indications are that screening of cargoes at sea may become prevalent in the U.S. as well.

The North Nab study area is therefore representative of the majority of the Licence Areas on the south coast of the United Kingdom, in contrast with those of the southern North Sea which are generally heavily-screened and of lesser direct relevance to U.S. dredging practices.

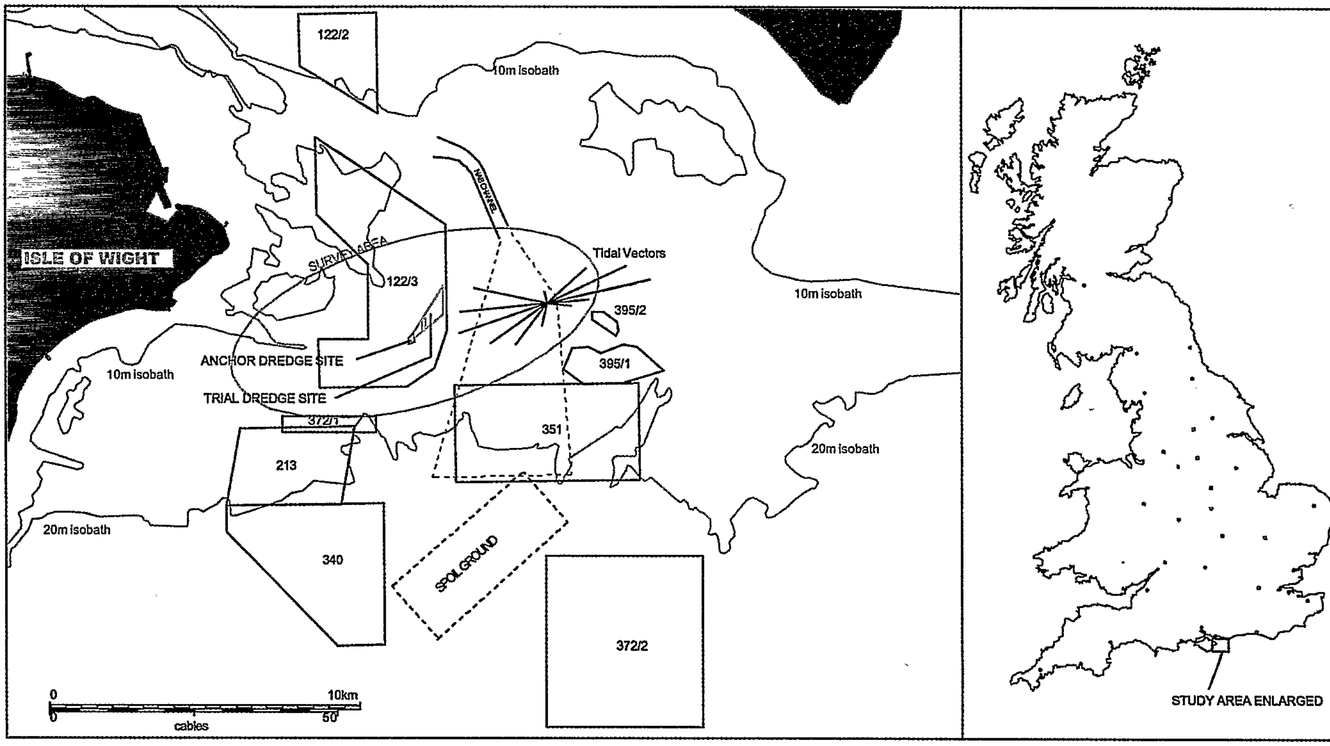


Figure 1. Study site location showing the study survey area and dredge licence North Nab 122/3 with small operating zones. Adjacent aggregate mining licences and spoil dumping ground are also outlined. Note the direction and magnitude of tidal vectors, the longest arrow equates to 1.8 kn (1.0 ms^{-1}).

The location of the study site and boundaries of the Licence Area are shown in Figure 1, together with the strength and direction of the tidal streams, broad boundaries of the area surveyed and the sampling stations. Within the boundaries of Licence Area 122/3, also shown are the sub-areas that have been exploited for gravel by different techniques (trailer suction dredging or anchor suction dredging) and for different times. Note also the presence of other dredge licence areas in the region, the nearest of which (Area 213) is some 4 nm to the SW of the active zone of 122/3. The spoil ground 4 nm to the SE of the study site is, for the purposes of this study, across tide, and is considered to have little bearing on the results. Other aggregate areas closer to the spoil ground will naturally have a more complex and cumulative effect which will blur the origin of effects due to dredging or dumping.

The different loading techniques practised at North Nab have provided unexpected benefits to the study objectives. Firstly, the presence of the two techniques in two distinct zones can be used to make a first assessment of the individual impact of each principal method of aggregate dredging on benthic biological communities, although it should be pointed out that less material is removed by trailer dredging than from the anchor-dredged site. Differences between the two dredging sites may therefore reflect dredging intensity, rather than the type of dredging method used. Secondly, the results also allow some comparisons of the nature of the recolonisation processes and rates of recovery in relation to anchor-dredging and trailer-dredging, as well as an assessment of the impact of the relatively small quantities of material discharged in the outwash for unscreened ('all-in') cargo loads.

Third, on a practical point, measurements of plume generation and decay originating from an anchored vessel are more straightforward to interpret using time-distance plots, due to the single source location. A trailing vessel will have a moving discharge zone that will compound the interpretation of the stage of plume development at any given point and hence time. Similarly, impacts observed at any point on the seabed will be compounded by the variable distance from the moving discharge point. This is important for determining not only the source terms for development of predictive models and assessments of impact for new extraction licences, but also for field validation of numerical models.

It is important to emphasise, however, that what is not included in this study is an assessment of the impact of the large quantities of material discharged as part of screening processes, common in other licence areas, as mentioned earlier. Similarly, the extent to which this quantity of material would affect sediment distribution, transport and sedimentation, or bed-form structure *etc.* is not known. Neither is it known how screening may alter the results of biological resources appraisal and rates of recolonisation reported in this project for the non-screening North Nab Licence Area 122/3.

Quite simply, analysis of the impacts of dredging a fully-screened cargo requires a comparative study at another site using the techniques of this project which have been proven in their principle and execution and which can be further refined in light of the observations made. The nature and rate of the recolonisation requires a specifically designed and systematic study that is co-ordinated with assessment of the differing dredge techniques and consequential plumes developed in a worked Licence Area.

MATERIALS AND METHODS

Survey Strategy

Six separate campaigns of data collection investigating the far field and then near field effects of dredging activities have been completed at the North Nab study site. Four other campaigns were aborted due to weather conditions and on one occasion due to damage to the dredger whilst on passage to the study site. Horizontal control of the survey was accomplished using a survey quality dGPS comprising a Trimble 4000SSi for primary positioning interfaced to a SeaSTAR differential corrections receiver. Layback to remote sensors such as the sidescan sonar fish or the grab sampler was established using measured offsets, vessel track and a TSS Meridian gyrocompass. Survey control was provided by the Integrated Navigation System developed by Coastline Surveys Limited and using the Trimble HYDROPRO navigation package.

Some 177 grab samples were obtained over 4 phases of the work using a standard 0.2 m^2 Hamon-type grab, deployed from the 23.3 metre survey vessel *MV FlatHolm.* Most of these samples were analysed for benthic community (see HITCHCOCK *et al.,* 2002b). Grain size analysis of the fractions 0.075 mm–125 mm by sieving determined the principal components of the seabed sediments (according to BS1377 and BS812: Part 102). Similarity analysis of the sediment size distributions was performed using standard non-parametric multivariate analysis methods.

Sidescan sonar imagery was obtained using a high quality GeoAcoustics Dual frequency 100/400 kHz towfish integrated to a GeoPRO sidescan mosaicing processing system. Sonography was recorded digitally on the mosaic system and concurrent high quality hard copy printed on an Ultra 200 three-channel thermal recorder. Trigger time and scan width was set at 333 and 67 milliseconds per channel depending on transmit frequency. The real-time facilities of this system enabled full coverage of the seabed to be confirmed whilst on site and promoted the accurate positioning of seabed calibration samples in zones of different seabed reflectivity.

The bathymetry of the survey area was established during each survey using a standard survey spread comprising a high-resolution single channel 208 kHz echosounder interfaced to a Seatex MRU-5 multi-reference motion sensor. Seabed levels were reduced to Chart Datum using recorded tides.

The survey zone was determined by pre-analysis of the dredge history of the site and assessment of tidal movements within the region. Tidal excursion on spring and neap tides is given by a local tidal diamond at 50° 40.1′N, 000° 56.3′W, some 1200 m to the east of the dredge site centre. Tidal streams reach up to 1.0 ms^{-1} on the flood (078°) but only 0.8 ms^{-1} on the ebb (252°). Maximum tidal excursion is slightly less than 13 km to the east and west. Based on the information obtained in previous studies on an area some 20 km to the east, we therefore designed the survey and sampling regime to extend up to 6 km in each direction, with the axis of the investigation aligned with the tidal excursion. The width of the survey area was delimited to 1000 m.

As mentioned earlier, comprehension of plume morphology formed by dredging activity at each site is fundamental in assessing any impacts of dredging beyond the limits of physical disturbance by the dredge head. It is primarily by this mechanism that any impacts will be extended beyond the active dredge zone. Over the past decade, we have developed in the U.K. novel techniques for tracking development and decay of marine dredging plumes using a combination of the latest ADCP systems and traditional water sampling techniques. These practices are now common worldwide. New advances in software analysis and presentation enable hitherto unknown representation of plume structure.

The form and magnitude of the plume is governed by three principal components;

(1) the dredging technique, including type of dredging plant in operation, method of overboard returns, and operational conditions such as speed over the ground;

(2) sensitivity to suspension and resuspension of the bed material *i.e.* the ease with which the bed material will be disturbed and will remain in suspension, largely determined by the characteristics of the sediment (geotechnical, rheological and micro-biological);

(3) condition of the overlying waters *i.e.* water depth, current velocity and shear, turbulence, temperature, wave climate, salinity *etc.*

A full description of ADCP systems procedures is outwith the scope of this paper, but see THEVENOT and JOHNSON (1994), LAND *et al.* (1994) and HITCHCOCK *et al.* (1998). The utility of ADCP techniques as interdisciplinary instruments for mapping sediment plumes are now well established and accepted.

Data Collection

Six field campaigns were undertaken. During March and June 1999 141 seabed samples were obtained over the entire area, including some repeat stations. In September 1999, a further 10 samples were obtained close into the dredge site, as it became apparent that the effects were much more limited in proximity to the dredging activity itself and, more than likely, located primarily within a few hundred metres of the active zone. In August 2000, a further 10 samples were obtained from within the active zone again, during an opportune effort to make a preliminary assessment of the expected rate of recovery.

Some 350 kilometres of high resolution sidescan sonar and bathymetry has been processed. These have allowed us to create high quality fully orthorectified digital mosaics of the seabed, over which discriminators of the footprints of impact of the dredging operation can be laid for further analysis.

The sediment plume generated by a small suction dredger, the *City of Chichester,* was monitored by ADCP techniques during the loading of an 'all-in' cargo. An RDI 1200 kHz

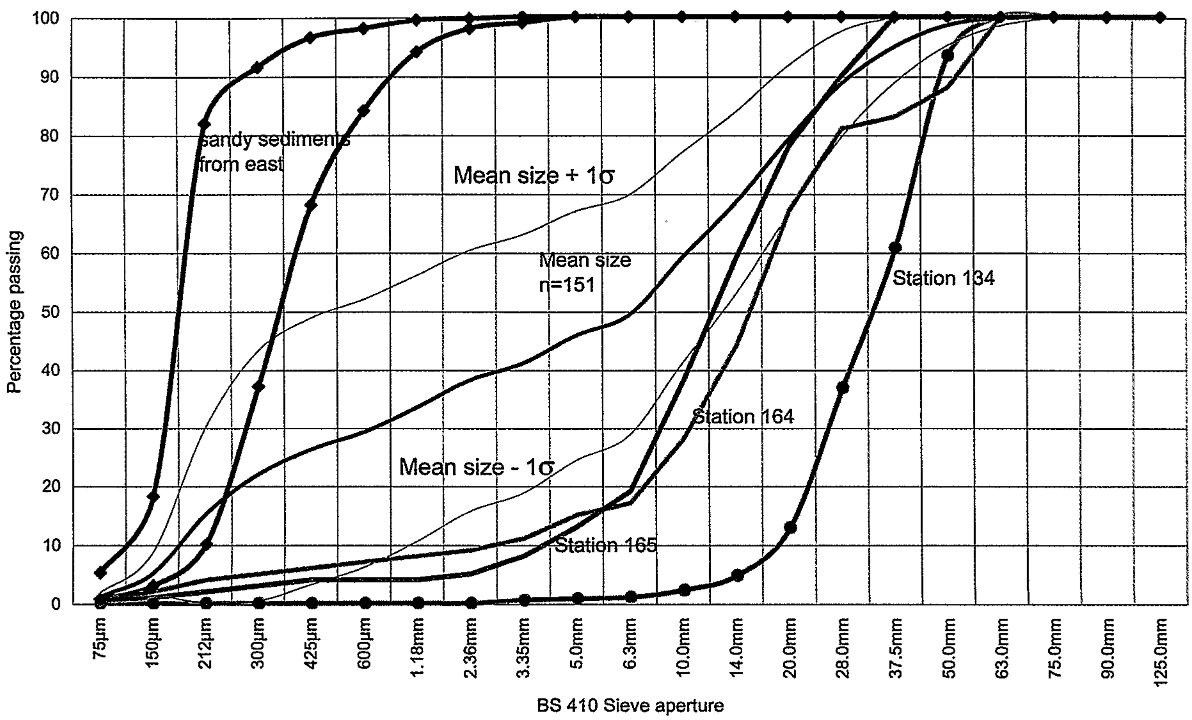


Figure 2. Mean particle size distribution and variance (1 sigma) for 151 samples obtained from the study site. The predominantly sand sized curves on the left were obtained from the eastern end of the study site and reflect a generally sandy seabed. The three curves to the right (stations 134, 164 and 165) were obtained from the actively dredged pits and show presence of very well sorted coarse gravels.

BroadBand unit was deployed over the bow of the survey vessel and the equipment and software configured for moving vessel mode. ADCP transects across the plume were conducted at differing ranges from the anchored dredge vessel, to determine the plume shape and morphology. Two distinct monitoring strategies were followed. In the first, the survey vessel conducted transverse profiles perpendicular to the plume axis at set distances downstream of the dredge vessel, and produced a series of profiles indicative of the status of the plume and its dispersing morphology. Water samples taken at varying points along each transect and at different depths give sediment mass per litre of seawater (suspended sediment concentration). The samples were too small for grading. Each of these profiles represents a time-dependent status of the plume, and the rate of dispersion and settlement of the sediments can be determined.

Secondly, the survey vessel deployed a mid-water drogue with a surface buoy in the plume just downstream of the dredge vessel. The survey vessel then conducted vertical and transverse profiling away from the dredger, always passing through the same parcel of water as indicated by the drogue surface buoy. This technique gives a time-based status of the plume but also removes some of the variability of the loading process and the 'pulsing' of overboard spilling of sediments from the dredge vessel. Specifically, within this study, we have not attempted to calibrate the ADCP backscatter signals with particular suspended sediment concentrations.

RESULTS

Granulometry

The deposits exposed within the centre of survey area generally comprise >50–60% gravels, this is the zone of active dredging and is clearly the material for which the licence was chosen. Figure 2 summarises the particle size distribution curves for the samples obtained (n = 151). Generally, the sediments are sandy gravels or gravelly sands. There is a clear subset of samples which are predominantly sand, where gravel content falls to less than 5%: these are located to the east of the survey area. To the west of the licence area, gravel content falls to less than 40% and there is an increase in silt content. Within the licence area grain size d_{50} ranges 6–12 mm: to the west this reduces to 4–8 mm and to the east reduces 1–2 mm. From Figure 2, the distinct sample stations 134, 164 and 165 are located within the dredge pit, and reflect a coarse gravelly deposit, which is the target resource. Silt content is generally less than 1–3%, with highest levels in the extreme west boundary of the study area, away from the dredge zone.

Figure 3 shows the boundaries of the principal sediment provinces based on multivariate analysis of the sediment classes, overlain onto the regional sidescan sonar mosaic of the region collected in 1999. The major sediment provinces are well indicated by the production licence area that closely follows the distribution of gravelly sediments. This supports

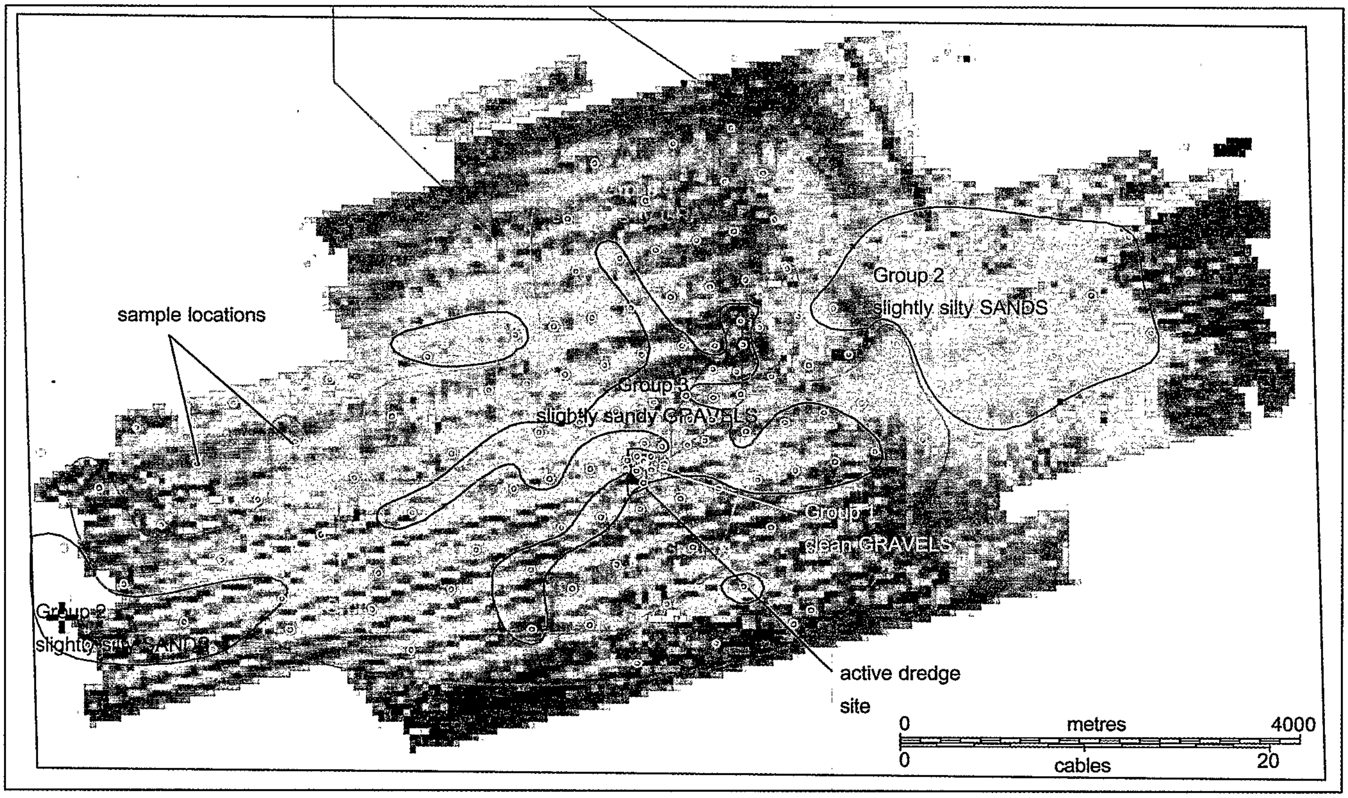


Figure 3. Sidescan sonar mosaic of the Area 122/3 study site with principal sediment provinces superimposed on the sonargraph. The correlation between sandy sediments and low reflectivity is clear to the east of the mosaic. Other than the exposed sub-bottom sediments of Group 1 (clean gravels), almost the entire licence area consists of slightly silty gravels. Note the elongated changes in sedimentary composition (Group 3) adjacent to the dredge zone aligned with the principal tidal vectors, to the South West, West, North and East.

the resource management Voluntary Initiative to restrict licensed areas of the seabed to the minimum required. These techniques enable a detailed assessment of the sediment distribution, and importantly reveal small groups of gravelly sediments that show an elevated sand content, distributed around the actively dredged area, not discernible by other geostatistical techniques. The zones of sandier gravels extend some 1500–2000 m away from the dredge location and correspond well with the predominant tidal axes away from the active dredge zone. These may be a result of geological conditions or more likely a result of dredging disturbances.

Sidescan Sonar Imagery

Inspection of the sidescan sonar mosaic presented in Figure 3 clearly shows the differing acoustic contrasts of the seabed in the principal sediment provinces. To the east, the lighter tone reflects the distribution of predominantly sandy size sediments. The remainder of the survey area is typically a uniform dark grey, characteristic of even, coarser sediments. The distribution of coarse sediments on the sonargraphs is again quite clearly matched by the licence boundaries. Other than a very small zone, some 500 m^2, on the extreme northwest boundary of the survey zone, there are no bedforms such ripples or megaripples. This localised development is near a small shelf of local solid exposure. Around the actively dredged area there is no evidence of development of sand ripples or other microtopographical features indicative of a localised sand transport path, as may be expected to develop during overboard release of sediments. We know that screening does not occur on this licence, so the potential quantity of remobilised fine sediments is small.

Anchor dredge activity can clearly be located on the sidescan sonar. Single dredge pits caused during isolated test dredging operations are also clear around the main dredge area. There is also localised evidence of trailer dredging activities in the designated zone, but these trails are poorly distinguished. Loading whilst trailing is not commonly undertaken. Anecdotal evidence from the vessels suggest that the method performs poorly in this locale, due possibly to presence of a lag gravel deposit through which the dredge head does not penetrate easily. Measurements from the sonographs indicate that the trailer dredge tracks are shallow, some 10–20 centimetres deep. Width is poorly distinguished.

Sediment Plumes

A composite image of the continuous backscatter profiling (CBP) of the plume developed by the 2300 tonne capacity *City of Chichester* during loading of an all-in cargo is shown in

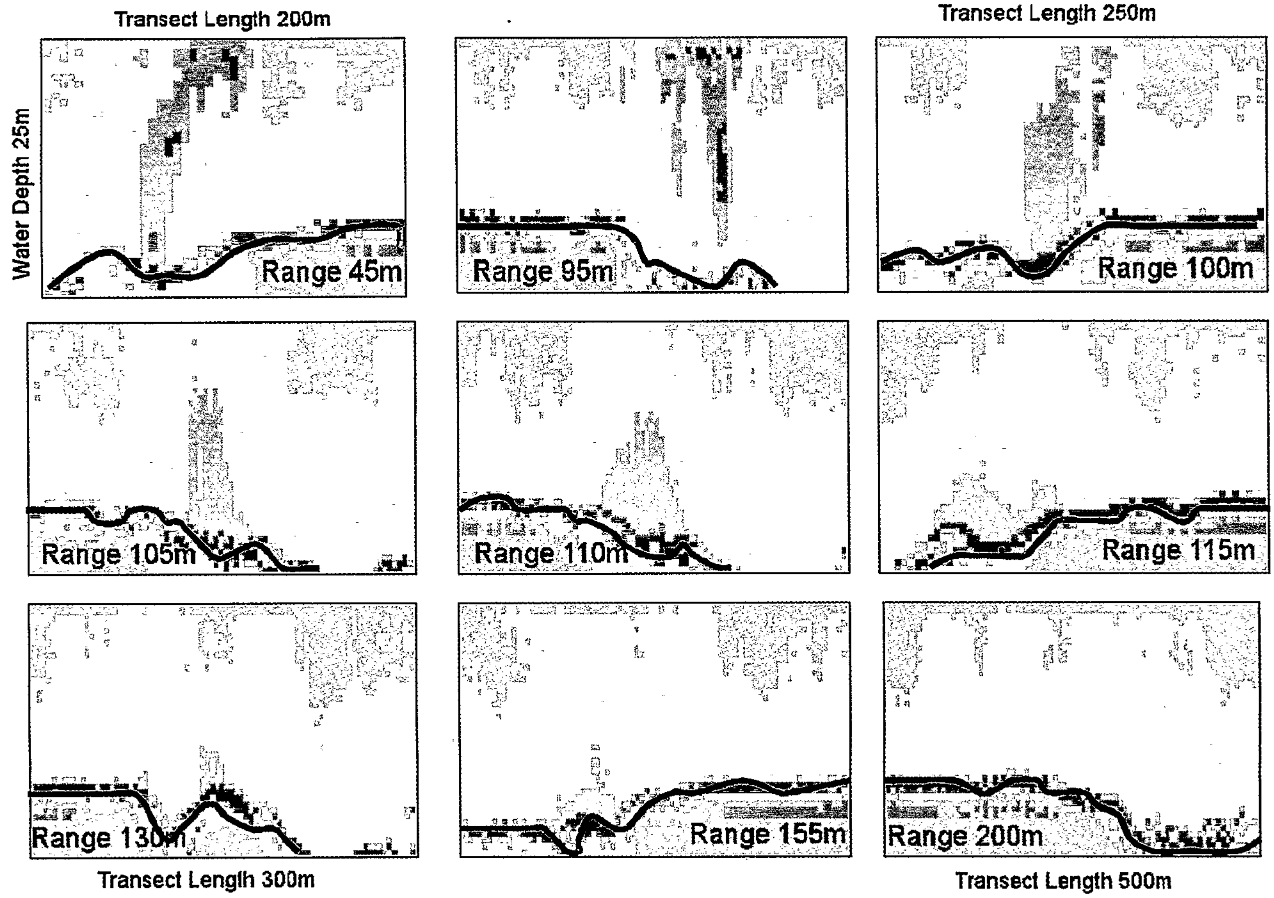


Figure 4. Series of Acoustic Doppler Current Profiles obtained with a 1200 kHz RDI BroadBand system astern of the 2300 tonne capacity suction dredger City of Chichester whilst loading at anchor without screening on Licence 122/3. Profiles show high intensity backscatter (red) close to and immediately astern of the dredger, reducing quickly to levels approaching background away from the dredger.

Figure 4. The screen-dump images show a series of transects downstream of the dredger at varying distances. Data collection at the far-field extremes of the survey, necessary to prove return distances to background levels, was curtailed by the presence of numerous small vessels at anchor. Nevertheless, the transects and samples obtained give a good indication of the near-field density current dynamic phase plume morphology. High intensity backscatter values are coloured red, reducing through yellow, white and to pale blue approaching background levels of backscatter. Close to the dredger, the plume can be visualised falling immediately below the vessel (45 metre image). The sequence 45 metres to 200 metres shows the dense plume falling to the seabed, and spreading laterally downstream of the operation. Scale of the transects changes with range from the dredge, such that the 45 metre transect is some 200 metres wide, whilst the 200 metre transect is some 500 metres wide.

Suspended sediment samples obtained by subsurface pumps immediately astern of the dredger are presented in Table 1 along with corresponding depths and distances downstream of the dredger. Pre-dredging background levels are 5–10 mg/l in settled conditions. Maximum values reached are approximately 5.5 g/l reducing to 450 mg/l further away from the vessel at the limit of the survey. Considerably more samples are needed for future works to resolve the fine scale eddies and internal structures that are developed during the overspill process. Included in Table 1 are corresponding results of a previous study on an adjacent site, using a similar methodology. In this instance, generally much lower concentrations of suspended sediments were recorded. Although the vessels are similar in size and operation, this may be due to different tidal conditions in the earlier study leading to much quicker dispersion of the plume. VAN DER VEER *et al.* (1985) measured overflow concentrations of suspended sediment from a small dredger to be 6300 mg/l, within range of the results obtained here. Background concentrations were found to average 60 mg/l.

Sampling data from our 1995 research (HITCHCOCK and DEARNALEY, 1995) indicated that at distances less than 100 metres from the dredger, total suspended solids concentrations ranged 480–611 mg/l in the lower water column, and 80–340 mg/l in the upper water column. Most of the sand had settled out reaching background levels within 250 metres, implying a forced settling rate of 32 mm/s in the water depths

Table 1. *Table showing the total suspended sediment concentrations in waters downstream of aggregate dredging operations on two English Channel sites (*Nab *and* OWERS*). Ten litre samples obtained using sub-surface pumps.*

Sample Number	Distance Downstream (metres)	Depth (metres)	Sample Volume (litres)	Suspended Solids (mg/l)
NAB18	65	2	8.54	1030.445
NAB23	66	5	7.594	5517.514
NAB14	84	18	9.049	1259.808
OWERS20	94	4		723
NAB24	98	2	7.367	1615.312
NAB31	109	2	6.9	695.6522
OWERS21	111	8		103
NAB19	133	5	9.298	1312.11
OWERS01	138	12		1170
NAB15	152	15	8.926	728.2097
OWERS02	156	16		1171
OWERS03	178	18		1346
NAB32	183	5	7.439	927.544
NAB20	192	10	8.595	1407.795
OWERS04	194	18		1225
NAB25	195	10	7.724	1993.786
OWERS16	201	4		47
NAB16	210	10	8.651	947.8673
OWERS17	227	8		304
OWERS18	248	12		582
NAB21	258	15	8.694	1702.323
OWERS19	259	18		613
NAB26	262	18	7.785	3301.22
NAB33	272	10	8.021	411.42
NAB22	331	18	8.363	442.425
NAB17	337	2	4.965	2819.738
NAB34	350	15	9.171	621.5244
NAB27	474	5	7.899	696.2907
OWERS10	491	1		46
OWERS08	534	18		18
OWERS09	549	18		22
OWERS07	561	16		18
OWERS06	573	12		18
OWERS05	585	8		26
NAB28	612	10	7.277	3091.933
NAB29	674	15	8.288	711.8726
OWERS11	675	4		10
OWERS12	691	8		13
OWERS13	707	12		13
OWERS14	724	18		25
OWERS15	740	18		38
NAB30	776	2	8.126	615.3089

and current speed encountered, whilst the silt content reached background within 480 metres implying a settling velocity of 17 mm/s. This study provides suspended solids concentrations an order of magnitude higher, in the range 0.5–5.5 g/l.

Figure 5 records two longitudinal profiles downstream of the dredging operation to the limits that were possible on the day. The first profile (45 metres to 820 metres) shows a reduction in backscatter with two distinct phases. At about 300 metres, there is a rapid reduction in suspended solids backscatter. It is not clear whether this is a phenomenon of irregular loading and hence discharge rates (the dredge density and rate varies by the minute), or may represent observations similar to previous work, with a major reduction in the plume density roughly 300 metres to 500 metres from the dredge site (NEWELL *et al.,* 1998; HITCHCOCK and DRUCKER, 1996).

Interestingly the second profile shows a near bed extension to the dense plume, extending beyond 800 metres, some 3–4 metres high in the water column off the seabed. This is important because it gives us, for the first time, some indication of a near bed extension to the benthic plume that has been observed by others (DICKSON and REES, 1998) and is discussed further in the following sections.

DISCUSSION

Impact Outside The Dredge Boundary

New software developed in this project has enabled us to re-process data collected in previous research and presented elsewhere (HITCHCOCK and DRUCKER, 1996). Figure 6 presents a 3D image of the 1996 plume data collected on the Owers Bank aggregate licences, some 25km to the east of the Nab study site. This re-processing has enabled us to identify a near bed extension to the dense dynamic phase of the plume that extends beyond the zone of monitoring, and hence well beyond the zone of previous detected impacts outside the dredge boundary. In water depths of 21 metres and currents of up 3 ms^{-1}, extraction of sand and gravels with screening would appear to generate a near-bed plume, some 2–4 metres thick, that extends downstream beyond 4.5 kilometres from the dredge site. The fate of the material is presently unknown since data does not exist beyond this zone.

However, the recent study by DICKSON and REES (1998) does suggest that benthic landers have monitored the progress of a near bed plume of sediments some 8 kilometres from a dredge site in the southern North Sea, although the dynamics are still to be fully resolved. This observation is important for two reasons: (i) using different technologies, independent studies have corroborated the presence of a near bed plume extending some way beyond the dredge site; and (ii) the extension of the near bed plume beyond the dredge zones gives credence to a mechanism for faunal community enhancement that has been observed in various studies (NEWELL *et al.,* 1998; POINER and KENNEDY, 1984).

It has often been assumed for the purposes of simulation models for British coastal waters that the dispersion of material rejected *via* the reject chute and spillways during the dredging process is controlled by *Gaussian* diffusion principles. Consequently, tidal currents could carry suspended material as much as 20 kilometres each side from a point source of discharge. Indeed, in water depths up to 25 metres and peak spring tide velocities of 1.75 ms^{-1}, very fine sand may *potentially* travel up to 11 kilometres from the dredging site, fine sand up to 5 kilometres, medium sand up to 1 kilometre and coarse sand less than 50 metres. In current regimes with a lower peak velocity of some 0.9 ms^{-1}, similar sized material may only travel up to 6.5 kilometres from the point of release (HR WALLINGFORD, 1993). Worst-case estimates have suggested that sediment plumes may persist for up to 4–5 tidal cycles.

Interestingly, detailed and extensive monitoring campaigns associated with the construction of the Størebælt Link have detected suspended sediment related to a specific dredg-

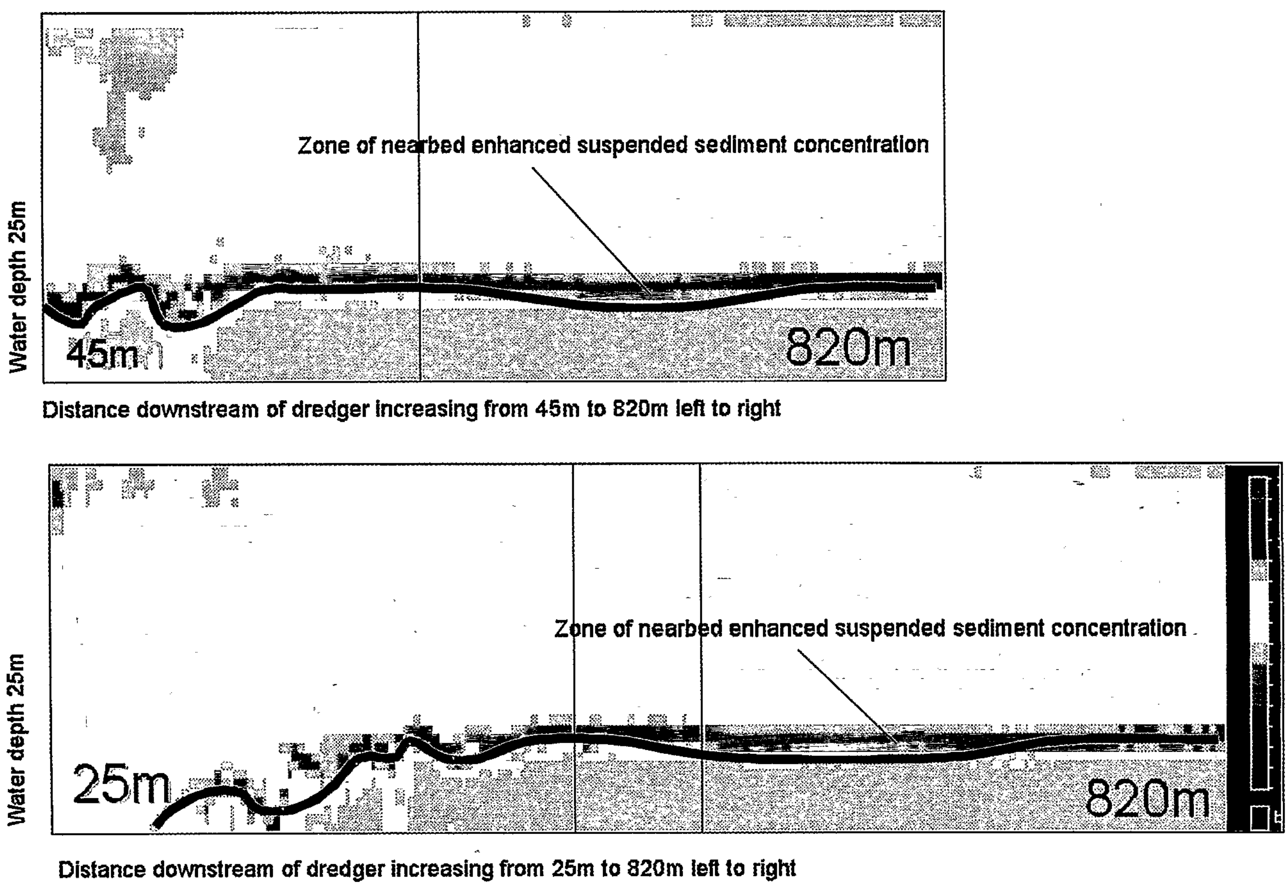


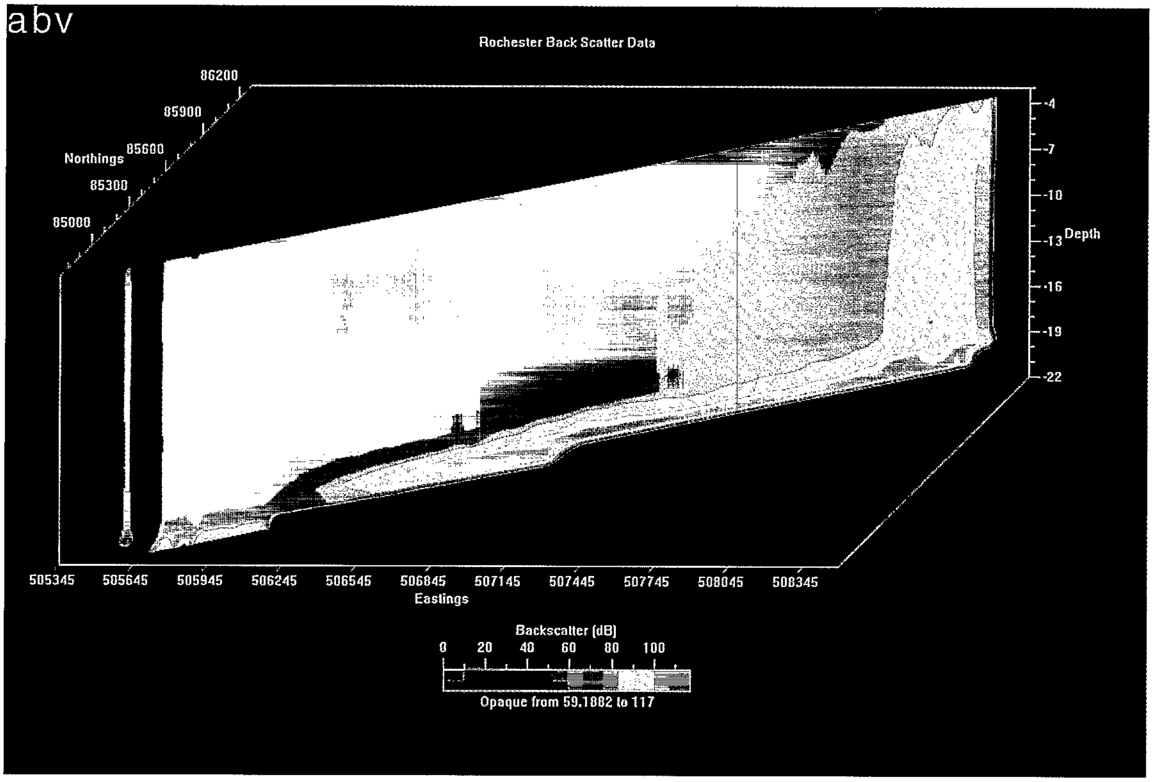
Figure 5. Backscatter profiles obtained downstream of the City of Chichester at Area 122/3 showing the persistence of the nearbed sediment plume to the limit of the monitoring area. Higher suspended solids concentrations (note possibly also includes air bubbles) are shown in the darker colours. The black line represents the seabed. Clear waters appear in light blue. The 45m range transect shows an asymmetrical plume representing greater discharge from one side of the vessel than the other (due to vessel trim noted during survey). The 95 m transect shows the plume as two distinct components, issuing from spillways either side of the vessel. Transects further away from the dredge vessel depict the higher concentrations of the plume body sinking closer to the seabed with distance downstream.

ing operation up to 35 kilometres from the source. However simulations have shown that 6 kilometres from the operations, the 'monthly average surplus suspended solids concentrations' caused by some of the most intensive dredging operations were at the same level as the background concentration (2 mg/l).

Investigations in Hong Kong were undertaken at an early stage when marine dredging for aggregate was considered (HOLMES, 1988; WHITESIDE *et al.,* 1995). The concern for plume impingement on sensitive spawning grounds necessitated monitoring of water quality during dredging operations. The investigations concluded that within the water column the practical effects of enhanced suspended solids concentrations are difficult, if not impossible to assess. The effects were observed to be short lived and of limited areal extent and therefore concluded that suspended sediment impacts within the water column were negligible, away from spawning and mariculture zones, even though *in situ* fines contents were significant.

Further, and probably related to the sampling methodology and dredging technique, suspended solids concentrations in the hopper surface waters were only 10000–30000 mg/l, reducing rapidly to 5000 mg/l adjacent to the dredge vessel in the sea. A rapid dilution is therefore observed. HOLMES (1988) observed that (1) the sand fraction settled quickly within a few hundred metres of the dredger (at a rate of 46mms^{-1} for 320 micron particles); and (2) the pelitic fines content will settle much slower at 0.1–1 mms^{-1} and will therefore disperse over a wider area, observed up to 4 kilometres. KIØRBOE and MØHLENBERG (1981) monitored the operation of a sand suction dredge in the Øresund, Denmark and concluded that any suspended solids concentrations likely to be detrimental were not present more than 150 metres downstream of the dredge. Levels adjacent to the dredge were up to 5000 mg/l, rapidly decreasing to 100 mg/l at 150 metres. Background levels were regained at 1000 metres downstream.

A plume dispersion model developed by WHITESIDE *et al.* (1995) for the surface layer (the upper 8 metres of the water column) for up to 40 minutes after discharge compares well



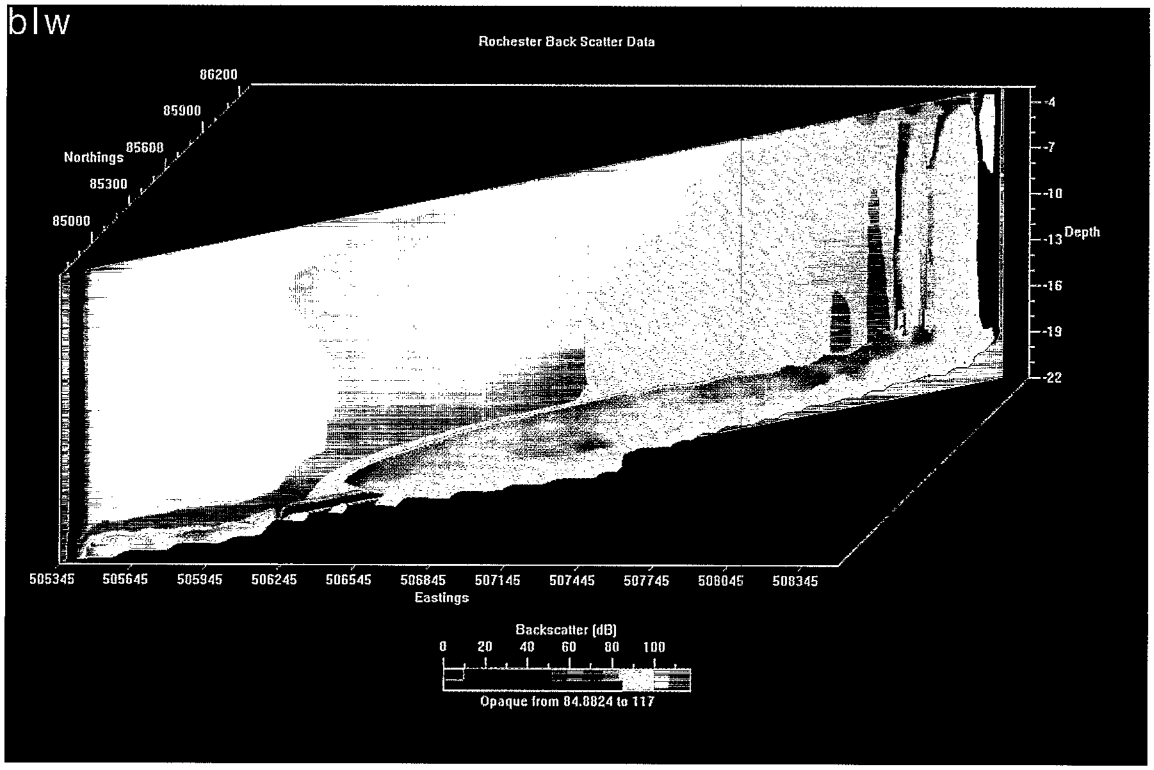


Figure 6. With newly developed software, backscatter profiles obtained in 1995 during screening operations on a deeper, more intensive and extensive aggregate licence located 25 km to the east have been reprocessed and reveal the presence of a noticeable nearbed sediment plume extending well beyond the initial zones of impact.

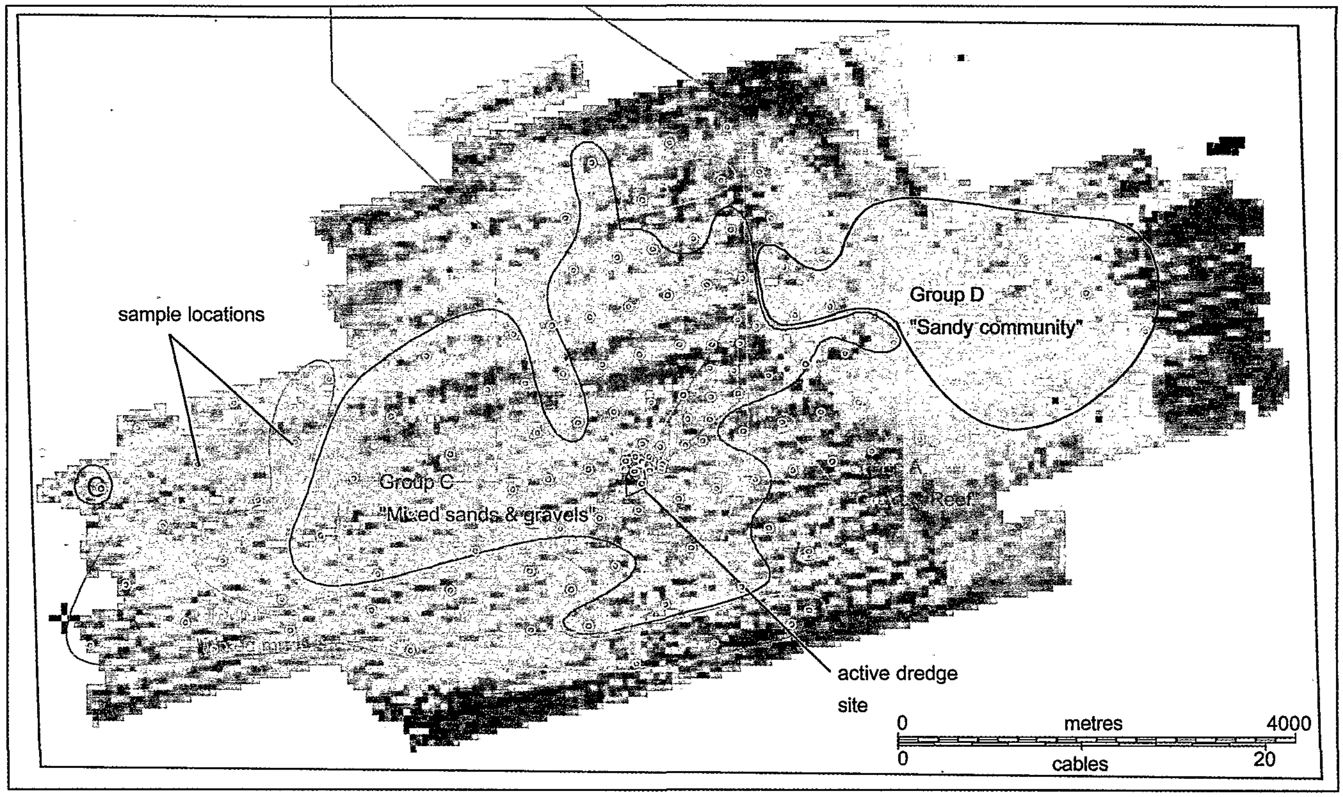


Figure 7. Superimposing the benthic community types on the sidescan mosaic and comparing with Figure 3, we can see that there is no correlating change in community type similar to the recorded changes in sediment province. Community Groups B and C pass over the tongues of sandy material downstream of the dredge zone (this does not appear to be an artifact caused by data density).

with plume decay measurements in the vicinity of the dredger. The contours for sediment deposition evidently remain as a narrow band extending for approximately 100 metres on each side of the track of the dredging vessel, much as recorded by GAJEWSKI and USCINOWICZ (1993) for Baltic waters.

Impact within the Dredge Boundary

There is little data worldwide to compare with the results of this study unlike the impacts beyond the dredge zone discussed above. Processing of the Nab ADCP data has produced an image of the plume that confirms the presence of a near bed plume extension mentioned elsewhere. This plume has the capacity to egress the 10 metre deep hole dredged below the level of the surrounding seabed. The limits of the plume extension may however, be limited by the flux of sediment available to contribute to the plume and also the limited time available for the plume excursion. An important operational feature of the Nab 122/3 licence is that exploitation commonly takes place for around an hour either side of low water, this being the expedient time for the vessel to return to port to discharge in the tidal berths found locally. This has important implications for the potential for plume dispersal, in that many dredging operations will not take place during peak tidal flows, but only in those weaker flows a few hours either side of low water.

Sediment Composition

Figures 3 & 7 clearly show the distribution of sediments (as discussed earlier) and faunal communities. For a detailed analysis of the benthic resources, see the accompanying paper by NEWELL *et al.* (2002). Importantly, the lack of correlation between the change in sediment type downstream of the dredging activity (the enhanced 'sandiness' of the gravels) and the faunal community suggests that either the type of community structure present is unaffected by the change in sediment composition or, more likely, is tolerant of the level of change that the community has been exposed to. However, an increased or prolonged exposure may cause a negative impact, or the existing exposure may cause a level of stress to the community that reduces its tolerance to other impacts, leading to the potential for 'cumulative' impacts.

Seabed Configuration

The most striking changes within the dredge boundary are produced by the dredging activity itself (Table 2). Anchor dredging produces the largest single features, with seabed pits reported by DICKSON and LEE (1973) some 4 metres deep by 50 metres diameter, whilst we have reported here bed levels up to 10 metres below the surrounding deposits, the base of the depression having dimensions of 300 metres × 100

Table 2. *Comparison of potential impacts according to the type of mining method.*

Type of Dredging	Advantages	Disadvantages
Deep isolated pits	impact on small area reduced or little modification of wave and current patterns	entrapment of bed load irregular, hummocky terrain increased possibility of disturbance of underlying strata e.g. clays seabed topography unsuitable for trawling stratification of water within deep pits possibility of anaerobic conditions in deepest pits reduced chances of faunal recovery
Shallow extensive furrows	reduced alteration of topography improved conditions for faunal recovery reduced possibility of exposure of underlying strata suitability for modern dredgers	may effect current and wave patterns extensive area impacted

metres. The fisheries concerns against this type of dredging methodology centre on the risk of snagging towed gear within the depression, and general unsuitability for beam trawling. Deep pits may also pose the risk of formation of an anoxic bottom layer of water with reduction of water circulation and accretion of fine sediments in certain hydrodynamic conditions, predominantly 'low energy'. However, our deployment of an underwater camera in the pits at the Nab 122/3 licence recorded little visual difference to water turbidity of the surrounding natural bed levels, whilst a similar number of individual fish and other benthic dwellers were observed.

ÅKER, HÄKKINEN and WINTERHALTER (1990) report that turbid waters could not be detected further than 'a few hundred meters', down current from the dredger. Normal water quality variations caused by current activity and storm suspension were found by them to be greater than that caused by sand extraction, although no values are given. They also consider that the operation had no 'clearly detectable' effect on fishing in the general area.

Trailer dredging produces a 'furrowed' topography and has been observed by DICKSON and LEE (1973), and more recently analysed in detail by DAVIES and HITCHCOCK (1992). Different types of dredge imprint are reported in the latter work. The dredge imprint will vary according to the type of draghead used, but some features more generally associated with one particular type of draghead can occasionally be found on others. Importantly, however, the furrow width is generally less than approximately 1 metre greater than the width of the draghead. Narrower dragheads produce deeper furrows, approximately 2.5 metres width by 0.5 metres deep. Wider dragheads such as the 'California Type' produce shallower and wider furrows 0.35 metres deep by 3.5 metres wide. Recently, some companies using the simple 'Fixed Visor' type of draghead have replaced them with California Type dragheads with significant improvements in the quality of cargoes loaded and simultaneous reduction in the loading times. DÉSPREZ and DUHAMEL (1993) report sidescan sonar observations of dredge furrows on the Klaverbank being 3 metre wide and approximately 0.5 metre deep. KENNY and REES (1996) observed furrows 0.3–0.5 metres deep but only 1–2 metres wide: however it is known that the furrows were made with a 'California Type' draghead of some 2.6 metres wide. One year after dredging, the furrows were no longer distinguishable by underwater camera, whilst after 2 years the furrows were barely detectable by sidescan sonar. ICES (1975) concede that trailer dredging does not greatly affect the action of seabed trawls. There has been little data put forward since to change this statement.

DAVIES and HITCHCOCK (1992) noted that many furrows were characterised by the formation of lateral *levées,* resulting from the draghead digging deeper into the seabed than the pumps could remove. This is an inefficiency in the system, and it is apparent that the wider dragheads do not suffer from such losses as much as the narrower types. There is thus less potential for interference with trawling activities.

Changes in composition of the seabed sediments may cause changes to the benthic community structure. DÉSPREZ and DUHAMEL (1993) noted that following intense dredging activity off Dieppe, the predominantly sandy gravel surface sediments were reduced to predominantly sandy sediments (possibly existing as a thin veneer of mobile sands deposited by the settling overboard returns). Further, they recorded dominance of several new species characteristic of finer sediments with establishment of communities of the Polychaetes *Ophelia acuminata, Nephtys sp.* and *Spiophanes bombyx* and the Echinoderm *Echinocardium cordatum.* These species were also observed in the sandy sediments present on the Klaverbank although in this case extensive rather than intensive dredging did not lead to distinguishable changes in predominant sediment grain size. A detailed assessment of the implications to benthic communities of dredging intensity is given in the associated paper in this journal by NEWELL *et al.* (2002).

Summary

We have shown that a small-scale operation at Licence Area 122/3 of some 150,000 tonnes per annum, even with intensive extraction rates per km^2, has a limited impact on the environment. The evidence suggests that, other than where sediments are physically disturbed by removal, physical resources are largely unaffected. There is some minor change in sediment characteristics. As reported in the accompanying paper by NEWELL *et al.* (2002), benthic biological resources would appear to be able to cope with the stresses induced by the minor change in sediment type, and indeed appear to benefit by the increased food resource provided by disturbance of the sediments.

What is also clear is that the development of a linear downtide extension to the nearbed, or benthic boundary, sediment plume provides a mechanism for potential extension of the impact well beyond the zone of extraction. This effect, apparently not significantly present on the North Nab 122/3 site, may be expected to be more significant for those areas where screening of cargoes takes place, and is suggested by the results of our studies on the Owers Bank, those of DICKSON and REES (1998) and anecdotal evidence from monitoring surveys of licences where screening is commonplace. More importantly, this may hold especially true for those deeper water communities (40 metres or so), less exposed to and tolerant of natural disturbances to the sedimentary regime (NEWELL *et al.,* 2002).

It is stressed that 'scaling up' of the results recorded so far from the comparatively shallow water small scale operations reported here to deeper water and more extensive operations with screening of cargoes is not a realistic option and should be avoided. Fundamental baseline data collection at these deep-water sites is required to understand the response signatures of the benthic communities to disturbances, both natural and anthropogenic, and the extent of plume migration under the different phases of development and dispersion.

ACKNOWLEDGEMENTS

This study was funded by the Minerals Management Service, U.S. Department of the Interior, Washington, D.C., under Contract Number 1435-01-99-CT-30980. The support of Mr. B. Drucker, Contracting Officers Technical Representative, during these studies is gratefully acknowledged. The study was supported by members of the UK British Marine Aggregate Producers Association, in particular, United Marine Dredging Ltd.

LITERATURE CITED

ÅKER, K.; HÄKKINEN, A., and WINTERHALTER, B., 1990. Submarine sand and gravel studies in the Eastern Gulf of Finland during the years 1983–1985. *In*: KAURANNE, L.K. and KÖNIGSSON, L.K. (eds.), Quaternary Economic Geology in the Nordic countries. *Striae,* 29, 31–38.

BONETTO, E., 1995. Dispersion in the marine environment of turbidity generated by overflow. *Terra et Aqua,* 58, 15–23.

DAVIES, C.M. and HITCHCOCK, D.R., 1992. *Improving the Exploitation of Marine Aggregates by a Study of the Impact of Marine Mining Equipment.* Marine Technology Directorate Research Grant GR/G 20059. M.T.D., U.K. Final Report, 110p.

DÉSPREZ, M. and DUHAMEL, S., 1993. *Report of the ICES Working Group on the Effects of Extraction of Marine Sediments on Fisheries—Comparison of Impact of Gravel Extraction on Geomorphology, Sediment & Macrofauna in two areas: Klaverbank(NL) & Dieppe(F)* ICES, Copenhagen.

DICKSON, R.R. and LEE, A., 1973. Gravel extraction: effects on seabed topography. *Offshore Services,* 6(6), 32–39.

DICKSON, R.R. and REES, J.M., 1998. *Impact of dredging plumes on Race Bank and surrounding areas.* CEFAS, LOWESTOFT. Unpublished Final Report to MAFF, U.K., 15p.

GAJEWSKI, L.S. and USCINOWICZ, S., 1993. Hydrologic and Sedimentologic Aspects of Mining Aggregate from the Slupsk Bank (Baltic Sea). *Marine Georesources & Geotechnology,* 11, 229–244.

HAMMER, R.M.; BALCOM, B.J.; CRUICKSHANK, M.J., and MORGAN, C.L., 1993. *Synthesis and analysis of existing information regarding environmental effects of mining—Executive Summary.* Continental Shelf Associates Inc, Jupiter, 38p.

HITCHCOCK, D.R. and DEARNALEY, M.P., 1995. Investigation of benthic & surface plumes associated with marine aggregate production in the United Kingdom: Overview of Year One *Proceedings of XVth Information Transfer Meeting,* Gulf Coast Region INTERMAR, New Orleans, USA. 10pp.

HITCHCOCK, D.R. and DRUCKER, B.R., 1996. Investigation of benthic and surface plumes associated with marine aggregates mining in the United Kingdom. *In*: The Global Ocean-Towards Operational Oceanography Volume 2. *Proceedings of the Oceanology International Conference.* ISBN 0-900254-12-2, 221–234.

HITCHCOCK, D.R.; NEWELL, R.C., and SEIDERER, L.J., 1998. *Investigation of benthic and surface plumes associated with marine aggregate mining in the United Kingdom—final report.* Contract Report for the U.S. Department of the Interior, Minerals Management Service. Contract Number 14-35-0001-30763. Coastline Surveys Ltd Ref. 98-555-03 (Final), U.K., 168p.

HITCHCOCK, D.R.; NEWELL, R.C., and SEIDERER, L.J., 2002a. On the impacts of marine aggregate mining on the seabed: Part I Physical. *Proceedings of XXIst Information Transfer Meeting,* Gulf Coast Region INTERMAR, New Orleans, USA. 9pp.

HITCHCOCK, D.R.; NEWELL, R.C., and SEIDERER, L.J., 2002b. On the impacts of marine aggregate mining on the seabed: Part II Biological. *Proceedings of XXIst Information Transfer Meeting,* Gulf Coast Region INTERMAR, New Orleans, USA. 9pp.

HOLMES, P.R., 1988. Environmental Implications of Exploiting Marine Sand. *Geological Society of Hong Kong,* May 1988, 143–159.

HR WALLINGFORD, 1993. *Shingle Bank, Hastings: Dispersion of dredged material Report EX 2811.* HR Wallingford, Wallingford.

ICES, 1975. *Second Report of the ICES Working Group on the Effects on the Fisheries of Marine Sand and Gravel Extraction Cooperative Research Report No.64.* Ijmuiden, 9–10 December 1975 ICES, Charlottenlund, 27p.

KENNY, A.J. and REES, H.L., 1996. The Effects of Marine Gravel Extraction on the Macrobenthos: Results 2 Years Post-Dredging. *Marine Pollution Bulletin,* 32, 8/9, 615–622.

KIØRBOE, T. and MØHLENBERG, F., 1981. Dispersion of suspended material from an operating sand suction dredge in the Øresund, Denmark. *Water,* 37, 303–309.

LAND, J.M.; KIRBY, R., and MASSEY, J.B., 1994. Recent innovations in the combined use of acoustic Doppler current profilers and profiling siltmeters for suspended solids modelling. *In: Proceedings of the 4th Nearshore and Estuarine Cohesive Sediment Transport Conference,* HR Wallingford, 1, p10.

VAN MOORSEL, G.W.N.M. and WAARDENBURG, H.W., 1990. *Impact of gravel extraction on geomorphology and the macrobenthic community of the Klaverbank (North Sea) in 1989.* Bureau Waardenburg, Culemborg.

NEWELL, R.C.; HITCHCOCK, D.R., and SEIDERER, L.J., 1998. Organic enrichment associated with outwash from marine aggregate dredging: a probable explanation for surface sheens and enhanced benthic production in the vicinity of dredging operations. *Marine Pollution Bulletin,* 38(9), 809–818.

NEWELL, R.C.; SEIDERER, L.J., and HITCHCOCK, D.R., 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology Annual Review,* 36, 127–178.

NEWELL, R.C.; SEIDERER, L.J.; SIMPSON, N.M., and ROBINSON, J.E., 2002. Impacts of marine aggregate dredging on benthic biological resources in coastal deposits. *Journal of Coastal Research* (in press).

POINER, I.R. and KENNEDY, R., 1984. Complex patterns of change in the macrobenthos of a large sandbank following dredging. *Marine Biology,* 78, 335–352.

PRICE, W.A.; MOTYKA, J.M., and JAFFREY, L.J., 1978. The Effect of Offshore Dredging on the Coastlines. *In: Proceedings of the 16th Coastal Engineering Conference,* 1347–1358.

THEVENOT, M.M. and JOHNSON, B.H., 1994. Verification of Numerical Modelling of the Fate of Disposed Dredged Material. *In* CLARKE-MCNAIR, E., (ed.), *Dredging '94: Proceedings of the 2nd International Conference on Dredging & Dredged Material Disposal,* 1, 180–189.

VAN DER VEER, H.W.; BERGMAN, M.J.N., and BEUKEMA, J.J., 1985. Dredging Activities in the Dutch Wadden Sea: Effects on Macrobenthic Infauna. *Netherlands Journal for Sea Research,* 19, 183–190.

WHITESIDE, P.G.D.; OOMS, K., and POSTMA, G.M., 1995. Generation and decay of sediment plumes from sand dredging overflow. *In: Proceedings of the 14th World Dredging Congress,* 14, 877–892.

Journal of Coastal Research	20	1	89–100	West Palm Beach, Florida	Winter 2004

Evaluating Shoreline Response to Offshore Sand Mining for Beach Nourishment

Sean W. Kelley, John S. Ramsey, and Mark R. Byrnes

Applied Coastal Research and Engineering, Inc.
766 Falmouth Road, Suite A-1
Mashpee, MA 02649, USA

ABSTRACT

KELLEY, S.W.; RAMSEY, J.S., and BYRNES, M.R., 2004. Evaluating shoreline response to offshore sand mining for beach nourishment. *Journal of Coastal Research,* 20(1), 89–100. West Palm Beach (Florida), ISSN 0749-0208.

An analytical approach that incorporates analysis of nearshore wave transformation and wave-induced longshore sediment transport was developed to quantify the significance of potential physical environmental impacts associated with offshore sand mining. Calculation of longshore sediment transport potential for a series of wave cases provided a method for determining the extent and magnitude of alterations to nearshore processes, but the magnitude of change alone did not provide enough information to determine the significance of changes for a particular coastline. This paper documents a method for evaluating the significance of borrow site impacts that incorporates temporal and spatial variations in the incident wave field. Example applications of this method are presented for borrow sites offshore Oregon Inlet, North Carolina; Martin County, Florida; and Corsons Inlet, New Jersey. As a management tool, this methodology holds several advantages over methods previously employed to assess the significance of borrow site impacts, including: 1) a model-independent component (observed shoreline change) is used to verify model results; 2) impacts associated with borrow site excavation can be directly related to their potential influence on observed coastal processes; 3) site-specific temporal variability in wave climate and sediment transport potential is calculated as part of the methodology; and 4) the procedure accounts for spatial and temporal variability in wave climate, as well as provides a means of quantifying significance of impacts relative to site-specific conditions.

ADDITIONAL INDEX WORDS: *Wave transformation modeling, longshore sediment transport, cumulative effects, Oregon Inlet, North Carolina, Martin County, Florida, Corsons Inlet, New Jersey.*

INTRODUCTION

During the past few decades, there has been increased interest in sand and gravel resources on the Outer Continental Shelf (OCS) of the USA (*e.g.,* FIELD and DUANE, 1974; MEISBURGER and WILLIAMS, 1980; WILLIAMS, 1987). The potential for exploitation of these sand resources as a source for beach and barrier island restoration has grown rapidly as similar resources in State waters are being depleted or polluted. Beach nourishment, as a form of erosion control, has become a standard engineering alternative to coastal engineering structures (*e.g.* groins, seawalls, and breakwaters) because nourishment projects dissipate wave energy and replenish the local sediment supply.

However, beach nourishment programs potentially can cause adverse environmental impacts at beach fill locations and borrow sites if an offshore sediment source is mined. In addition to concerns regarding biological resources, the physical effects of offshore sand mining on the incident wave field and associated sediment transport regime may alter local shoreline change. This is demonstrated well in the example of a 1983 nourishment of Grand Isle, Louisiana (COMBE and SOILEAU, 1987) where a 2.1 million cubic meter (MCM) beach fill was constructed using sand from two borrow sites located 800 m offshore. Modifications to the wave and sediment transport climate of the area resulted in the unintended formation of large cuspate bars and erosion hot spots on the beach, which persisted long after the borrow sites had filled.

Many past offshore borrow site studies have used computer modeling of waves and shoreline change to determine post-dredging impacts (*e.g.,* HORIKAWA *et al.,* 1977; KRAUS *et al.,* 1988). Less attention has been focused on determining the relative significance of potential changes to the physical environment associated with offshore sand mining. To this end, an analytical approach was developed that incorporates analysis of nearshore wave transformation and wave-induced longshore sediment transport. The most effective means of quantifying incremental and cumulative physical environmental changes from sand dredging on the continental shelf is through the application of wave transformation numerical modeling tools that recognize the random nature of incident waves as they propagate onshore. Spectral wave models, such as STWAVE (*e.g.,* SMITH and HARKINS, 1997), REF/DIF-S (*e.g.,* CHAWLA *et al.,* 1994), SWAN (BOOIJ *et al.,* 1999), and others typically reproduce field measurements. As such, spectral wave transformation modeling was applied to evaluate the potential negative effects of sand removal from offshore borrow sites to coastal and nearshore environments. Although the interpretation of wave modeling results is relatively straightforward, evaluating the significance of predicted changes for accepting or rejecting a borrow site is more complicated.

A three-phase approach was implemented to evaluate the

7 received and accepted in revision 6 June 2003.

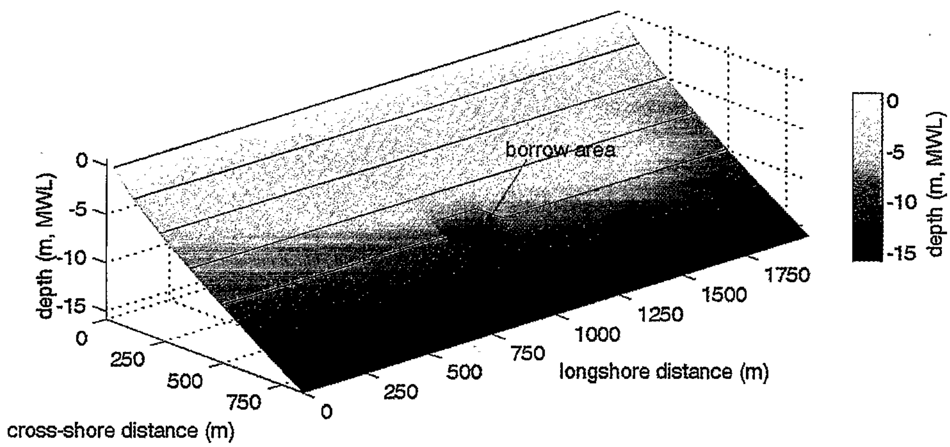


Figure 1. Surface plot with 2.5-m contours of bathymetry grid used for idealized borrow site model runs.

potential physical effects of offshore sand mining on local wave and sediment transport processes. First, a standard method was developed to quantify the significance of changes associated with borrow site excavation and to determine the influence of borrow site geometry on wave refraction and sediment transport patterns. Because large spatial and temporal variability exists within the wave climate at a particular site, determination of physical impacts associated with sand mining must consider the influence of process variability. The second phase of the project focused on wave spectra development, wave transformation modeling, and coastal sediment transport calculations. The final phase addressed potential cumulative effects and significance of sand dredging from offshore sand borrow sites. A site-specific determination of acceptable limits of borrow site impacts relative to sediment transport potential was determined for each case.

WAVE AND SEDIMENT TRANSPORT PROCESSES

In recent years, there has been increased focus on the nearshore zone due to rapid development of coastal regions and the need to protect infrastructure from storms and long-term coastal erosion. This effort has concentrated on developing analytical tools to evaluate the transformation of waves in shallow water and to quantify sediment transport induced by breaking waves along the shoreline. Although improvements have been made, evaluation of coastal processes still requires a combination of analytical capability, interpretation of many complex and often apparently conflicting data sets, and experience gained from analyzing a variety of shorelines.

Nearshore Wave Transformation

Variations in seafloor elevation tend to dominate wave transformation as waves propagate into intermediate and shallow water. Although a small amount of energy is lost through bottom stresses (frictional drag), most nearshore wave transformation results from six processes: 1) refraction, 2) shoaling, 3) breaking, 4) diffraction, 5) reflection, and 6) wave-current interactions. These processes determine the size and incident angle of breaking waves, the dominant factors influencing nearshore sediment transport. Although minor wave diffraction and reflection may occur at an offshore borrow site, typically, the combined influence of wave refraction, shoaling, and breaking dominate transformation processes. Therefore, consideration of these three dominant processes represents the critical components of any spectral analysis used to evaluate alterations to a wave field associated with offshore sand mining.

Excavation of an offshore borrow site can alter wave heights and wave propagation direction. The existence of an offshore trough or trench may cause waves to refract toward the shallow edges of the borrow site. This alteration to the wave field changes local sediment transport rates, where some areas may experience a reduction in longshore transport and other areas may show an increase. The magnitude and significance of the change at the shoreline would depend upon the wave climate and the borrow site distance from shore. Analysis of wave modifications at an idealized borrow site was performed using STWAVE to illustrate how alterations in offshore bathymetry can modify existing wave conditions and resulting sediment transport processes. Figure 1 shows the configuration of a hypothetical borrow site, excavated into idealized bathymetry developed using straight and parallel contours and an Ay^m profile for southern New Jersey (DEAN, 1977). The idealized borrow site was located approximately 400 m offshore, centered on the -10 m (mean water level, MWL) bathymetric contour, with an excavation depth of 3 m below the seafloor. To evaluate a range of wave transformation possibilities, wave spectra centered at $-30°$, $-15°$, $0°$, $15°$, and $30°$ relative to shore normal were modeled, each with the same significant wave height and peak period, and having an equal percent occurrence (20%).

Figure 2 illustrates the influence of the idealized borrow site on nearshore waves for a single wave condition approaching the shoreline from $-30°$ relative to shore-normal. For this wave modeling case, the influence of the borrow site extends approximately 900 m alongshore measured at the breaker line. In addition, the maximum increase and decrease in

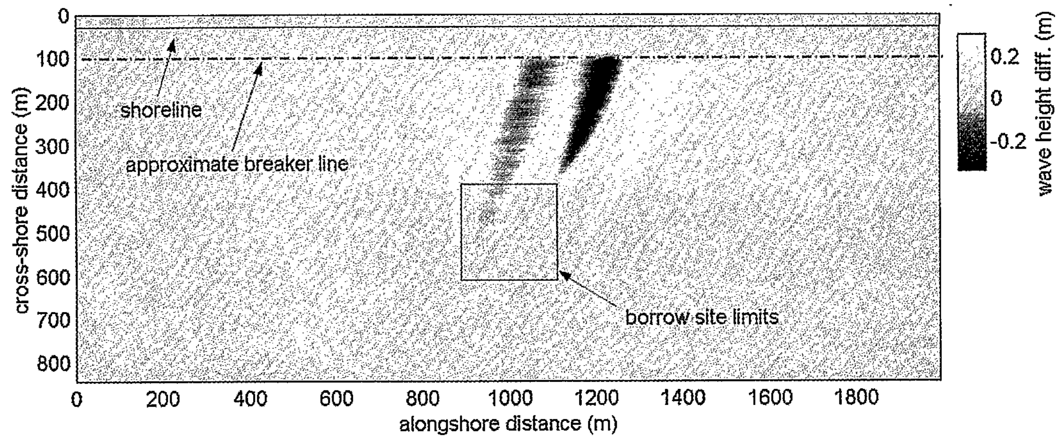


Figure 2. Shaded surface plot of wave height difference ($H_{post} - H_{existing}$) resulting from borrow site excavation (incident wave height of 1.2 m and period of 8 sec approaching the shoreline at 30 deg from shore-normal).

wave height resulting from borrow site excavation are of similar magnitude (approximately ±0.3 m). Waves propagating across the borrow site tend to refract toward shallow water along the edges, creating well-defined areas of wave energy focusing (increase in wave heights) landward of the borrow site. Due to the proximity of this borrow site to the beach, its influence on nearshore wave processes is more pronounced than for a sand borrow site further offshore. However, the nearshore location of the borrow site creates a rather limited longshore region of influence.

Nearshore Sediment Transport Patterns

Generally, beach shape is governed by relatively short-term events, such as severe storms. Large volumes of sand are eroded from the beach face and deposited nearshore during storm events. However, much of this material is recovered over longer time scales as lower energy waves move sand landward, causing the beach face to accrete. Seasonal trends in wave climate influence cross-shore sediment transport as well. Typically, large winter waves erode the beach face and mild summer waves build the beach. Because beach shape is dynamic, the best estimate of a typical profile is the stable beach shape that forms when exposed to average wave conditions.

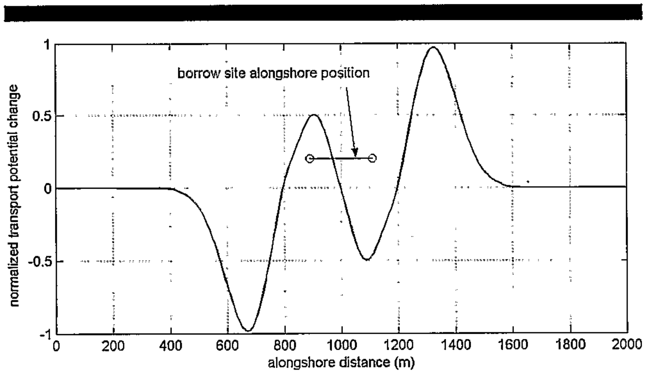


Figure 3. Change in computed longshore sediment transport potential for idealized borrow site.

Although the influence of borrow site excavation on the wave field is a critical step in evaluating the physical effects associated with sand mining, an evaluation of wave field alterations alone does not directly provide information needed to assess potential impacts to the shoreline (*i.e.,* changes in sediment transport patterns). Calculation of longshore sediment transport potential for a series of wave cases provides a method for determining the extent and magnitude of alterations to nearshore processes. For the idealized borrow site (see Figure 1), a curve representing the annualized sediment transport potential along this model shoreline was generated (Figure 3). Transport values were computed using modifications to the CERC formula (*e.g.,* BODGE and KRAUS, 1991) proposed by KAMPHUIS (1990). The plot indicates that peak transport rates would increase to a maximum value at an alongshore distance of approximately 350 m from the center of the borrow site. These increases in sediment transport potential directed away from the borrow site are a result of wave focusing. In contrast, the small peaks in sediment transport potential between the two large peaks result from the shadowing of the borrow site created by wave condition combinations. For example, waves propagating over the borrow site from the right (15° and 30° wave conditions) create a shadow zone along the shoreline that is centered slightly to the left of the borrow site. This shadow zone is characterized by a decrease in left-directed sediment transport. Therefore, the overall effect is to create an increase in net right-directed (left-to-right) transport.

By computing the change in sediment transport potential over the shoreline distance (δQ/δy, where Q is the longshore sediment transport and y is the longshore coordinate), a normalized curve of anticipated shoreline change resulting from excavation of an offshore borrow site can be developed. Figure 4 illustrates normalized shoreline change resulting from wave conditions presented above. Due to wave focusing

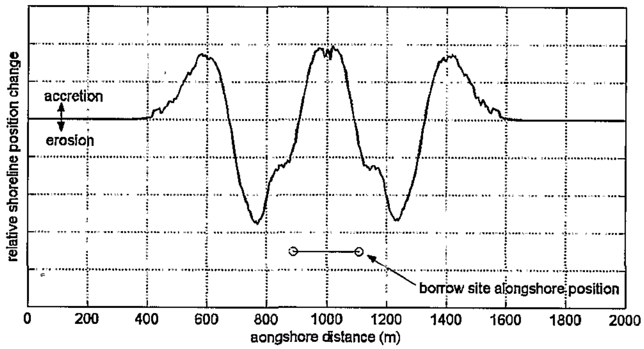


Figure 4. Computed cross-shore change in shoreline position based on modifications to longshore sediment transport potential by idealized borrow site.

caused by the borrow site configuration, increased erosion occurs along the shoreline on either side of the borrow site. Sand eroded from these two areas feeds the central shadow zone, as well as shoreline regions further from the borrow site.

DETERMINING SIGNIFICANCE OF BORROW SITE IMPACTS

As previously stated, calculated longshore sediment transport potential for a series of wave cases provides a method for determining the extent and magnitude of alterations to nearshore processes, but not the significance of changes for a particular coastline. For coastlines that experience large inter-annual variations in incident wave energy, alterations in the direction and quantity of longshore sediment transport will be highly variable as well. Therefore, a relatively large alteration in sediment transport, attributed to a proposed offshore sand mining project, may not be resolved in the observed shoreline change record due to high natural variability in the wave climate. For a shoreline site with a limited range of wave conditions (*e.g.,* a site dominated by ocean swell generated from a narrow direction band), alterations in natural sediment transport processes from proposed offshore dredging activities may be relatively large compared with natural variability. In the present study, a method based on historical wave climate variations, as well as local wave climate changes directly attributed to borrow site excavation, was developed to determine appropriate criteria for assessing the significance of alterations in longshore sediment transport resulting from dredging at offshore borrow sites.

Methods for Evaluating Borrow Site Impacts

One standard method for evaluating borrow site impacts is to perform wave and sediment transport modeling. Information developed from these modeling efforts is used to quantify potential physical environmental impacts associated with dredging activities. Although changes in sediment transport potential and wave energy flux associated with re-direction of waves generally are used as impact evaluation criteria, determining acceptable limits for these impacts is not a straightforward process. Existing methodologies have described alterations to the wave field at various locations (*e.g.,* directly landward of the borrow site, at a fixed reference line, at the breaker line; BASCO, 1999), but the shoreline or breaker line appear to be most appropriate. In this manner, calculated longshore transport rates (based on wave modeling results) can be validated based on evaluation of observed shoreline change.

During 1999 and 2000, the U.S. Minerals Management Service (MMS) employed two different techniques for determining the significance of borrow site impacts associated with nearshore wave transformation. BASCO (1999) developed a statistical approach to evaluate changes in wave climate at a pre-defined offshore reference line, as well as a method for determining the statistical significance of impacts. Although this method incorporates spectral wave modeling results and is statistically sound, it requires arbitrary user-defined limits. For example, rejection of the borrow site was based on greater than 50% of the reference line experiencing significant wave climate modifications. The 50% modification criteria and the length of the reference line are based on the user's judgment rather than scientific principles.

For borrow site studies in Alabama (BYRNES *et al.,* 1999) and New Jersey (BYRNES *et al.,* 2000), the significance of borrow site impacts was evaluated relative to potential error estimates associated with wave height and direction (ROSATI and KRAUS, 1991). Although use of wave information uncertainties offers a simple tool to address potential shoreline response to borrow site dredging, it also contains shortcomings. The method indicates the potential errors in wave information; however, it does not evaluate potential errors directly associated with the predictive wave models. If the same offshore wave field is defined for existing and post-dredging conditions, the error associated with wave measurements (direction and wave height) may not be the most appropriate indicator of borrow site impacts. It was concluded that if percent changes in longshore sediment transport caused by offshore sand mining were less than the percent error determined for wave height/direction estimates, the impact was insignificant.

Although the above methodologies provide reasonable quantitative estimates of significance associated with offshore sand mining, a new methodology for evaluating borrow site impacts that incorporates spatial and temporal changes in the wave field was developed. All three approaches use site-specific wave analyses as the basis for quantifying potential alterations to nearshore processes. However, the spatial and temporal variation method incorporates natural, site-specific variability in wave climate as a basis for determining significance.

Spatial and Temporal Variations Approach

Spatial (longshore) and temporal variations in local wave climate were determined for specific borrow sites to judge the significance of modeled impacts relative to site-specific wave characteristics. A shoreline that experiences a wide variety of wave conditions from year to year also experiences large

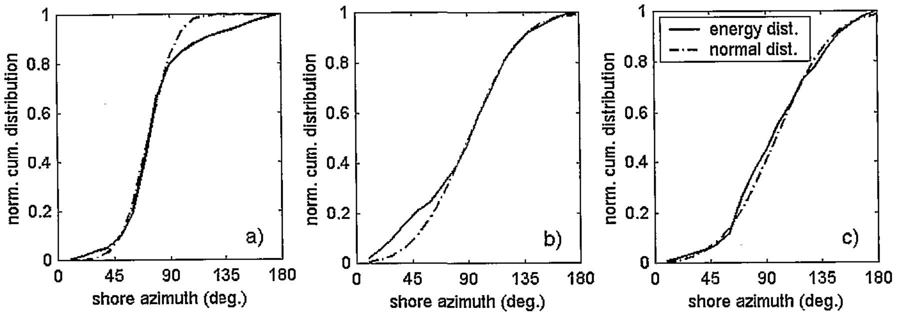


Figure 5. Comparisons of cumulative distributions of wave energy from three WIS stations located at a) Station 67, offshore New Jersey; b) Station 56, offshore North Carolina; and c) Station 14, offshore Florida. Normalized energy distributions based on wave approach angle to the shoreline (solid line) are plotted against normal distributions (dash-dot line) determined for each data set.

variability in sediment transport rates. Thus, the level of acceptable borrow site impacts would be relatively high. Conversely, a shoreline that experiences a limited range of wave conditions cannot accept the same level of borrow site impacts. Because the natural variability in inter-annual shoreline movements change along the coast, certain portions of the shoreline will be more tolerant of alterations to the wave climate and associated sediment transport patterns.

The significance determination method developed for this study relies on similar wave modeling results as those required for previous studies. Wave modeling is performed for several separate one-year periods to determine the characteristic inter-annual sediment transport variability along a shoreline. In this manner, temporal variations in wave climate are considered relative to long-term average conditions. Therefore, wave data records of adequate length (*i.e.,* cover several years) are required for a statistically significant analysis. For the east coast of the U.S., the Wave Information Study (WIS; HUBERTZ *et al.,* 1993) hindcasts of the U.S. Army Corps of Engineers (USACE) provided data records of appropriate length for use with the proposed method at several convenient offshore locations. If available, other sources of long-term wave data (*e.g.,* buoy data) could be used. In this study, wave modeling was performed at three locations for the entire 20-year wave hindcast time series and for 20 one-year blocks of the wave record. From these wave model runs, sediment transport potential curves were derived for average annual conditions (based on the full 20-year WIS record) and each one-year period (based on the 20 one-year wave records parsed from the full record). Based on this information, the average and standard deviation in calculated longshore sediment transport potential is determined every 200 m along the shoreline.

Assuming the temporal component of sediment transport potential is normally distributed across all approach angles to a shoreline, the suggested criterion for accepting or rejecting a potential borrow site is based on a range of one-half standard deviation ($\pm 0.5\sigma$) about the mean (μ). This normal distribution simplifying assumption is based on comparisons relative to the distribution of wave energy approaching a shoreline. Figure 5 illustrates this comparison for three wave hindcast stations on the U.S. East Coast. The cumulative wave energy distribution by incident wave direction for each station is plotted with the normal distribution determined for each location. The comparison shows a reasonable fit for each of the three areas. If any portion of the sediment transport potential curve associated with a sand mining project exceeds $\pm 0.5\sigma$ of the natural temporal variability about the sediment transport potential determined for existing (pre-dredging) conditions, the site would be rejected.

One standard deviation (σ) incorporates approximately 68% of the variability of a random variable, and $\pm$ 0.5σ about the mean incorporates approximately 38% of the variability. Therefore, for σ determined from 20 one-year model runs, there is a 62% chance that the mean transport for any given year will fall outside the $\pm 0.5\sigma$ envelope about the mean, and an 85% chance of falling outside this envelope during any two-year period. The envelope provides a basis for judging the impacts of a borrow site relative to natural variability of the sediment transport climate along a coastline. Because there is a greater than 50% chance that the transport computed for a particular year will fall outside of the $\pm 0.5\sigma$ envelope about the mean, impacts determined for a particular borrow site that fall within this envelope likely will be indistinguishable from observed natural variations. For this reason, sites with large natural variation in wave climate and associated sediment transport potential could sustain greater impacts associated with an offshore sand mining project.

The initial application of this method (KELLEY *et al.,* 2001) used 1σ as the significance criterion, based on splitting the 20-year wave-hindcast record into five four-year periods, as opposed to 20 individual years for the present criterion. The standard deviation of transport computed using the 20-year record divided into five four-year periods is approximately 80% of 1σ determined for 20 individual one-year model runs. Therefore, the 0.5σ envelope was chosen because the $0.5\sigma+\mu$ level has an associated probability that is approximately 80% of the $1\sigma+\mu$ level, making the two significance envelopes roughly equivalent.

To ensure that spectral wave modeling and associated longshore sediment transport potential could be applied effectively to evaluate long-term alterations to the littoral system, a comparison of model predictions with observed shoreline change was performed. This analysis provided a semi-quantitative method for determining whether (a) longshore wave-induced transport is responsible for observed shoreline change, and (b) long-term shoreline change trends are consistent with the shorter-term (20-year) sediment transport potential analyses. An evaluation of model output was performed using a comparison of computed gradients in sediment transport with historical shoreline change data. The basis for this comparison is the relationship between shoreline movement and the longshore gradient of sediment transport (*e.g.,* DEAN and DALRYMPLE, 2002). Simply expressed, this relationship is

$$\frac{\partial Q}{\partial y} \propto \frac{\partial x}{\partial t} \tag{1}$$

where Q is sediment transport, y is alongshore distance, x is the cross-shore position of the shoreline, and t is time. A comparison of results should illustrate similar trends in long-term shoreline change and transport potential computed using wave conditions that represent long-term average conditions. Good general agreement between these two quantities would suggest that the transport potential model reasonably represents long-term coastal processes for a given area, and thus, the model's ability to predict the likely impacts that would result from offshore dredging.

As a management tool, this methodology provides several advantages over methods previously employed to assess the significance of borrow site impacts. First, observed long-term shoreline change is compared with computed longshore change in sediment transport potential. Close comparison between these two quantities indicates that longshore sediment transport potential calculations are appropriate for assessing long-term natural change. Therefore, this methodology has a model-independent component (observed shoreline change) used to ground truth model results. Second, the method is directly related to sediment transport potential and associated shoreline change. Therefore, impacts associated with borrow site excavation can be directly related to their potential influence on observed coastal processes (annualized variability in shoreline position). Third, site-specific temporal variability in wave climate and sediment transport potential is calculated as part of the methodology. For sites that show little natural variability in inter-annual wave climate, allowable coastal processes impacts associated with borrow site dredging similarly would be limited, and *vice versa.* In this manner, the inter-annual temporal component of the natural wave climate is a major component in determining impact significance. Finally, similar to methodologies incorporated in previous MMS studies, the longshore spatial distribution of borrow site impacts is considered. However, the allowable limit of longshore sediment transport variability is computed from the temporal component of the analysis. Therefore, the final results of this analysis provide a spatially-varying envelope of allowable impacts in addition to the modeled impacts directly associated with borrow site excavation. The methodology accounts for spatial and temporal variability in wave climate, as well as providing a defensible means of assessing significance of impacts relative to site-specific conditions.

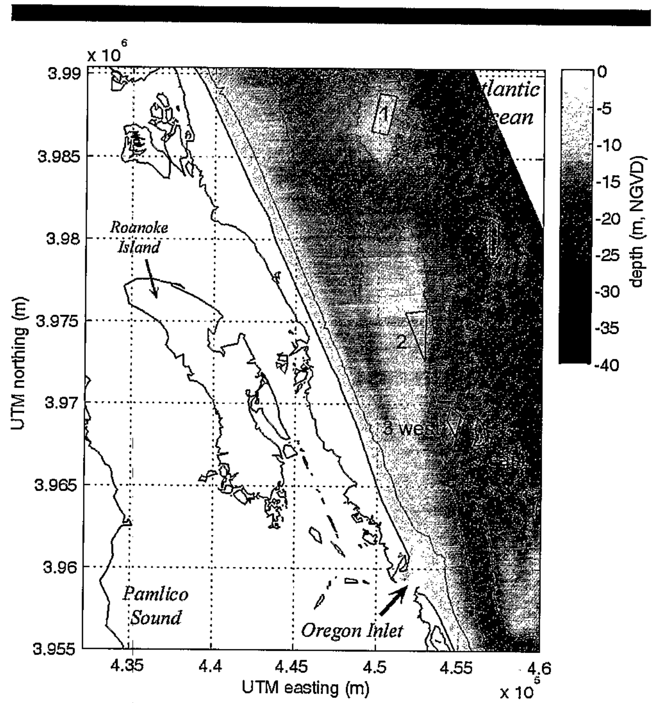


Figure 6. Bathymetry surface and borrow sites for offshore North Carolina. As designed, Site 1 is a 7.2 MCM borrow area, with a 3-m excavation depth; Site 2 has 5.8 MCM, with a 3-m excavation depth; Site 3 east has 1.4 MCM, with a 2-m excavation depth; Site 3 west has 2.5 MCM, with a 3-m excavation depth; and Site 4 has 2.3 MCM, with a 2-m excavation depth.

SEDIMENT TRANSPORT VARIATIONS AT PROPOSED BORROW SITES

The potential impacts of dredging at three proposed borrow sites offshore Dare County, North Carolina (Figure 6); offshore Martin County, Florida (Figure 7); and offshore Corsons Inlet, New Jersey (Figure 8) were evaluated within the context of natural variations in wave climate and sediment transport rates. For the North Carolina, Florida, and New Jersey examples, nearshore wave heights and directions along the shoreline landward of proposed borrow sites were estimated using the spectral wave model STWAVE to simulate the propagation of offshore waves to the shoreline. Offshore wave conditions used as input for wave modeling were derived from measured spectral wave data from offshore data buoys or hindcast simulation time series data from the USACE Wave Information Study (WIS; *e.g.,* HEMSLEY and BROOKS, 1989; and HUBERTZ *et al.,* 1993). In general, buoy data are the preferred source of wave information, because they represent actual offshore wave conditions rather than hindcast information derived from large-scale models. However, very few sites along the U.S. coast have wave measurement records of sufficient length to enable their use as a source of long-term information.

Offshore North Carolina

The shoreline north of Oregon Inlet in the North Carolina Outer Banks has been the focus of many previous monitoring

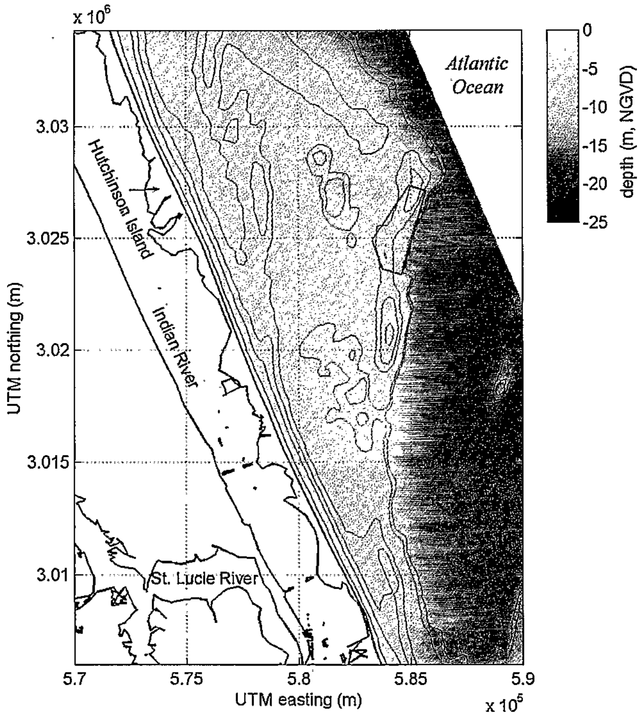


Figure 7. Bathymetry surface and borrow site for offshore Martin County, Florida. As designed, the site is a 24 MCM resource, with a 4.5-m excavation depth.

and modeling studies (*e.g.*, INMAN and DOLAN, 1989; LARSON, 1995; KIM, WRIGHT, and KIM, 1997; MILLER, 1999). In the present study, the potential impacts of five offshore borrow sites were investigated. Wave input conditions for simulations offshore North Carolina were developed using hindcast data from WIS station 56, located approximately 33 km northeast of Bodie Island, NC (HUBERTZ *et al.*, 1993). This WIS record covers a 20-year period from January 1976 to December 1995.

Historical shoreline change analysis provides a without-project assessment of shoreline response for comparison with predicted changes in wave-energy focusing at the shoreline resulting from potential offshore sand dredging activities. Because continuous measurements of historical shoreline change are available at 50-m alongshore intervals (see BYRNES *et al.*, 2003), model results (wave and sediment transport) at discreet intervals along the coast can be compared with historical data to develop process-response relationships for evaluating potential impacts. Shoreline data covering the periods 1849 to 1980 for Dare County, North Carolina were used to quantify trends. Methods for compiling and analyzing historical data sets are described in BYRNES and HILAND (1994). Alongshore variations in sediment transport were determined from computed values of transport potential for each shoreline for modeled existing conditions.

Trends in shoreline change generally agree with modeled transport gradients for the North Carolina coast north of Oregon Inlet (Figure 9). Results of both analyses illustrate a stable to erosional shoreline, with an area of maximum erosion between 5 and 7 km north of Oregon Inlet. For the modeled transport gradient, there is an area of accretion located approximately 3 km north of the point of maximum erosion that is not indicated in the shoreline change analysis. This may be due to a lack of detailed nearshore bathymetry data for a 2 km section of coastline at this location. Bathymetry data used for developing the model grid was from the U.S. National Ocean Service (NOS) Geophysical Data System (GEODAS) database (NOS, 1998), but supplemental data digitized from a National Oceanic and Atmospheric Administration (NOAA) navigational chart were required in the area north of the inlet. Therefore, the bathymetry data in this area does not have a high level of detail as is available in the data used for adjacent sections of coast, and may affect the model results.

An exact match between the gradient in sediment transport potential and measured shoreline change was not expected due to the differing time scales of the two analysis techniques (several decades for shoreline change and 20 years for sediment transport potential). Significant migration of Oregon Inlet also may be responsible for some of the differences between observed and modeled shoreline change trends, where the peak in erosion likely has migrated south with the inlet. Therefore, the peak erosion area determined from the gradient of modeled transport potential, based on 20 years of recent wave information, may be more representative of present conditions than long-term shoreline change (based on more than 100 years of shoreline data). Overall, good agreement exists between observed shoreline change and longshore gradient in modeled transport potential. Minor differences between the two methods, especially in the region of maximum erosion, likely are due to long-term alterations (spanning several decades) in shoreline position and the historical migration of Oregon Inlet.

In Figure 10, the computed change in transport potential for the two modeled scenarios (where sites 3 east and 3 west were modeled alternately with sites 1, 2, and 4) falls within the $\pm 0.5\sigma$ significance envelope determined for this shoreline reach. Therefore, according to the impact significance analysis, the modeled borrow site configurations are acceptable without any additional stipulations. It is likely that if sites 3 east and 3 west were dredged at the same time as the other three sites, the resulting change in computed sediment transport potential would exceed the 0.5σ significance envelope. If the impacts did fall outside the envelope, a redesign of the borrow site configuration would be required to minimize the impact.

Offshore Eastern Florida

Results from the analysis of a single large borrow site offshore the east coast of Florida are shown in Figure 11. This proposed site is located approximately 5 km offshore, approximately 17 km north of St. Lucie Inlet. The resource site was identified to contain approximately 24 million cubic meters (MCM) of sand, with an excavation depth of 4.5 m (15 ft). Analyses of potential changes due to dredging at this site were conducted in a similar fashion as the previous analyses

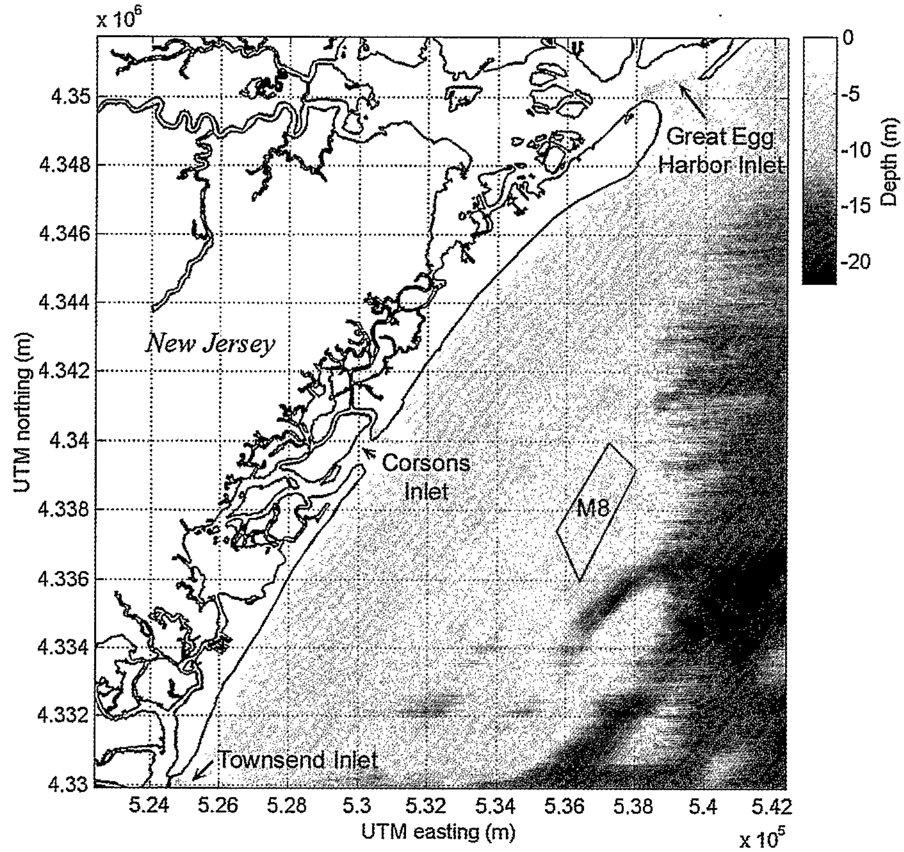


Figure 8. Bathymetry surface and borrow site limits for offshore New Jersey.

presented for offshore North Carolina. Waves from WIS station 14 (HUBERTZ *et al.,* 1993) were used as input conditions for STWAVE model runs developed for this area. The $\pm0.5\sigma$ maximum influence envelope determined for this shoreline, along with the change in sediment transport potential resulting from dredging the borrow site, is shown in Figure 11. Unlike offshore North Carolina, the significance envelope is exceeded in an area updrift of the borrow site and nearly exceeded in an area downdrift of the borrow site. Because the resulting changes to longshore transport are determined to be greater than the allowable envelope for an approximate 2-km length of shoreline, this site would be rejected and would require redesign to reduce potential adverse modifications to the sediment transport regime. Additional model runs for this site indicated that an excavation depth of approximately 2 m would bring the transport variability caused by the borrow site within the $0.5\sigma+\mu$ envelope. Therefore, an approximate 12 MCM excavation at this site would be deemed acceptable based on potential impacts associated with coastal sediment transport processes.

Multiple Dredging Events Offshore New Jersey

As an example of evaluating potential cumulative effects associated with multiple dredging events at a single borrow site, wave and sediment transport modeling results were analyzed for multiple dredging excavation depths at Site M8, located approximately 7 km seaward of Corsons Inlet, New Jersey. This analysis applied the initial method for evaluating impacts, where the 20-year wave-hindcast record was split into five four-year periods, rather than 20 individual years. As described previously, the significance envelope resulting from this analysis technique is roughly equivalent to the $0.5\sigma+\mu$ envelope developed from splitting the 20-year wave hindcast record into individual years. Waves from WIS station 67 (HUBERTZ *et al.,* 1993) were used as input conditions for STWAVE model runs. The $\pm1\sigma$ maximum influence envelope determined for this area, along with changes in sediment transport potential resulting from a series of dredging depths at Site M8, are illustrated in Figure 12.

As the borrow site is excavated to greater depths (see Figure 12), the impact it has on wave-induced sediment transport potential along the shoreline increases. Exploring a range of reasonable excavation depths provides site-specific information regarding anticipated increase in impacts relative to dredging depth. Because of the proximity of the site to shore and its relatively large perimeter, deep excavations at Site M8 would have pronounced effects on modeled sediment transport patterns at the shoreline. Model runs were

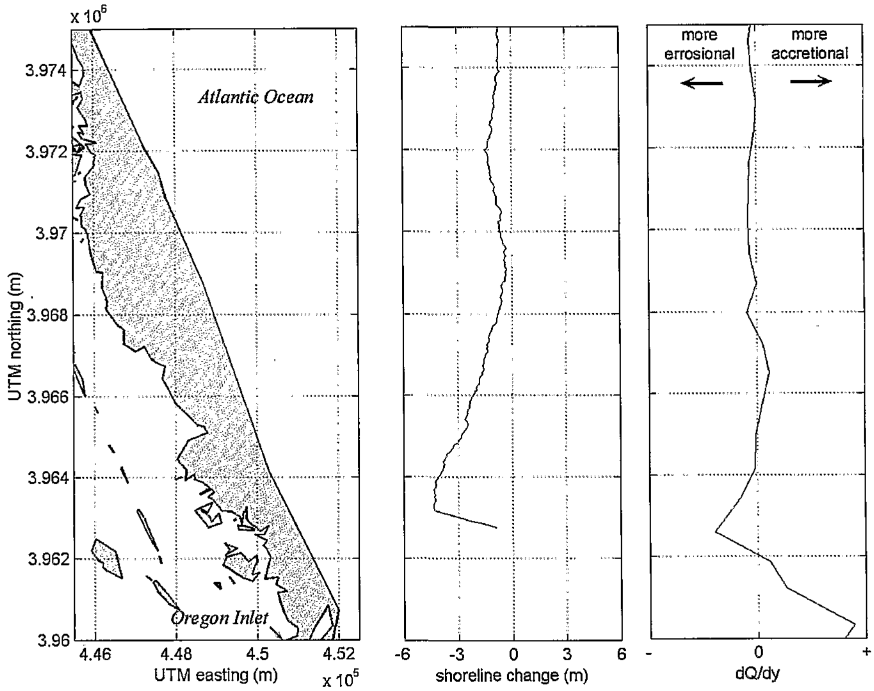


Figure 9. Comparison of historical shoreline change and gradient of modeled transport potential (δQ/δy) for the North Carolina shoreline.

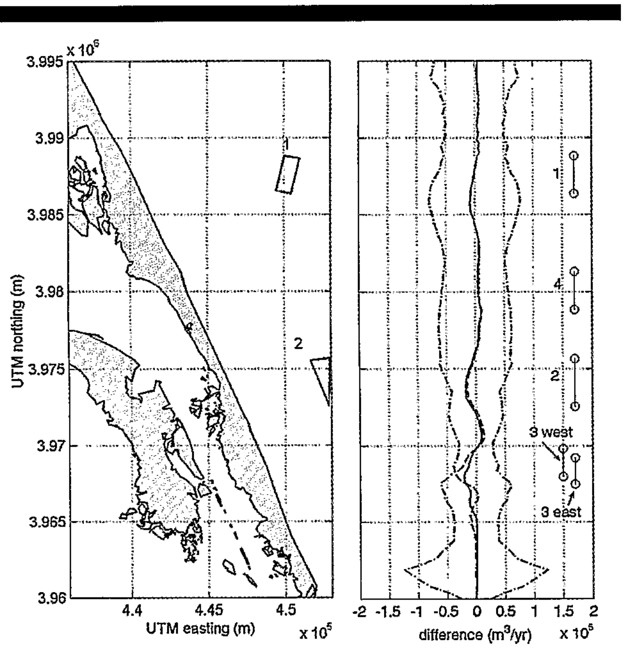


Figure 10. Plot of transport potential difference between existing and post-dredging conditions, with the $\pm 0.5\sigma$ maximum influence envelope (dash-dot line), for borrow sites located offshore North Carolina. The plot shows change in transport for Sites 1, 2, and 4, modeled with 3 east (solid black line) and 3 west (dashed line), separately. The longshore extent of each borrow site also is indicated. A positive difference in sediment transport potential is defined as an increase in north-directed transport.

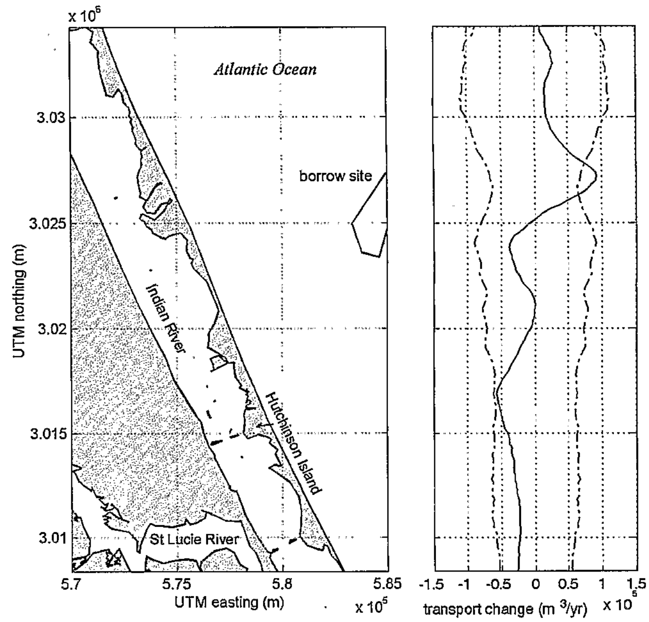


Figure 11. Plot of transport potential difference between existing and post-dredging conditions (solid black line), with the $\pm 0.5\sigma$ maximum influence envelope (dash-dot line), for a single 24 MCM borrow site located approximately 5 km offshore Martin County, Florida. A positive difference in sediment transport potential is defined as an increase in north-directed transport potential.

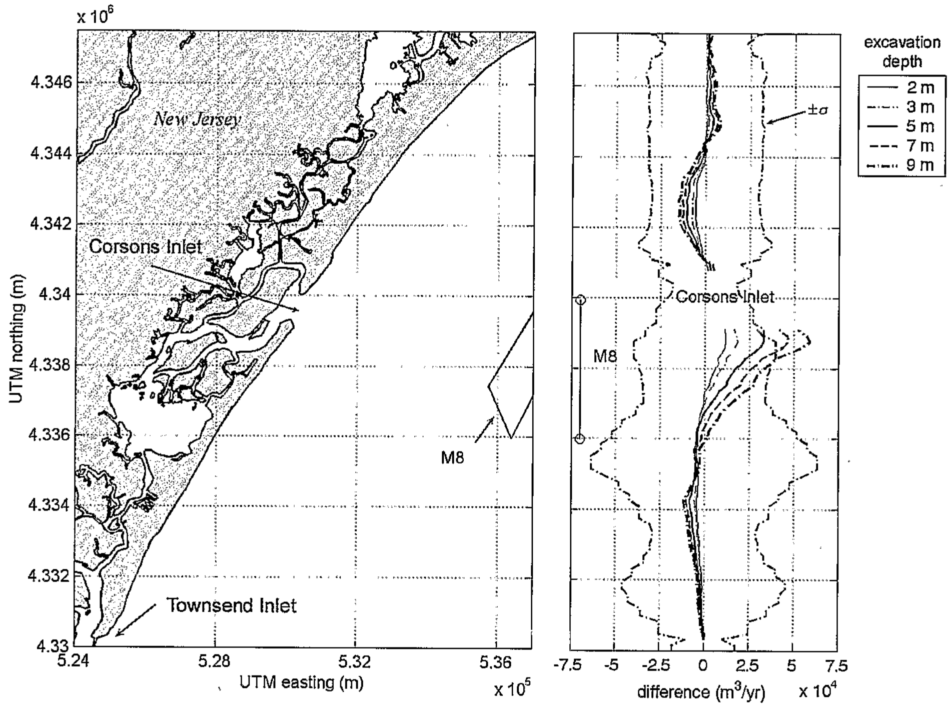


Figure 12. Plot of change in sediment transport potential computed for five excavated depths at Site M8, offshore Corsons Inlet, New Jersey. The indicated dash-dot envelope represents the maximum transport influence that is allowed by the impact significance criterion, or $\pm 1\sigma$ about the mean sediment transport potential for this case.

made for 2, 3, 5, 7, and 9 m excavation depths. The resulting change in sediment transport potential at the shoreline associated with each of these model scenarios is shown in Figure 12. Included with the plot of transport difference is the envelope of maximum change as defined by the impact significance criterion. Based on this information, excavation depths greater than 5 m would not be acceptable for this site, as the allowable limit criterion is exceeded along a portion of the shoreline south of Corsons Inlet.

DISCUSSION

To establish useful criteria for estimating impacts of sand mining on the nearshore littoral system, a comparison of sediment transport potential and long-term shoreline change was performed at each of three sites. The analysis provided a semi-quantitative method for determining whether longshore wave-induced transport was responsible for observed shoreline change and whether long-term shoreline change trends were consistent with the 20-year sediment transport potential analysis. In general, the comparison indicated that the longshore gradient in computed wave-induced sediment transport followed similar trends as observed long-term shoreline change. Exceptions occurred at locations where STWAVE modeling was not applicable (areas where wave diffraction was important) or where wave-induced processes may not control sediment transport rates (in the vicinity of tidal inlets).

Because modeled longshore gradients in sediment transport potential generally matched observed shoreline change trends, wave and sediment transport modeling provided a reasonable basis for evaluating long-term shoreline response associated with offshore sand mining. Because the natural variability in inter-annual shoreline migration changes along the coast, certain portions of a shoreline will be more tolerant of alterations to the wave climate and associated sediment transport. The method used to evaluate borrow site impacts provided a reliable technique for developing acceptable site-specific limits associated with changes in sediment transport potential.

Based on site-specific analyses for each of the three sites, an evaluation of impacts to the local wave and sediment transport regime ranged from insignificant to unacceptable. For offshore North Carolina, the two modeling scenarios indicated that the influence of excavating four borrow sites with a combined sand volume of between 16.7 and 17.8 MCM was deemed acceptable based on the significance criterion. As expected, excavation of Site 3 west had a greater impact on nearshore sediment transport patterns due to the large sand extraction volume, its proximity to the shoreline, and the relatively shallow water depths. Because it has been suggested that borrow sites located in close proximity illustrate additive impacts (KELLEY *et al.,* 2001), the influence of multiple sites on sediment transport along a coastline is an additive effect, rather than a more complicated non-linear effect or amplification. Therefore, it is likely that excavation of Site 3 east and Site 3 west would cause changes to the transport potential to fall outside the significance envelope, and the excavation plan would be considered unacceptable.

Due to the relatively shallow water at the borrow site offshore Martin County, Florida (approximately 8 to 10 m), a 4.5 m excavation creates a pronounced effect on nearshore sediment transport processes. The maximum influence of this borrow site causes a reduction in net south-directed transport of nearly 100,000 m^3/year. As a result of limited variability in incident wave climate, the influence of the 24 MCM sand mining scenario exceeds the allowable $\pm 0.5\sigma$ limit about the mean natural sediment transport potential (μ). By reducing the excavation depth to less than 2.3 m (an excavation volume of approximately 12 MCM), the influence of borrow site excavation on sediment transport potential falls within the significance criterion boundary. It is likely that re-orientation of the borrow site and/or expansion of the borrow site surface area with a decreased excavation depth also will decrease the impact to sediment transport process.

The quantitative methodology for assessing borrow site impacts can be used to determine allowable excavation depths. An example of this analysis was shown for the southern New Jersey coast, where the influence of dredging Site M8 to depths ranging from 2 to 9 m was evaluated. Due to the relatively narrow variability in wave-induced sediment transport potential (one standard deviation about the mean of approximately $\pm$40,000 m^3/year), it was determined that the maximum allowable excavation depth for this site is about 5 m. Although variability in sand transport potential along the shoreline of Martin County, Florida is significantly larger than off the coast of southern New Jersey (allowable limits about the mean of approximately $\pm$75,000 m^3/year compared to $\pm$40,000 m^3/year), excavation of the shallow shoal offshore Florida has a larger influence on wave refraction and associated sediment transport potential.

CONCLUSIONS

A quantitative method for evaluating the significance of changes to coastal processes that result from offshore sand mining is introduced and applied at three borrow site locations along the east coast of the U.S. As the basis for this method, temporal variations in wave climate and longshore sediment transport are evaluated relative to average annual conditions. The suggested criterion for accepting or rejecting a potential borrow site is based on a range of one-half standard deviation ($\pm 0.5\sigma$) about the mean. If any portion of the sediment transport potential curve associated with a sand mining project exceeds $\pm 0.5\sigma$ of the natural temporal variability about the sediment transport potential determined for existing conditions, the site would be rejected.

Sediment transport changes that fall within this envelope will be indistinguishable from observed natural variations. For this reason, sites with large natural variation in wave climate and associated sediment transport potential could sustain greater changes associated with an offshore sand mining project.

As a coastal management tool, this analysis procedure provides several advantages over methods previously employed to assess the significance of borrow site impacts. First, it has a model-independent component (measured shoreline change) with which to validate model results. Second, impacts associated with borrow site excavation can be directly related to their potential influence on observed coastal processes. Third, site-specific temporal variability in wave climate and sediment transport potential is calculated as part of the methodology. Finally, the method accounts for spatial and temporal variability in wave climate, and provides a means of assessing significance of changes relative to site-specific conditions.

LITERATURE CITED

BASCO, D.R., 1999. *A methodology and criteria to assess the impacts of sand volume removed in federal waters on the nearshore wave climate.* Coastal Engineering Center, Old Dominion University, Norfolk, VA.

BODGE, K.R; and KRAUS, N.C., 1991. Critical examination of longshore transport rate magnitude. *Proceedings, Coastal Sediments '91* (ASCE), pp 139–155.

BOOIJ, N.; RIS, R.C., and HOLTHUIJSEN, L.H. 1999. A third-generation wave model for coastal regions, Part I, Model description and validation. *Journal Geographical Research,* C4(104), 7649–7666.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; KELLEY, S.W.; SNYDER, D.B.; CÔTÉ, J.M.; RAMSEY, J.S.; THIBAUT, T.D.; PHILLIPS, N.W., and WOOD, J.D., 2003. *Collection of Environmental Data Within Sand Resource Areas Offshore North Carolina and the Implications of Sand Removal for Coastal and Beach Restoration.* U.S. Department of the Interior, Minerals Management Service, Leasing Division, Sand and Gravel Unit, Herndon, VA. OCS Report MMS 2000-056, Volume I: Main Text 257 pp. + Volume II: Appendices 70p.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; RAMSEY, J.S.; SNYDER D.B.; BOSMA, K.F.; WOOD, J.D.; THIBAUT, T.D., and PHILLIPS, N.W., 1999. *Environmental Study of Identified Sand Resource Areas Offshore Alabama: Volume I: Main Text, Volume II: Appendices.* U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 99-0052, Volume I: Main Text 326 p. + Volume II: Appendices 132p.

BYRNES, M.R.; HAMMER, R.M.; VITTOR, B.A.; RAMSEY, J.S.; SNYDER, D.B.; WOOD, J.D.; BOSMA, K.F.; THIBAUT, T.D., and PHILLIPS, N.W., 2000. *Environmental Survey of Potential Sand Resource Sites: Offshore New Jersey.* U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 2000-052, Volume I: Main Text 380 p. + Volume II: Appendices 291p.

BYRNES, M.R. and HILAND, M.W., 1994. Compilation and Analysis of Shoreline and Bathymetry Data (Appendix B). *In*: KRAUS, N.C.; GORMAN, L.T., and POPE, J. (eds.), *Kings Bay Coastal and Estuarine Monitoring and Evaluation Program: Coastal Studies.* U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Technical Report CERC-94-09, pp. B1–B89.

CHAWLA, A.; ÖZKAN-HALLER, H.T., and KIRBY, J.T., 1998. Spectral model for wave transformation over irregular bathymetry. *Journal of Waterway, Port, Coastal and Ocean Engineering,* 124, 189–198.

COMBE, A.J., III and SOILEAU, C.W., 1987. Behavior of Man-Made Beach and Dune Grand Isle, Louisiana. *Proceedings Coastal Sediments '87* (ASCE), pp. 1232–1242.

DEAN, R.G., 1977. *Equilibrium Beach Profiles: U.S. Atlantic and Gulf coasts.* University of Delaware, Department of Civil Engineering, Ocean Engineering Report No. 12.

DEAN, R.G. and DALRYMPLE, R.A., 2002. *Coastal Processes with Engineering Applications.* Cambridge University Press, Cambridge, UK.

FIELD, M.E. and DUANE, D.B., 1976. Post Pleistocene History of the United States Inner Continental Shelf: Significance to the Origin of Barrier Islands. *Geological Society of America Bulletin,* 87, 691–702.

HEMSLEY, J.M. and BROOKS, R.M., 1989. Waves for Coastal Design in the United States. *Journal of Coastal Research,* 5(4), 639–663.

HORIKAWA, K.; SASAKI, T., and SAKURAMOTA, H., 1977. Mathematical and Laboratory Models of Shoreline Changes Due to Dredged Holes. *Journal of Faculty of Engineering,* XXXIV(1), the University of Tokyo, Japan, pp. 47–57.

HUBERTZ, J.M.; BROOKS, R.M.; BRANDON, W.A., and TRACY, B.A., 1993. *Hindcast Wave Information for the US Atlantic Coast.* WIS Report 30(AD A356 321), U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

INMAN, D.L., and DOLAN, R., 1989. The Outer Banks of North Carolina: Budget of sediment and inlet dynamics along a migrating barrier system. *Journal of Coastal Research,* 5(2), 193–237.

KAMPHUIS, J.W., 1990. Alongshore sediment transport rate. *Proceedings 22nd Coastal Engineering Conference* (ASCE).

KIM, S.C.; WRIGHT, L.D., and KIM, B.O., 1997. The combined effects of synoptic-scale and local-scale meteorological events on bed stress and sediment transport on the inner shelf of the Middle Atlantic Bight. *Continental Shelf Research,* 17(4), 407–433.

KELLEY, S.W.; RAMSEY, J.S., and BYRNES M.R., 2001. *Numerical Modeling Evaluation of the Cumulative Physical Effects of Offshore Sand Dredging for Beach Nourishment.* U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 2001-098, 95 pp. + 106p. appendices.

LARSON, M., 1995. Model for decay of random waves in surf zone. *Journal of Waterway, Port, Coastal, and Ocean Engineering,* 121(1), 1–12.

MEISBURGER, E.P. and WILLIAMS, S.J., 1980. *Sand Resources on the Inner Continental Shelf of Cape May Region, New Jersey.* U.S. Army Corps of Engineers, Coastal Engineering Research Center, Miscellaneous Report 80-4, 40p.

MILLER, H.C., 1999. Field measurements of longshore sediment transport during storms. *Coastal Engineering,* 36(4), 301–321.

NATIONAL OCEAN SERVICE, 1998. Geophysical data system for hydrographic survey data. Version 4.0, National Ocean Service, Washington, DC.

ROSATI, J.D. and KRAUS, N.C., 1991. *Practical Considerations in Longshore Transport Calculations.* CETN II-24, U.S. Army Engineer Waterways Experiment Station, Coastal and Hydraulics Laboratory, Vicksburg, MS, 6p.

SMITH, S.J. and HARKINS, G.S., 1997. Numerical wave model Evaluations using laboratory data. *Proceedings Waves '97 Conference* (ASCE, Reston, Virginia).

WILLIAMS, S.J., 1987. *Geologic Framework and Sand Resources of Quaternary Deposits Offshore Virginia, Cape Henry to Virginia Beach.* U.S. Geological Survey, Open-File Report 87-667, 60p.

Journal of Coastal Research | 20 | 1 | 44–60 | West Palm Beach, Florida | Winter 2004

Potential Impacts of Sand Mining Offshore of Maryland and Delaware: Part 1—Impacts on Physical Oceanographic Processes

Jerome P.-Y. Maa†, Carl H. Hobbs, III†, S.C. Kim‡, and Eugene Wei§

†Virginia Institute of Marine Science
College of William and Mary
Gloucester Point, VA 23062, USA

‡Environmental Laboratory
ERDC
Corps of Engineers, US Army
Vicksburg, MS 39180, USA

§National Ocean Service
NOAA
Silver Spring, MD 20910, USA

ABSTRACT

MAA, J.P.-Y.; HOBBS, III, C.H.; KIM, S.C., and WEI, E., 2004. Potential impacts of sand mining offshore of Maryland and Delaware: part 1—impacts on physical oceanographic processes. *Journal of Coastal Research,* 20(1), 44–60. West Palm Beach (Florida), ISSN 0749-0208.

In an effort to assess the possible changes to physical oceanographic processes that might result from alteration of bathymetry as a result of dredging or sand mining, we evaluated the differences in the output of various numerical models run with the natural and hypothetical post-dredging bottom conditions. Fenwick and Isle of Wight Shoals offshore of the Delaware-Maryland border of the mid-Atlantic continental shelf served as the test site. We considered two dredging scenarios, a one-time removal of 2×10^6 m^3 of sand from each of two shoals and a cumulative removal of 24.4×10^6 m^3, but only the larger appeared significant.

The study of wave transformation processes relied upon a series of runs of the REF/DIF-1 model using sixty wave conditions selected from analysis of the records from a nearby, offshore wave gauge. The model was tuned and calibrated by comparing measured near-shore wave conditions with data calculated using the same measured offshore waves that generated the real near-shore conditions. The modeled, post-dredging data indicated an increase in wave height of up to a factor of two in the area between the dredged shoals and the shore and, in some locations, a lesser increase in breaking wave height and a decrease in breaking wave height modulation. The model results also may help explain the existing pattern of erosion and relative stability.

Application of the well-known SLOSH model (Sea, Lake, and Overland Surges from Hurricanes) for storm surge and POM (Princeton Ocean Model) for tidal currents indicates that the likely dredging related changes in those processes are negligible.

ADDITIONAL INDEX WORDS: *Dredging, wave transformation, tidal current, storm surge, shoreline responses, numerical simulation.*

INTRODUCTION

A well maintained beach can serve several purposes, *e.g.,* (1) reducing the rate of land loss, (2) providing a public recreational area, and (3) protecting valuable properties and infrastructure that are located near the coastline. Thus, a great deal of effort has been devoted to understanding the physical processes on the adjacent beach that might be changed by offshore sand mining. Among all possible physical processes, the following three may have a direct influence: waves that reach the coastline; local tidal currents; and storm surges that are responsible for raising the water level. The possible impacts on biological processes at the sand mining sites and beach nourishment sites were reported separately as part 2 in this JCR volume.

One can use several approaches, either separately or in combination, to protect an eroding beach. In the coastal sector near the Maryland–Delaware border, especially around Ocean City, Maryland, the beach has been nourished throughout the past two decades. It has become increasingly difficult to find terrestrial sources of good, beach-quality sand. Near shore submarine sources are limited and problematical. The continual loss of sand to shore normal and alongshore transport processes requires a reliable source of good quality sand for future nourishment.

Two offshore shoals, Fenwick Shoal and Isle of Wight Shoal (Figure 1), have been identified as potential sources for beach-quality sand (CUTTER *et al.,* 2000; HOBBS, 2002). Fenwick Shoal is approximately 10 km west of the Maryland–Delaware border. Isle of Wight Shoal is about 8 km south of Fenwick. There is concern that utilization of sand from these shoals may cause unwanted alterations to the shoreline, which may be near its dynamic equilibrium state. Sand mining at these two shoals definitely will alter the wave transformation processes which, depending upon the mining plan, may induce unfavorable consequences.

Understanding the possible changes in the shoreline resulting from dredging requires a comprehensive understanding of the wave climate, the wave transformation processes, the possible changes of wave transformation caused by changing the bathymetry, and the associated shoreline responses.

4 received and accepted in revision 6 June 2003.

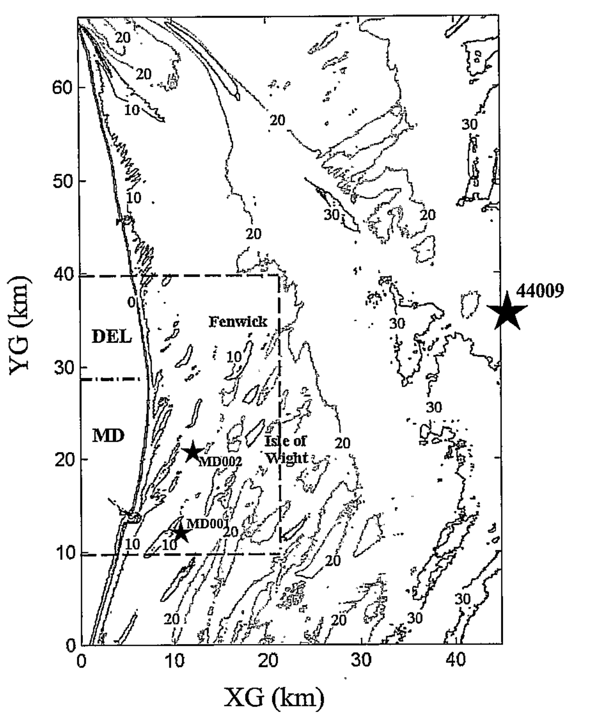


Figure 1. Bathymetrical contours (meter) of the entire computation domain. The computing results will be displayed for a much smaller display domain marked by the dashed lines. The relative locations of wave station 44009, MD001, MD002 are also marked.

In a study of a similar problem at Sandbridge Shoal, Virginia, MAA and HOBBS (1998) concluded that if sand taken from the shoal were limited on the order of 10^6 m^3, the impact on wave transformation would cause a less-than-five-percent change of local breaking wave height for the most severe sea condition (wave height = 6.2 m, period = 20 s) applied at the offshore. The five percent change is not significant because the change was determined using a wave transformation model (RCPWAVE) that is known to overestimate wave height near shore (MAA *et al.,* 2000). Thus, the actual change might be negligible small considering the overall accuracy of offshore wave conditions (*i.e.,* 5% in wave height, 1 second in wave period, and $\pm$ 5 degrees in wave direction, MEINDL and HAMILTON, 1992).

The foci of the present study are (1) determining if the possible impact resulting from a one-time sand mining event on the order of 2×10^6 m^3 of sand at each of the two shoals is acceptable and (2) estimating the possible alterations to waves resulting from removal of significantly more sand, on the order of 10^7 m^3.

In order to estimate the possible impact, a computational bathymetric grid system was established first, followed by a study of wave climate in this area. Wave data measured at offshore station 44009 (from 1986–1998) were used (Figure 1). Sixty wave conditions were selected to cover the majority of possible wave conditions that would be affected by altering the bathymetric condition, and the REF/DIF-1 wave transformation model was used to check the original wave height distribution in this study domain. For the one-time sand mining, we found that the possible change of wave transformation is negligibly small. Thus, further discussion of this scenario is omitted in this paper.

To find the possible impact of cumulative sand mining at the two sites, the same 60 offshore wave conditions were rerun with bathymetry altered to provide a total of 24.4×10^6 m^3 sand. Details on the modeled sand mining plan and the results on changing waves are given in this paper.

In addition to the analysis of the possible changes in wave transformation resulting from sand mining, possible changes to tidal currents and storm surge were also checked. By applying the suite of tidal constituents determined by analyzing a year long record obtained at Ocean City, Maryland and the same sets of bathymetric data used in the wave transformation studies to the Princeton Ocean Model (BLUMBERG and MELLOR, 1987), the possible alterations for tidal currents at maximum flood and ebb were identified. Similarly paired runs of the SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model (JELENIANSKI *et al.,* 1992) provided information on the possible alterations to storm surge.

BATHYMETRY

Bathymetric data sorted into one degree latitude-longitude domains were obtained from the NOAA Data Center. The data and the retrieving software were both provided on CD-ROM. An arbitrary and sufficiently large domain about 80 km in the east-west direction and about 100 km in the north-south direction was used for bathymetry data retrieval. The original coordinates of the data were latitude and longitude, which were transferred to the Maryland State Plane Coordinate System using the CORPSCON software from the Waterways Experiment Station, U.S. Army Corps of Engineers. Bathymetric data for inland waterways were removed, and a computing grid of 44.970 Km and 67.560 km (Figure 1) with uniform cell size (30 meters in XG-direction and 60 m in YG direction) was generated, where XG and YG stand for the X and Y direction of the computing Grid. Thus, the computing grid has 1500 and 1127 grid points in the XG and YG directions, respectively. The small cell size is needed for simulation of wave diffraction. The large computational domain is necessary to minimize the possible inaccurate boundary effects specified at the lateral boundaries for wave transformation simulation. For displaying the computation results, however, a much smaller domain (hereafter called the display domain) marked as the dashed line in Figure 1 is sufficient.

The coordinates of the origin of this computational grid are E561.000 km and N61.000 km in NAD83 Maryland State Plane Coordinate System, and YG is rotated 4.2 degrees from the Maryland State Plane Coordinates' North coordinate.

Two mining areas were selected at the two shoals (Figure 2 and Table 1) with a possible maximum sand removal of 24.4 $\times 10^6$ m^3 if a constant dredging depth of three meters is selected. This scenario represents a possible cumulative sand removal from the two shoals over 10 to 20 years. The selection of these two mining areas was arbitrary and was based on the geometry. It is suggested that it would be better to

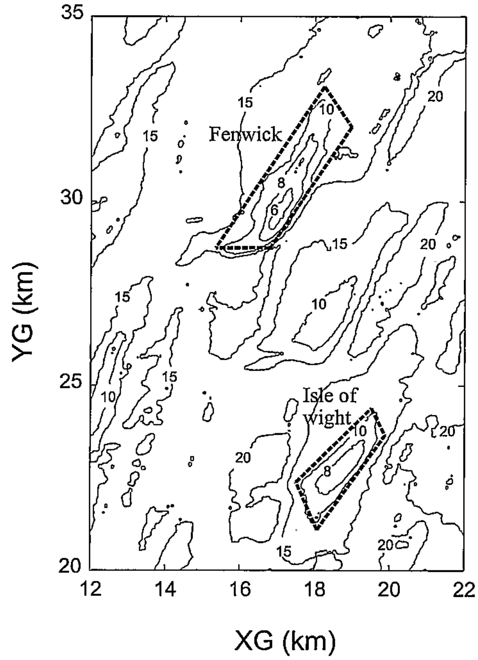


Figure 2. Detailed bathymetric contours (meter) at the vicinity of Fenwick and Isle of Wight Shoals. The modeled areas for sand mining for a total of 24 × 10^6 m^3 are marked as dashed polygons, and the coordinates are given in Table 1.

flatten a shoal rather than to create a depression on an otherwise flat area.

WAVE DATA

The National Data Buoy Center (NDBC) has a moored buoy station, 44009 (Lat. 38°27′49″ N, Long. 74°42′07″ W), located about 40 km offshore of the Ocean City at a water depth of 28 m. This station has collected non-directional wave spectrum information since May 1986 and directional wave spectrum information since 1993. All processed data were archived at the National Oceanic Data Center (NODC) in Washington, D.C. Because of the site's proximity (Figure 1), these wave data are used directly in this study.

Near shore, the U.S. Army Corps of Engineers had one wave station (MD001, Figure 1), north of Ocean City, Maryland (Lat. 38°24′00″ N, Long. 75°30′00″ W) from Oct. 1993 to Jan. 1998. The Corps also has another station, MD002 (Lat. 38°20′24″ N and Long. 75°04′12″ W), south of Ocean City. The water depth is 9 m at both stations. Wave measurements at these two near shore stations are directional wave distributions.

In this study, wave data at the two near shore stations are used for verifying the accuracy of calculated wave heights using the wave information (significant wave height, peak wave period, and peak wave direction) specified at the offshore boundary where station 44009 is located. For example, wave records from Nov. 1 to Nov. 30, 1997 at both stations 44009 and MD001 (Figure 3) show the differences in wave conditions between these two stations. For this period, the

Table 1. *Coordinates of the marked points for the modeled cumulative sand mining (in Maryland State Plane Coordinates, NAD83, meters).*

Item	Fenwick Shoal	Isle of Wight Shoal
Area	5.36 × 10^6 M^2	2.82 × 10^6 M^2
Volume	16 × 10^6 M^3	8.4 × 10^6 M^3
E (m)	578,406.0000	580,071.0630
N (m)	88,298.5469	81,889.3906
E (m)	581,607.3750	582,308.5630
N (m)	92,705.9219	83,820.7109
E (m)	582,123.0000	582,634.3130
N (m)	91,535.0156	83,205.1953
E (m)	579,939.2500	580,428.6250
N (m)	88,286.2266	80,750.1406

wave conditions are almost the same for MD001 and MD002. Notice that in this period the offshore wave height varies from less than 0.5 m to 5 m, which is a sufficient range for calibrating the wave transformation model selected.

Wave Statistical Analysis

The joint distribution of significant wave height and peak energy wave period for station 44009 reveal that the most frequently occurring wave has a period of 9 seconds and significant wave height of 0.6 meters. Wave height greater than 6 m is rare, occurring only a few times during the entire 13 years of observation (1986–1998) with a total duration of 46 hours which is about 0.04 percent of the record.

The available directional wave data (1993–1997) indicates that waves mainly come from the following 7 directions: SSE, SE, ESE, E, ENE, NE, and NNE (Figures 4 and 5). A few large waves came from NNW and NW, but were ignored in this study because they travel offshore away from the area of interest.

Assuming the available wave directional information represents the true wave direction distribution, we can regroup

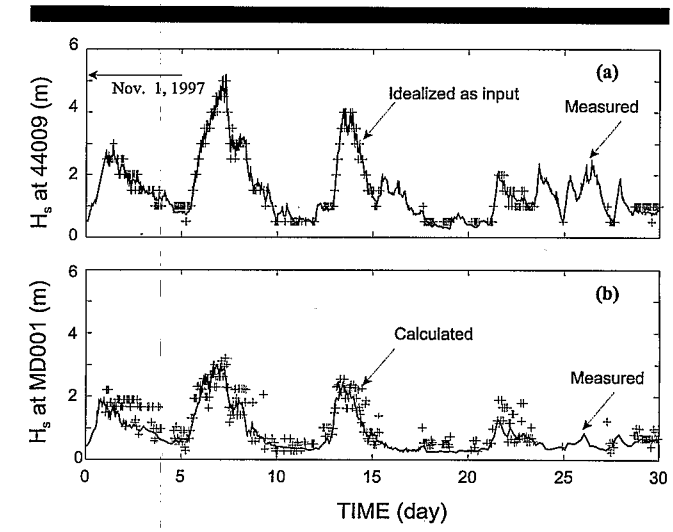


Figure 3. Verification of REF/DIF-1 wave transformation model. (a) The measured and specified idealized input wave conditions at station 44009, (b) The measured and calculated wave heights at MD001.

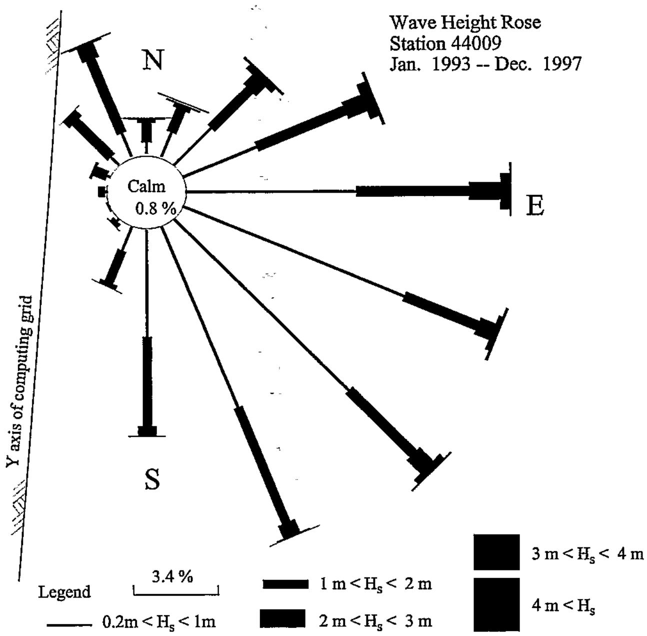


Figure 4. Significant wave height rose at station 44009. The scale of 3.4% occurrence is plotted in the legend.

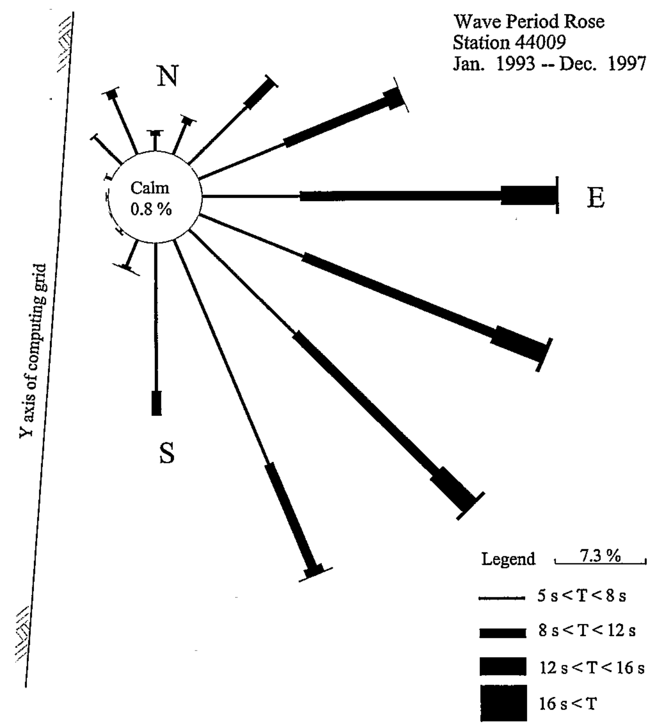


Figure 5. Peak energy wave period rose at station 44009. The scale of 7.3% occurrence is plotted in the legend.

the waves into bins for analyses. For practical and feasible computational purposes, we sorted wave height from 0.25 to 8 m with an interval of 0.5 m, wave period from 3 to 20 s at an interval of 2 s, and wave direction into 16 major directions. Using the above conditions for sorting, the joint probability distribution of wave height and period that occurred for the ENE direction is given in Table 2 as an example. Notice that wave conditions in the four major directions (ENE, E, ESE, SE) counted for more than 50 percent of all wave conditions, and only from the SE direction, wave period has reached 20 seconds.

Wave Height

Table 3 shows the annual maximum significant wave heights (H_s) that were observed at station 44009 from 1986 to 1998. The recorded maximum significant wave height (7.6 m with a peak wave period of 16.7 seconds, occurred on 1/04/92) during the 13 observational years suggests that the possible most severe sea can be rounded for a significant wave height of 8 m and wave period of 20 s. Notice that among the observed maximum H_s, only one is possibly induced by a hurricane (August 16, 1995). The famous "Halloween Storm" (also know as "the Perfect Storm") happened in late October 1991 did not produce the largest H_s in 1991.

Based on wave height, we suggested four categories (Table 4) of wave severity: The most severe sea (M) has a wave height of 8 m, severe sea (S) has a wave height of 6 m, rough

Table 2. *Height and period join distribution (in %) for waves coming from ENE (total 8.60%).*

H (m)	4s	6s	8s	10s	12s	14s	16s	>17s
0.5	0.1638	0.3545	0.3009	0.3515	0.3277	0.0596	0.0060	0
1.0	0.3128	0.9294	0.4737	0.5898	0.4975	0.0089	0.0	0
1.5	0.0834	0.5898	0.4290	0.5362	0.3634	0.0119	0.0	0
2.0	0	0.3426	0.3098	0.2800	0.1728	0.0149	0.0089	0
2.5	0	0.0715	0.1430	0.0983	0.0626	0.0119	0	0
3.0	0	0.0060	0.1370	0.1341	0.0626	0	0	0
3.5	0	0.0030	0.0715	0.0745	0.0387	0	0	0
4.0	0	0	0.0298	0.0298	0.0060	0	0	0
4.5	0	0	0.0030	0.0268	0.0030	0	0	0
5.0	0	0	0.0030	0.0060	0.0030	0	0	0
5.5	0	0	0	0.0030	0.0030	0	0	0
6.0	0	0	0	0.0119	0.0	0	0	0
6.5	0	0	0	0	0.0089	0	0	0
7.0	0	0	0	0	0.0030	0	0	0
Σ		2.1419	1.5522	0.1072	0.0149	0		

Table 3. *Observed annual maximum significant waves.*

Date	Time	H_Significant (m)	T_Peak (sec)
12/03/86	08:00	4.7	12.5
1/02/87	08:00	5.9	11.1
4/08/88	04:00	4.3	9.1
2/24/89	17:00	5.4	11.1
10/26/90	18:00	4.6	10.0
11/10/91	03:00	4.9	9.1
1/04/92	11:00	7.6	16.7
10/27/93	12:50	4.6	11.1
12/23/94	19:50	5.4	12.5
8/16/95	10:50	4.2	14.3
1/08/96	04:00	7.0	11.1
11/08/97	06:00	5.2	11.1
2/05/98	16:00	7.4	12.5

sea (R) has a wave height of 4 m, and Northeaster (N) has a wave height of 2 m.

Wave Direction

The available directional wave data indicate that large waves can come from the following seven directions: NNE, NE, ENE, E, ESE, SE, and SSE (Figure 4). Large waves coming from NNE to ENE are mainly caused by northeasters. Long period waves from these two directions, however, are relatively rare (Figure 5). Most of the waves from the NNE and NE are less than 8 sec. Long period waves mainly come from the ENE, E, ESE, and SE because of the long fetch. Thus, waves coming from ENE, E, ESE, and SE are selected as the important wave directions because of the possible long and large waves. Large and long waves coming from the SSE must be induced by hurricanes and the chance of this is relatively small, and thus, is not selected in this stage of study.

Model Waves

Based on the measurements at station 44009, we identified 60 wave conditions (Table 4) that included the above selected sea severities (M, S, R, G), five wave periods (10s, 12s, 14s, 16s and 20s), and four wave directions (ENE, E, ESE, and SE). Notice the 8 m wave height selected for the most severe sea would have much less impact if it comes with a short wave periods (*e.g.,* 12, and even 14 s) because they will be broken far away from coast, and thus, those short wave periods were excluded. Similarly, for the severe sea, wave periods of 10 s and 12 s are excluded. These 60 wave conditions can roughly represent the major wave components that should be modeled for possible changes due to the cumulative sand mining at the Fenwick Shoal and Isle of Wight Shoal. Short wave periods (less than 10 s) are excluded because the possible impact, if any, on these short period waves would be small. Our calculation results given in Figures 12 and 13, and Table 5 proved that the possible effect on breaking wave height is negligible when wave period is 10 s. We did not run a particular measured wave condition (for example, the most frequently occurring waves, T = 9 s, H = 0.5 m) because (1) the period is too short to be significantly affected by the modeled dredging, and (2) through checking the selected 60 wave

Table 4. *A selection of wave heights and periods for modeling.*

Wave Height (m)	Wave Period (s)
Most Severe Sea, 8	16, 20
Severe Sea, 6	14, 16, 20
Rough Sea, 4	10, 12, 14, 16, 20
Northeaster, 2	10, 12, 14, 16, 20

conditions, most of the waves that might be affected by dredging were considered. Because of the stochastic nature of waves, as well as the nonlinear process of energy dissipation caused by bottom friction, we should examine all possible wave conditions, and that is why 60 waves were selected to represent the entire wave field.

Selection of Wave Models

The many numerical models available for simulating water wave transformation can be divided into two categories: (1) Wave hindcast/prediction models (*e.g.,* SWAN, HISWAP, NSW in Mike 21, and STWAVE) and (2) Wave transformation models (*e.g.,* RCPWAVE, REF/DIF-1, REF/DIF-S, RIDE, and EMS module in Mike 21). Models in the first category are solving the generalized equation (Eq. 1) of wave spectral action density redistribution.

$$\frac{\partial N}{\partial t} + \frac{\partial c_x N}{\partial x} + \frac{\partial c_y N}{\partial y} + \frac{\partial c_\omega N}{\partial \omega} + \frac{\partial c_\theta N}{\partial \theta} = \frac{S}{\sigma} \quad (1)$$

where $N(t, x, y, \omega, \theta) = E(t, x, y, \omega, \theta)/(\omega - Vt)$, E is energy density, ω is the absolute frequency, t is time, x and y are two horizontal directions, θ is spectral wave direction, c_x, and c_y are energy propagation speed in x and y directions, respectively, c_θ and c_ω are energy propagation speed in θ and ω domain, respectively, $\sigma = [gk \tanh(kd)]^{1/2}$ is the intrinsic frequency, g is the gravitational acceleration, k is wave num-

Table 5. *Summary of changes on breaking wave height modulation along the coast.*

Wave Dir.	T = 10s	12s	14s	16s	20s
ENE : M[1]	—[5]	—	—	0.5	0.38/1.33
: S[2]	—	—	0.6	0.64/1.22	0.69
: R[3]	NG[6]	0.9	1.38	0.83	0.86/1.33
: N[4]	0.5	NG	NG	0.83	NG
E : M	—	—	—	0.5/1.54	0.61/0.75
: S	—	—	0.88	0.7/1.14	0.94/1.72
: R	NG	NG	NG	1.2	1.27/1.2
: N	0.9	0.33	0.87	0.5	0.71
ESE : M	—	—	—	3.0	1.75/2.67
: S	—	—	NG	NG	1.22
: R	2.0	NG	NG	2.25	1.6/0.75
: N	NG	NG	2.25	2.0	NG
SE : M	—	—	—	1.12	NG
: S	—	—	1.33	1.28/1.16	1.55
: R	NG	1.83	1.5	1.5	2.0
: N	NG	0.46	2.0	1.55	NG

[1] : represents the Most Severe Sea wave condition.
[2] : represents Severe Sea wave condition.
[3] : represents Rough Sea wave condition.
[4] : represents Northeaster wave condition.
[5] : — denotes not included in computation.
[6] : NG denotes for negligible small.

ber, d is water depth, and S is the summation of energy source and sink terms representing the effects of wind energy input, S_i, bottom friction, S_f, white capping, S_c, breaking dissipation, S_b, as well as wave-wave interactions, S_w. Details of each source and sink terms are not presented here, but these are important items that affect the model performance.

SWAN model is solving Eq. 1 directly without any simplification. Because there are five dimensions (t, x, y, θ, and ω) to deal with, it is slow in computation. To speed up the computing speed, different degrees of parametricization or simplification were made. For example, HISWAP model uses parametricization on frequency domain, and thus, reduce to four dimensions (t, x, y, and θ). The STWAVE uses parametricization on frequency and direction domains and further assumes the steady state to obtain high computing speed. All the wave hindcast/prediction models also included some of the wave transformation processes (*e.g.,* shoaling, refraction, bottom friction) to improve accuracy at near coastal areas, but some of the processes (*e.g.,* diffraction, reflection) are hard to be included. Thus, these models are good for open coasts that do not have a complicated bathymetry, and wave reflection is negligible.

All models in this category also called "phase average" models because detailed wave phase information is not available and grid size can be relatively large, *e.g.,* on the order of ½ wave length. This is one of the advantages to use this kind of model for a large domain.

Models in the second category are designed to simulate wave transformation processes by solving the simplified mild slope equation (RADDER, 1979), the original mild slope equation (BERKHOFF *et al.,* 1982), or the extended mild slope equation (PORTER and STAZIKER, 1995; SUH *et al.,* 1997) given next. These models don't have the capability to simulate wave growth, white capping, and wave-wave interactions. Thus, the use of models in the second category is limited to the conditions in which wave growth is not important, *i.e.,* the wind is not strong or the study domain is not large enough to produce significant wave growth.

$$\nabla(CC_g\nabla(\phi)) + k^2CC_g(1 + if)\phi + [gf_1(\nabla^2h) + gkf_2((\nabla h)^2)]\phi = 0 \qquad (2)$$

where ϕ is the complex velocity potential function for wave field, ∇ stands for spatial gradient, C is the wave phase velocity, C_g is the group wave velocity, k is wave number, i is $(-1)^{1/2}$, f is a factor for all kind of wave energy loss, f_1 is a function of bottom curvature, ∇^2h, and f_2 is a function of bottom slope square, $(\nabla h)^2$. All models in this category also called "phase determined" models because detailed wave phase information can be calculated and wave direction can be calculated from the phase information. It requires, however, the grid size to be less than 1/7 of the wave length to have reasonable accuracy on wave phase. This is probably the drawback of using this kind of model because the computing domain cannot be large to have a reasonable computing speed.

Even in the second category, not all the models have the same capability (MAA *et al.,* 2000). For example, REF/DIF-1 (KIRBY and DALRYMPLE, 1991; 1994) solved the simplified mild slope equation with excellent computing efficiency but only work on monochromatic waves for weak diffraction and no wave reflection. On the other hand, RIDE solved the extended mild slope equation for all the five major wave transformation processes but at the cost of computing time. We chose the REF/DIF-1 over others for the following reasons:

1. The spectrum models used for wave prediction do not have the capability to simulate combined wave diffraction and refraction, which are the major effects that should be considered for this study.
2. When dealing with each component wave for open coasts without wave reflection nor strong wave diffraction, the REF/DIF-1 is an accurate wave transformation model for wave energy distribution.
3. The spectrum model that can simulate combined wave diffraction and refraction, *i.e.,* REF/DIF-S, actually ignores wave-wave interactions and runs REF/DIF-1 many times by considering the major contribution from the major direction, period, and wave heights with minor contributions from other frequencies, directions, and heights. Thus, the results are smoothed and better match the random waves. The results of a narrow-band wave spectrum transformation, however, should be approximately the same as that obtained from REF/DIF-1. This is because a narrow-band wave spectrum has limited contribution from other minor frequencies, directions, and heights. Thus, it can be reasonably represented by a single significant wave height and a single peak-energy wave period. For this reason, we selected using REF/DIF-1 to check the transformation process more clearly and efficiently. Instead of selecting only a few wave conditions, we selected 60 wave conditions, so we can see the differences between pre- and post dredging and between different wave conditions more clearly.
4. The concern of over/under prediction by using REF/DIF-1 is not necessary because we are dealing with each component of a wave spectrum. The random sea is better represented using a wave spectrum, but each component's behavior still can be modeled accurately using a monochromic wave model.

Calibration of REF/DIF-1

While using REF/DIF-1, a user may select to use (1) linear wave, Hedges weak non-linear (HEDGES, 1976), or Stokes' non-linear wave model; (2) select a bottom friction type of laminar, percolation, or turbulent wave boundary; and (3) select a pass-through or reflection lateral boundary conditions.

To address the first choice, we tried the three possible options by comparing computing results with the measurements at the near shore station MD001. The results from the second choice, *i.e.,* Hedges weak non-linear wave model, provided the closest match with observations, and thus, was used for all other computations.

To allow oblique incident waves (or normal incident waves which changed their direction while propagating toward the coast line) to pass-through the lateral boundary without reflection, the pass-through boundary condition was selected for all the studies. The lateral dimension on the computing grid was also selected to be large enough (67.56 km) to avoid any influence by the possible imperfect boundary conditions in the numerical scheme.

It is well documented that bottom friction caused by turbulent wave boundary is the major source of energy loss (MAA and KIM, 1992). It is also documented that one should test a model by using different wave friction factors in order to match the predictions and observations (MAA and WANG, 1995). In summary, the reasons to conduct the calibration of a wave transformation model are (1) to make sure that the selected wave model can accurately simulate the wave transformation processes that are critical for the objective. Only through calibration, is it possible to know if the selected model has been set up properly. Any bug in the application of the selected computer model can be removed, assuring correct results. (2) Only when the wave model results are accurate, can the calculation of shoreline responses be meaningful. (3) Application of any model requires acceptance of many assumptions, including selecting a proper value for bottom friction. The calibration process provides the ability to apply rational, as opposed to arbitrary values. (4) Calibration is a form of quality control. Verification of a model's results against measurements builds confidence for others as to the modeling results.

In this study, we selected a month (Nov. 1–30, 1997, Figure 3) to calibrate the bottom friction coefficient. Wave measurements at Station 44009 were used as input wave conditions specified at the offshore boundary of the computing domain. Wave measurements at the near shore stations MD001 were selected to check the computing results. The coordinates of MD001 were translated to grid locations and wave heights calculated at all the nine neighboring grid points were averaged to compare with the measurements.

Even within one month, there are too many wave conditions to calculate if all the measured offshore wave conditions are used directly. For this reason, we sorted the wave conditions according to the specific intervals given before, and the number of wave conditions were reduced to 113 based on 10 different wave heights (5.0, 4.5, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, and 0.5 m), six wave periods (4, 6, 8, 10, 12, and 14 s), and seven wave directions (NNE, NE, ENE, E, ESE, SE, and SSE). Using these 113 wave conditions, a time series of idealized wave conditions at the offshore boundary can be obtained (Figure 3a). Because waves that travel away from shore are excluded in this comparison, some data are excluded, and thus, the time series (marked as + in Figure 3a) is not a continuous line.

By trial and error, we found that a wave friction factor of 0.02 yielded the best match of the calculated and measured wave heights (Figure 3b). Considering that significant wave height is a widely accepted parameter to represent wave severity, the comparison given in Figure 3b shows that even a rather simple model (REF/DIF-1) performs well in wave height.

During the calibration period (Nov. 1–30, 1997), the maximum significant wave height at the offshore boundary was five meters. This is not large enough to include the possible most severe sea (H_s = 8 m), but is close to the severe sea condition (H_s = 6 m), thus, the calibration is considered sufficient and satisfactory.

WAVE TRANSFORMATION FOR THE ORIGINAL BATHYMETRY

In order to obtain a baseline for estimating the possible impact of sand mining at the two offshore shoals, wave transformations for the original bathymetry were performed first. Sixty possible wave conditions were selected to represent the majority of possible waves which can be affected by the potential sand mining.

Examples of the calculated wave height distributions in the display domain are shown in Figures 6 to 9. All other calculated distribution of wave height can be found in CUTTER *et al.* (2000). These figures use a gray scale to show the normalized wave height distribution, H/H_o (local wave height/incident wave height).

In general, large waves attenuated significantly because of the great energy dissipation caused by the large near-bed velocity. Large waves also may break on the shoals, as seen by the dark gray areas in Figures 6–9 (waves coming from two of the major directions, ENE and E). Notice that in the area between XG = 8 to 20 km and YG = 10 to 13 km, waves could be quite large if coming from east.

For the Northeaster and rough sea conditions (H_s = 2 and 4 m, T = 10–20 s), wave height distributions show mixed results toward the coast. Near the location mentioned above (XG = 8–20 km and YG = 10–13 km), which is south of Ocean City, waves from East tend to converge. The high wave energy (for all waves from the east) may be responsible for causing the shore line retreat at this area.

The relatively severe beach erosion south of Ocean City has been noticed for at least 100 years, long before constructing the jetties. After the construction of jetties at the Ocean City Inlet in 1930s, the severity increased because the jetties block the southward sediment transport, at least for many years before the by-pass system was implemented (SMITH, 1988).

Notice that near the Maryland-Delaware border (XG = 7–10 km, and YG = 24–28 km), the extensive wave height attenuation is obvious (the dark gray in Figures 6 to 9) which may be caused by wave shoaling and breaking after waves pass the Fenwick Shoal.

For a random sea that has many wave frequencies centered at a given frequency used in the REF/DIF-1 model, we may expect the wave height images shown in Figures 6 to 9 would be smoothed. The general trend, however, should be the same.

It should be noted that energy loss caused by bottom friction is not a linear process. This is because the energy loss is proportional to u_b^3, where u_b is the near bed velocity induced by waves. Figures 6 to 9 clearly show this nonlinear process. Local wave heights within the area between XG = 10–15 km and YG = 10–12 km are roughly 8 m, 7 m, 6 m, and 4 m, but the incident offshore wave heights are 8 m, 6 m, 4 m and 2 m. Wave period is 16 s and coming from the east for all the four cases.

If bottom friction is not considered, one may use a unit deepwater wave height, H_o = 1, to estimate local wave heights for all levels of sea severity. If including energy loss caused by bottom friction, the idea of using offshore unit wave height cannot be defended. This is the reason why four wave

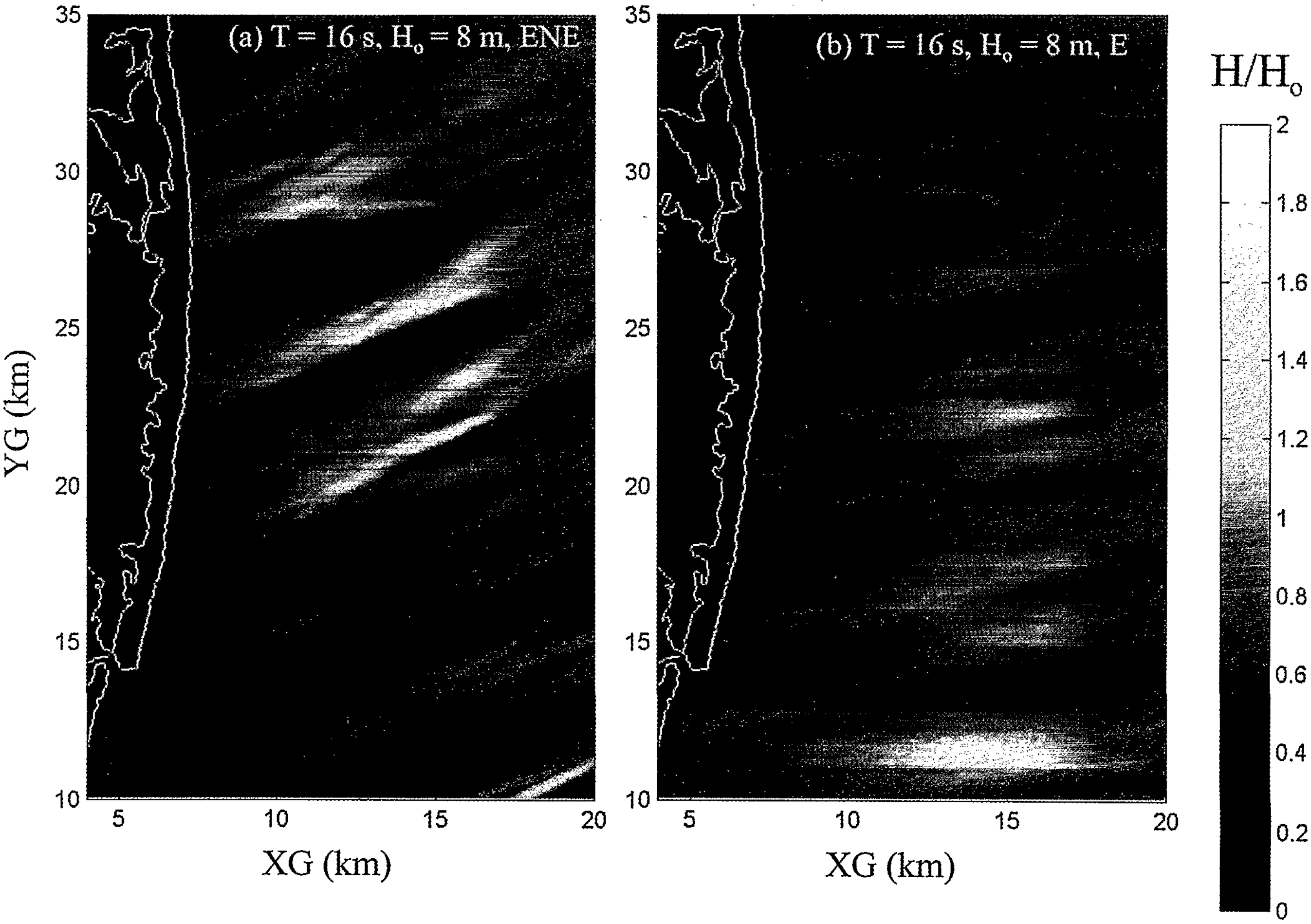


Figure 6. Normalized wave height distribution for the original bathymetry with H_o = 8 m and T = 16 s, and coming from (a) ENE, and (b) E. The planned dredging sites over Fenwick and Isle of Wight Shoals are marked by the dashed-dotted polygons.

heights were included in the study. It also implies that when simulating beach responses using all the reorganized wave heights and wave periods, one has to calculate hundreds of wave conditions.

CHANGES OF WAVES AFTER CUMULATIVE MINING

The dredging scenario is for a long term (10 to 20 years) sand mining event on the order of 24×10^6 m^3. The objective is to assess the possible alteration of waves by sand mining at the two shoals. The same wave conditions that were used for checking the pre-mining wave height distribution were used again.

Sample plots of the normalized wave height difference (*i.e.,* $\Delta H/H$, in unit of %) are shown in Figures 10 and 11 to give a general idea of the difference in computed wave height between the offshore dredging sites and the coast. Comparison of other wave height differences can be found in CUTTER *et al.* (2000). Solid contours represent increase (*i.e.,* $\Delta H/H > 0\%$) and dashed contours represent decrease (*i.e.,* $\Delta H/H < 0\%$). The modeled dredging areas are shown as the dashed-dotted polygons in these figures. It is important to point out that because the distance between these two dredging sites (Fenwick Shoal and Isle of Wight Shoal) is large, there is no interaction between the alterations to wave transformation. In other words, the possible impact caused by dredging at the modeled sites can be treated independently. Note that the severely affected ($\Delta H/H > 50\%$) areas are limited for large incident wave heights and the significantly affected area are limited on the north and south sides of the entire affected area, see the contours in Figure 10 for H_o = 6 m. When H_o is not significantly large, the difference is limited (*i.e.,* $\Delta H/H < 40\%$, see Figure 11). In the middle of these severely affected areas, wave heights are actually reduced ($\Delta H/H < 0\%$), indicated by the dashed contours. The most affected areas are between the shoreline and the dredging sites. At the dredging sites, there are only small differences in terms of wave height alteration.

The most significant difference is the great increase of wave height downstream of the south end portion of the Fen-

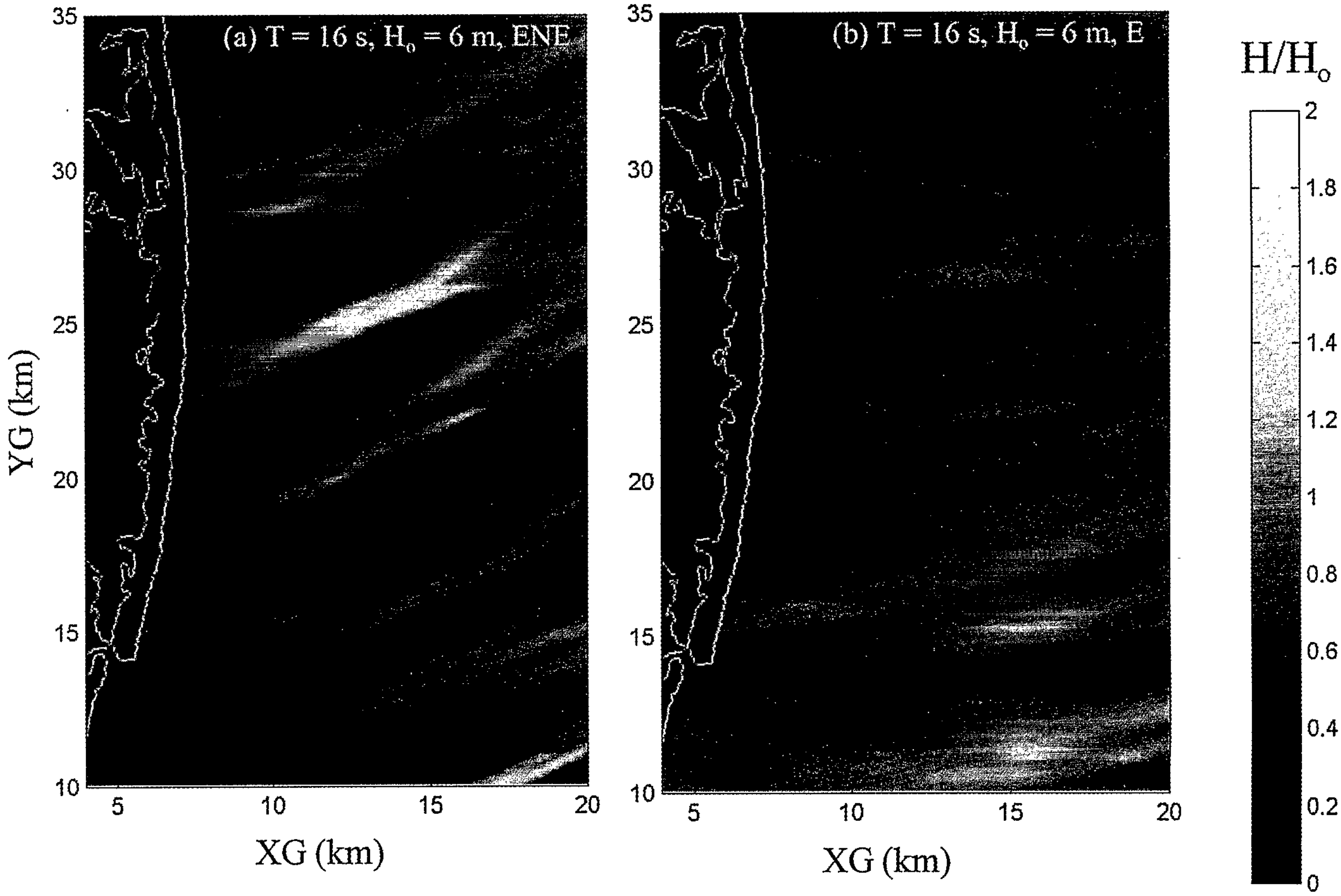


Figure 7. Normalized wave height distribution for the original bathymetry with H_o = 6 m and T = 16 s and coming from (a) ENE and (b) E.

wick Shoal. For other affected areas wave height changes are either a moderate increase or decrease. The large increase of wave height is caused by the proposed dredging that increases the water depth to 9 m (original 6 m), and thus, no wave breaking attenuation at the south of the Fenwick shoal.

As far as the possible shoreline variations are concerned, we need to consider the change of breaking wave height along the shore. Here we suggest using the Breaking wave Height Modulation (BHM) as an index to examine the change of breaking wave condition (MAA *et al.*, 2001). BHM is actually the amplitude of breaking wave height along the coast. The larger the BHM, the more the local shoreline changes. If BHM = 0, it represents an ideal case that the shoreline will not change because the alongshore gradient of transport force is zero. The BHM at any location along the shore for the original bathymetry is assigned as 1 as a reference. The increase of BHM at any location indicates an increase of alongshore sediment transport at that location. On the other hand, a decrease of BHM represents the alongshore force gradient is reduced. Examples of the changes of breaking wave heights in the display domain are plotted in Figures 12 and 13. Comparison of all the breaking wave height profiles can be found in CUTTER *et al.* (2000).

We will use one specific case to explain the possible changes in details, and summarize the results in Table 5. For the most severe sea (Ho = 8 m, T = 20 s) coming from the ENE, Figure 12 indicates that the BHM increases a little (BHM = 1.33) between YG = 20 and 22 km, but the BHM has a significant decrease (BHM = 0.38) between YG = 25 to 27 km. If waves come from the E, the possible impact is positive (*i.e.*, BHM = 0.61 at YG = 30.5 km and 0.75 at YG = 19 km). For waves that come from the ESE, the results are all negative (BHM = 1.75 at YG = 30.5 km and BHM = 2.67 at YG = 23 km). If the waves come from SE, then there is almost no change.

When wave period decreases, the big difference in BHMs for waves coming from ENE at the Maryland and Delaware board diminishes. This is an indication that when considering the impact on wave transformation, more attention should be paid to long period waves.

The results on breaking wave height modulation are a mix of positive and negative (Table 5). Within the 60 studied wave conditions, 18 wave conditions do not show a measurable or significant change. Although for some waves that come from ESE there is a relatively large negative impact (*e.g.*, BHM > 2.), it is not a really significant negative impact because of

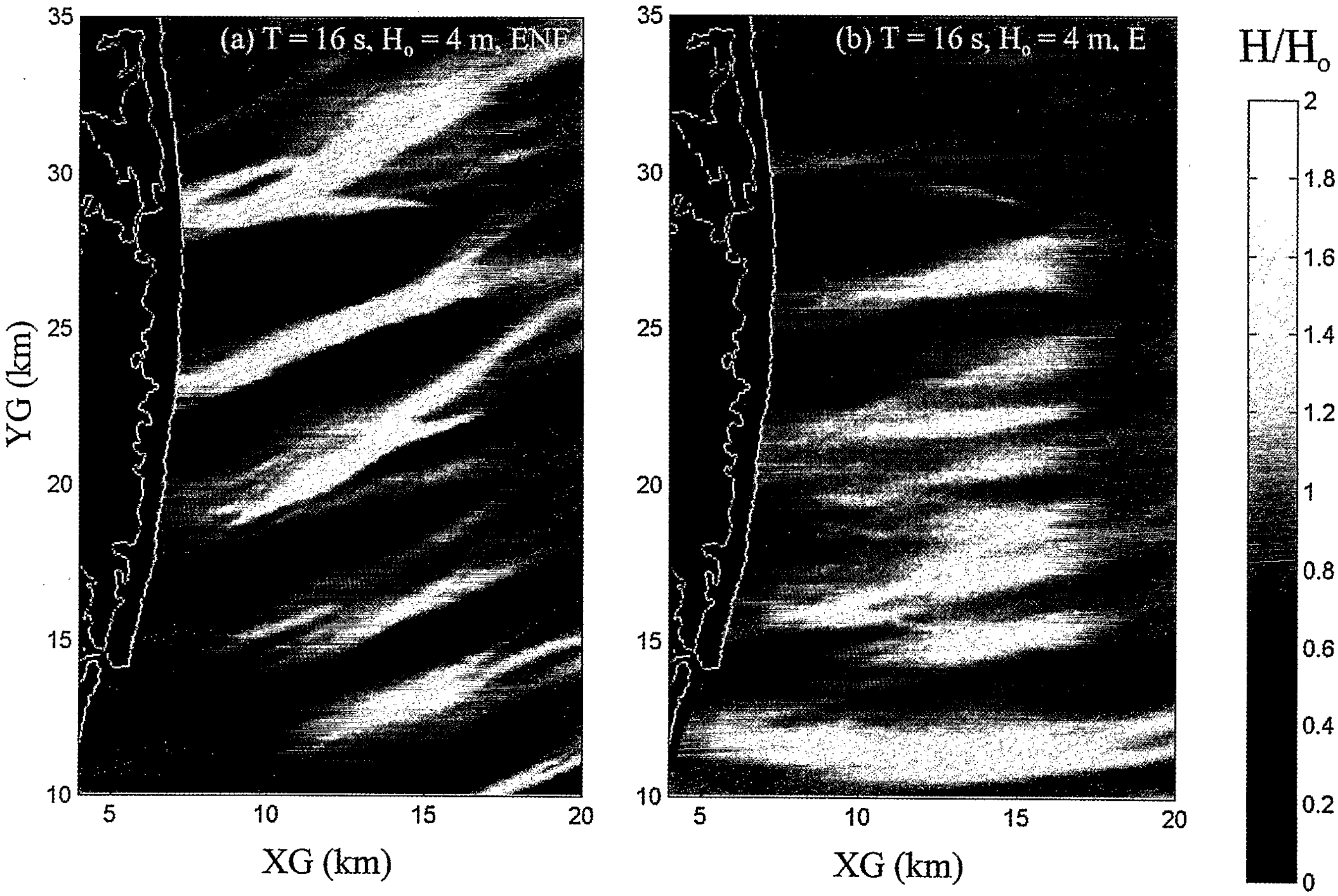


Figure 8. Normalized wave height distribution for the original bathymetry with H_o = 4 m and T = 16 s, and coming from (a) ENE and (b) E.

the originally small BHM. It is necessary to note that the numbers displayed in Table 5 are indices to show the relative significance. Absolute value of the change is another important information for making judgment. The most important feature in Figures 12 and 13 is the obvious reduction of BHM around YG = 26 km, the border between Maryland and Delaware. The original low breaking wave height means the sediment transport at this location is minimal. The obvious reduction of BHM (mainly for long period waves) actually increases the breaking wave height, and thus, indicates that the along shore sediment transport will move more sediment away from this location. Shoreline recession would be expected as a consequence. This is a negative impact at this particular location, however, the increased amount of sediment transport, moving either north or south, will benefit the downstream beaches. If sand resources are taken from the two shoals as modeled, some sort of beach protection project should be considered, or at least a monitoring project that closely checks the shoreline change at the Maryland and Delaware border should be established. If it is necessary to maintain the original shoreline, then part of the sand resources obtained from the offshore mining should be placed at this location.

POSSIBLE IMPACT ON TIDAL CURRENTS

The possible influence on tidal currents, especially the near bottom current, caused by the planned sand mining at the offshore shoals was studied using the three-dimensional (3-D) barotropic version of the Princeton Ocean Model (POM, BLUMBERG and MELLOR, 1987). As the POM is a well known model, the formulation part of this model is omitted, only the open boundary conditions, model verification, modeling results for the original tidal current distributions, and modeling results of the possible differences caused by sand mining are presented.

The orthogonal curvilinear model grid used for tidal current modeling is the same as that displayed in Figure 1, except that the cell size is increased to 300 m × 600 m in the east-west and north-south directions, respectively. The total dimensions also are the same: 44.97 km × 67.56 km. There are 6 sigma layers in the vertical direction, *i.e.,* the total water depth was divided into 6 layers. The thickness of these layers varies at each cell because of the different total water depths. The model computation internal and external time steps were 90 and 6 seconds, respectively. The horizontal diffusion coefficient was set as a constant of 50 m^2/s.

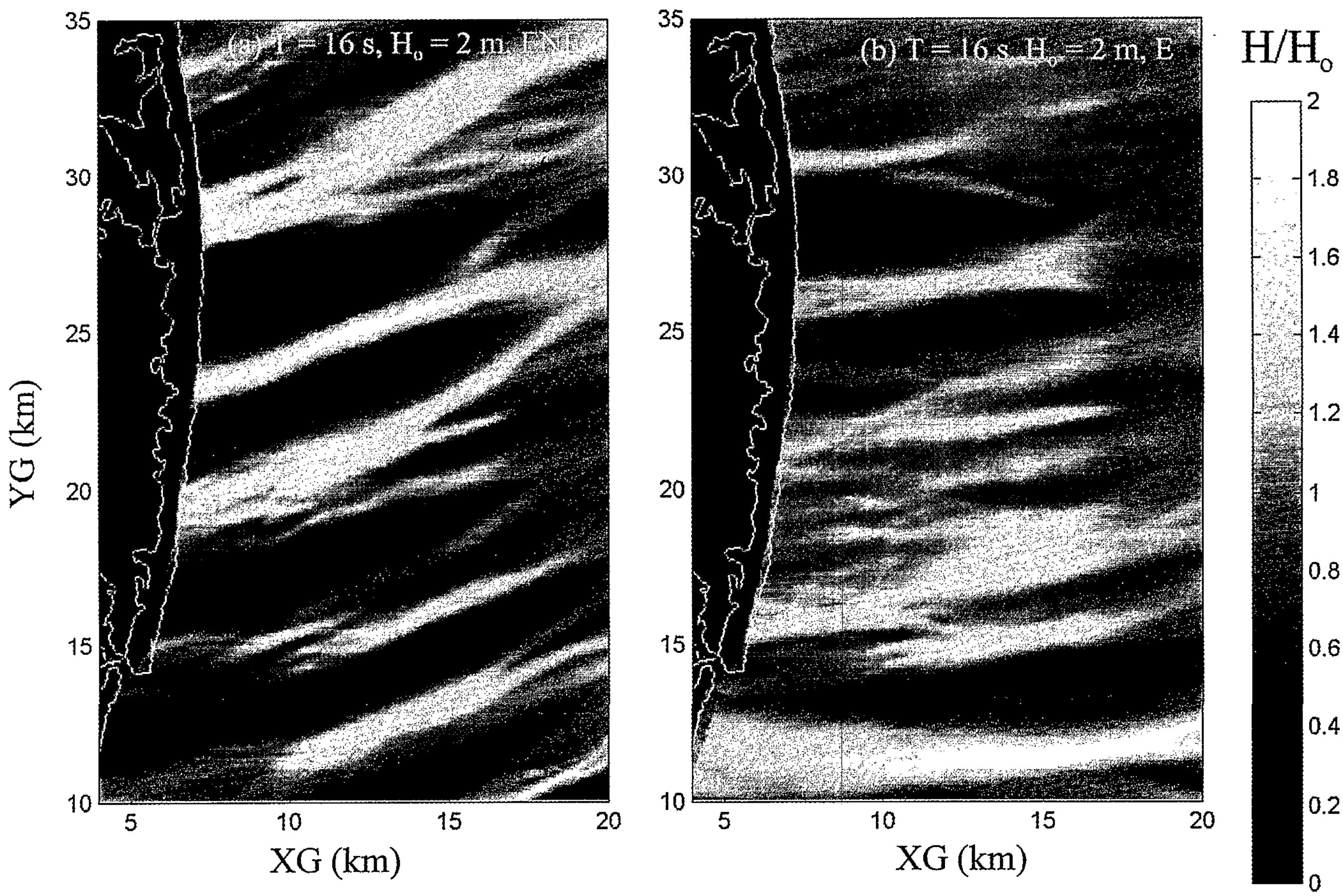


Figure 9. Normalized wave height distribution for the original bathymetry with H_o = 2 m and T = 16 s, and coming from (a) ENE and (b) E.

Since tidal waves mainly propagate in the shore-normal direction at this study site, and the eastern open ocean boundary of the model domain is located only about 45 km offshore, the tidal level gradient is expected to be insignificant within this short distance. Therefore, the eastern open ocean boundary can be specified using the tidal levels measured from a tidal station on the west side of the study domain: Ocean City, Maryland. The only unknown is the phase angle required to produce a matched tidal time series at the Ocean City. To obtain the amplitudes of each tidal component, hourly water level records at Ocean City Inlet (NOS Station ID 8570283), Maryland for the entire year of 1985 were processed by using least square harmonic analysis for 29 tidal constituents. Using the 29 constituents, a tidal time series can be reconstructed to remove the wind effects: wind set-up or set-down. The reconstructed tide levels with a specified phase angle were specified as the east open ocean boundary condition while a velocity radiation condition was specified at the north and south boundaries. As mentioned before, the gradient of water surface elevation is negligibly small in this small domain, the reconstructed tidal elevations really serves three purposes: (1) to provide the boundary condition at the offshore border, (2) to serve as a base for finding the correct phase angles that can be used at the east boundary of the computing domain, and (3) to verify the model performance by comparing the calculated and the reconstructed tidal elevation at the Ocean City Inlet.

Using the original bathymetry, the POM model was run with a cold start (assuming the tidal elevation and tidal current are all zero is the computation domain) for 30 "days." Comparison of the model calculated tide levels at Ocean City, Maryland with the re-constructed tide levels reveals very good agreement, less than 1 cm RMS (root-mean-square) error. This calibration indicates that the model is capable of reproducing the water levels accurately for the existing bathymetry in the study area. Although there is no tidal current information available to verify the simulated velocity, the model produces a reasonable (20 cm/s) maximum surface current speed at proposed dredging sites. Therefore, the model can be used to evaluate the tidal current changes before and after the proposed sand mining.

Contours of near-bed (bottom layer) tidal flow fields at the maximum flood and the maximum ebb, within the display domain (Figure 14) reveal that the near-bed tidal current is weak, less than 5 cm/s for the near shore (water depth < 10 m), except at the shoals, where the near-bed maximum flood

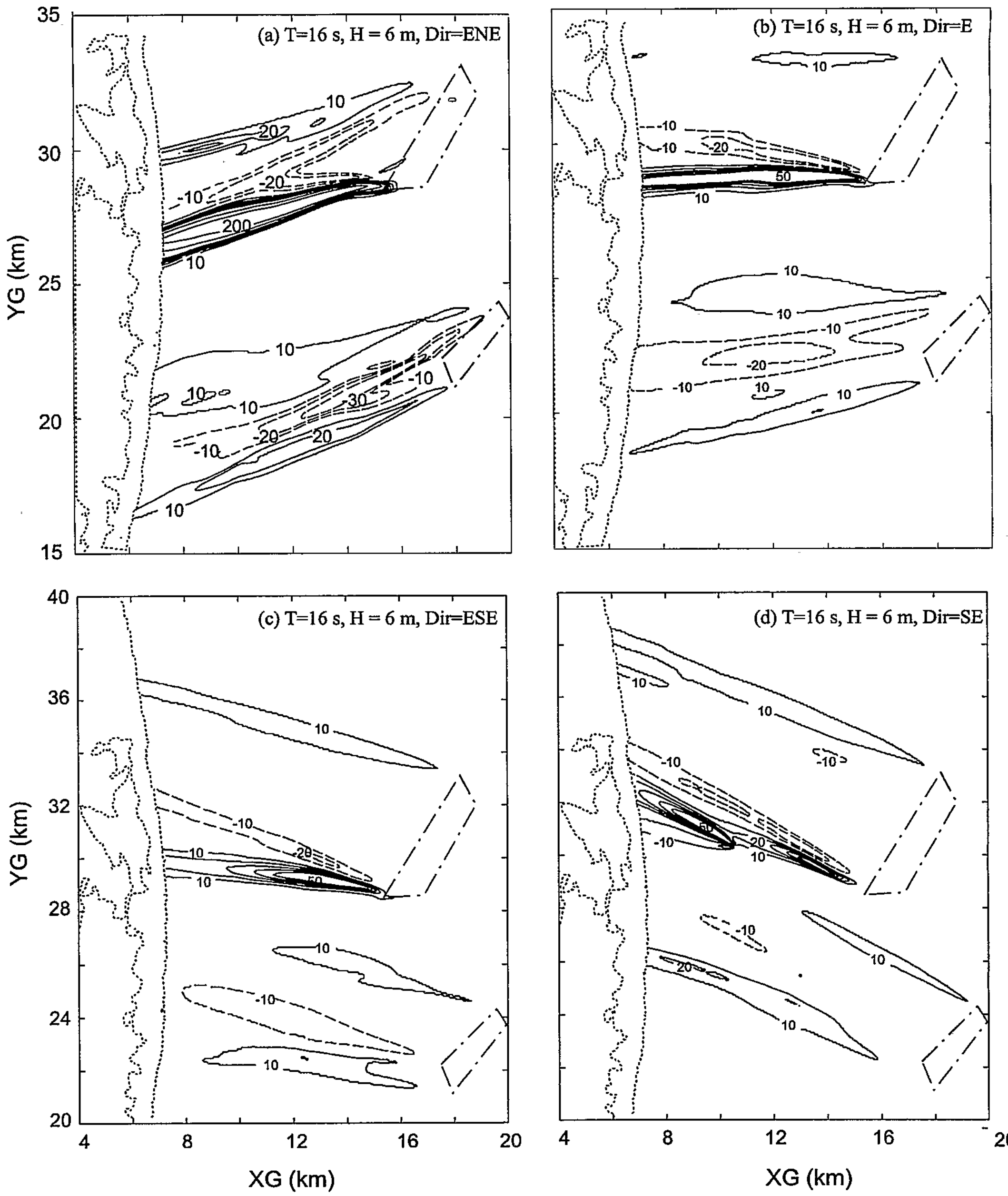


Figure 10. Calculated changes of wave height (ΔH) normalized by the original wave height (H) for cumulative sand mining with H_o = 6 m and T = 16 s coming from (a) ENE, (b) E, (c) ESE, and (d) SE.

velocity is on the order of 8 cm/s. For the maximum ebb, the same conclusions also hold. Velocity vectors (Figure 15) within a small domain that includes Fenwick Shoal and Isle of Wight Shoal for the maximum flood and ebb reveal clearly the effect of bathymetry on tidal currents. When the tidal current is forced to flow over the shoal, the velocity increases because of the decreasing water depth. If the tidal current can find an easy way to avoid climbing the shoal, it will take the easy route.

Using the same offshore boundary condition, the same lateral boundary condition and the bathymetry with the cumulative sand mining, the POM model was re-run to find the possible differences. For better visual presentation of the differences in such a small tidal current environment, we normalized the differences by presenting them in percentages (Figure 16) for the two extreme conditions: maximum flood and ebb. It clearly shows that a maximum difference on the order of 10% can result. In general, where the water depth increases because of dredging, the tidal current velocity decreases. Immediately downstream of the dredging site, and on the leeward side of tidal flow, tidal current velocity increases. The affected area is rather large, but the amount of

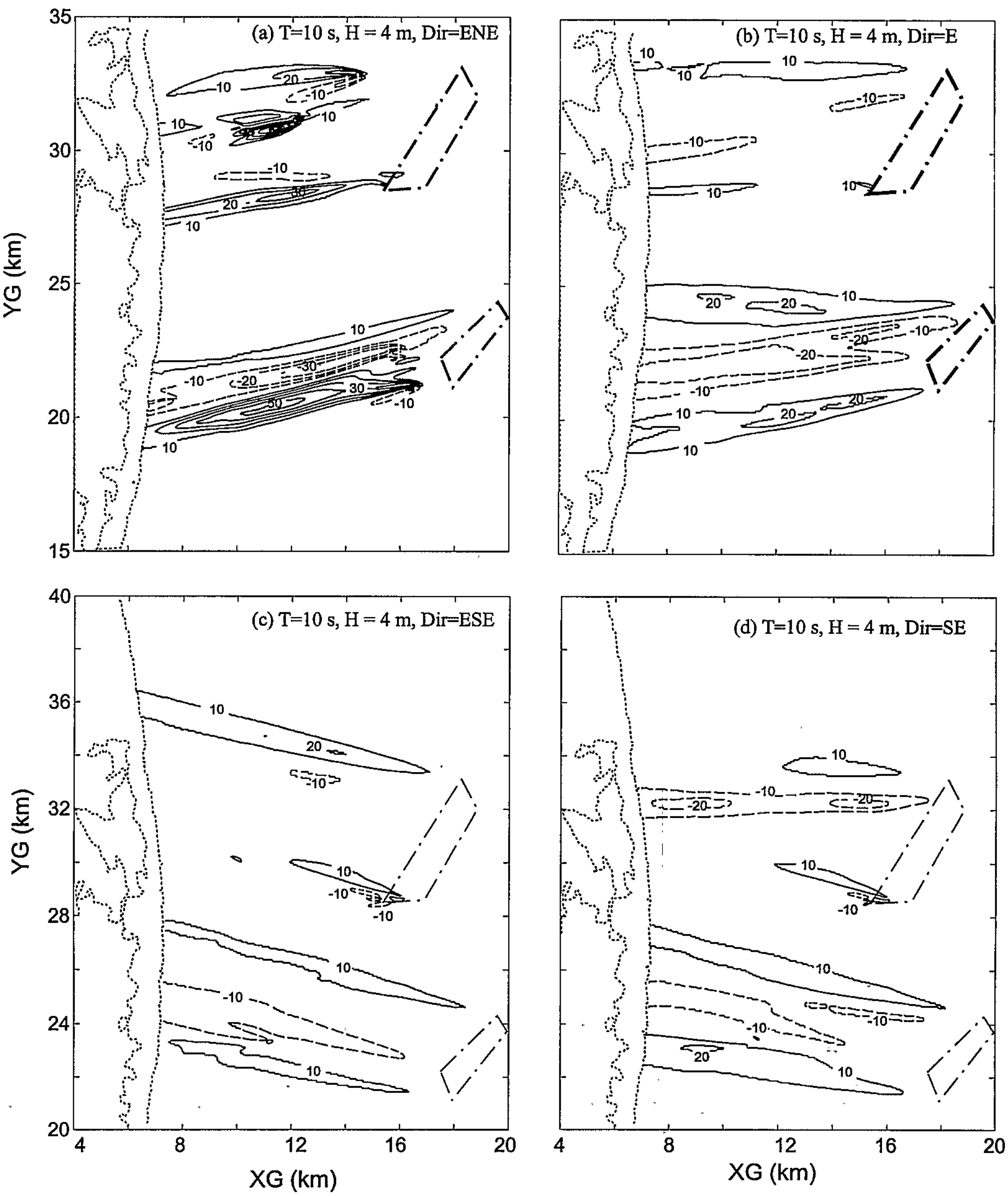


Figure 11. Calculated changes of wave height (ΔH) normalized by the original wave height (H) for cumulative sand mining with H_o = 4 m and T = 10 s coming from (a) ENE, (b) E, (c) ESE, and (d) SE.

velocity increase is rather small, even as a percentage. If one considers that the maximum tidal current velocity is only around 8 cm/s at the shoal and around 5 cm/s away from the shoal, the change in tidal current caused by the proposed dredging should not affect biological living conditions.

POSSIBLE INFLUENCE ON STORM SURGE

Coastal storm surge, defined as the anomaly of water level from astronomical tide, is also known as wind tide because it stems from storms of tropical or extratropical origins. The storm surge has been expressed as barotropic response of coastal water body to meteorological forcing and the controlling parameters are geometry of coastlines and bathymetry (*e.g.* MURTY, 1984).

The SLOSH (Sea, Lake, and Overland Surges from Hurricanes) model (JELESNIANSKI *et al.,* 1992) was used in this study to assess possible changes resulting from the hypothetical sand mining. This model is the standard model used by NOAA to generate evacuation maps for Federal Emergency Management Agency. For this reason, details of this model are not given.

A polar grid with 130 by 280 grid cells was constructed for

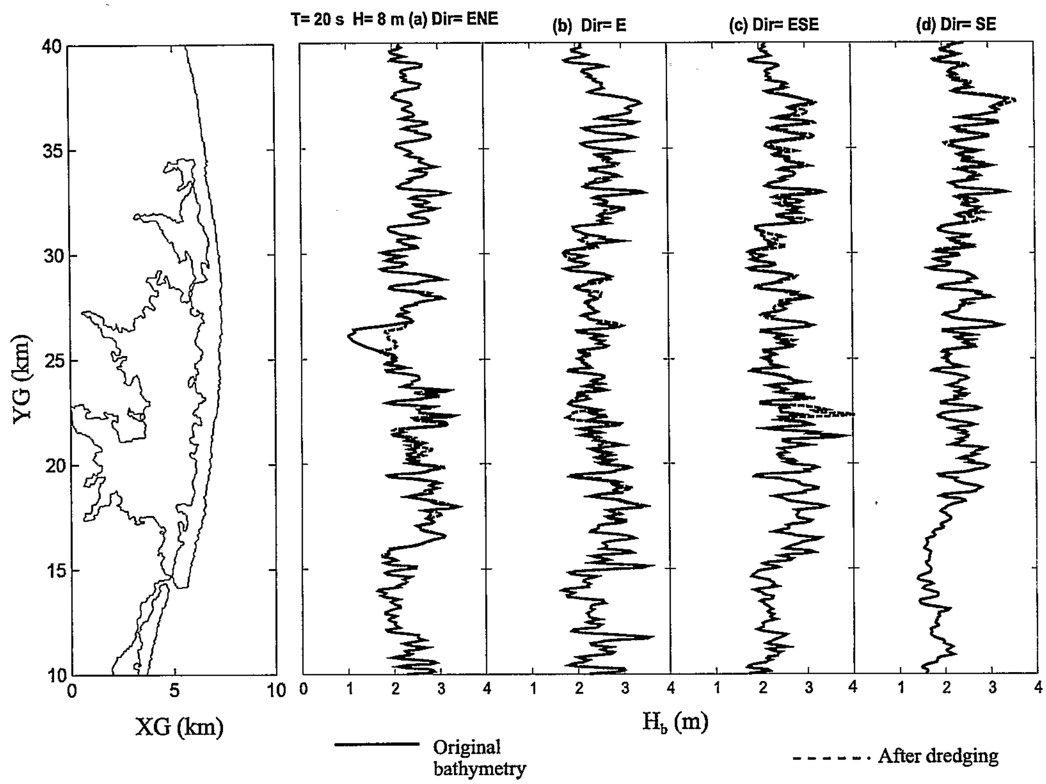


Figure 12. Comparison of breaking wave heights for original bathymetry and after cumulative sand mining with H_o = 8 m and T = 20 s.

this study. The coastal grid cells are approximately 150 m by 150 m. In order to investigate the impact from dredging of offshore sand shoals, we selected 10 stations along the coast to monitor the possible change of surges.

Tropical storms with an 86 mbar central pressure drop and 24-km maximum wind radius (comparable to category 4 storm) were used to simulate the coastal storm surges. Two orthogonal tracks of across-shore and along-shore directions were simulated. The results indicate that maximum surges were produced from the cross-shore track simulation (Figure 17). It clearly shows the higher coastal surges on the right hand side of the storm landfall points as would be expected. After re-run the SLOSH model with the post-mining bathymetry, the changes are about 0.1 cm that is negligible compared to the maximum surges of 3.5 m. Figure 18 shows the maximum surge from the along-shore track. In general, the coastal surges were lower compared to that generated from a cross-shore hurricane. South-north propagation of surges was evident, and the changes were also around 0.1 cm that again is negligible compared to the maximum surge of 2.5 m.

CONCLUSIONS

The possible impact on oceanographic parameters: wave transformation, tidal currents, and storm surge that might be caused by cumulative sand mining at Fenwick Shoal and Isle of Wight Shoal for a period of 10 to 20 years for a total of 2.4×10^7 m^3 of sand are summarized as follows.

Using high quality raw bathymetric data, a computing domain of 44.970 km × 67.560 km was created for studying the possible changes on wave transformation and tidal currents. This grid is large enough to directly use wave data measured at an NOAA offshore wave station, 44009. The grid cell size, however, is small enough (30 m × 60 m) to show the effect of wave diffraction.

A total of 13 years of wave measurements from NDBC buoy station 44009, about 45 km offshore at the Ocean City, were used to analyze the possible choices of wave heights, periods, and directions that should be analyzed for alteration because of the modeled dredging at the two shoals. Two near shore wave stations, MD001 and MD002, provide about 4 years measurements. The measured waves at these two near shore stations are almost identical. Data from both the offshore and near shore stations provide a complete set for verifying the selected wave transformation model.

Sixty wave conditions are selected as model wave conditions. These wave conditions include four possible wave heights (2 m, 4 m, 6 m, and 8 m), five wave periods (10 s, 12 s, 14 s, 16 s, and 20 s), and four wave directions (ENE, E, ESE, SE). As wave energy loss caused by bottom friction is not a linear process, all four wave heights have to be included in the calculations. REF/DIF-1 was selected because of its excellent accuracy and computing efficiency. The model was calibrated using one-month of wave measurements (Nov. 1 to 30, 1997) from stations 44009 and MD001.

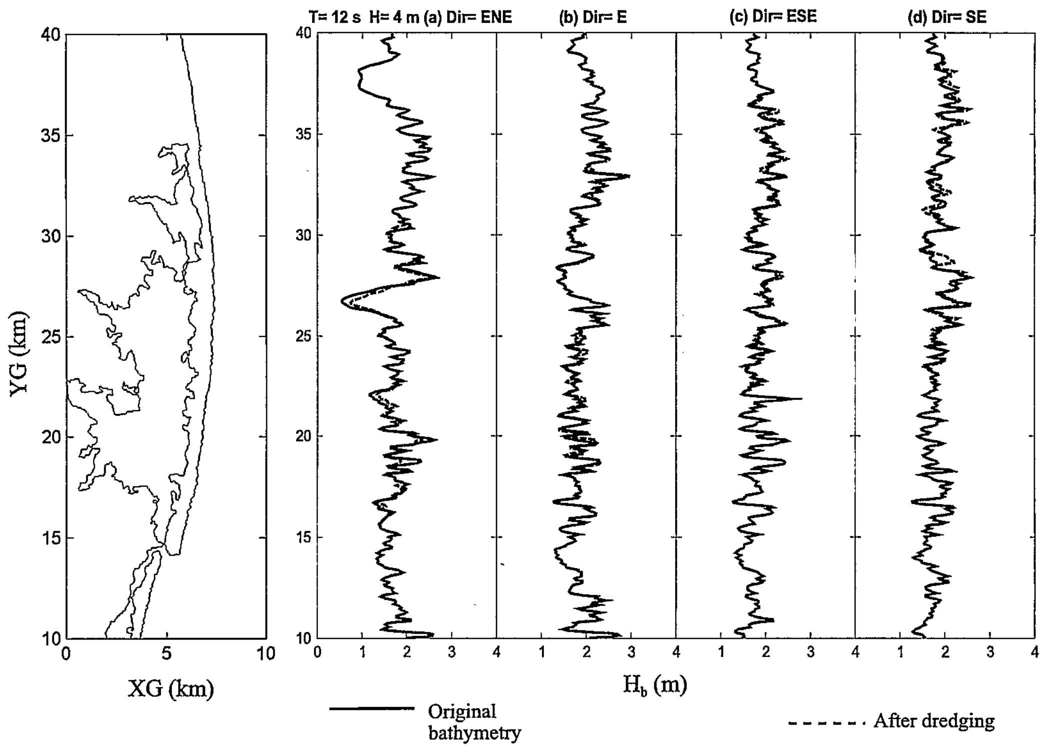


Figure 13. Comparison of breaking wave heights for original bathymetry and after cumulative sand mining with H_o = 4 m and T = 12 s.

The calculated wave height distributions for the original bathymetry indicate that just south of Ocean City, waves coming from East have a tendency to converge. The high wave energy (for all waves that come from East) may be responsible for causing the shoreline retreat south of Ocean City. Near the Maryland–Delaware border, there is an area of extensive wave height attenuation due to wave shoaling and breaking after waves pass Fenwick Shoal that is approximately 10 km offshore. The relatively small breaking wave

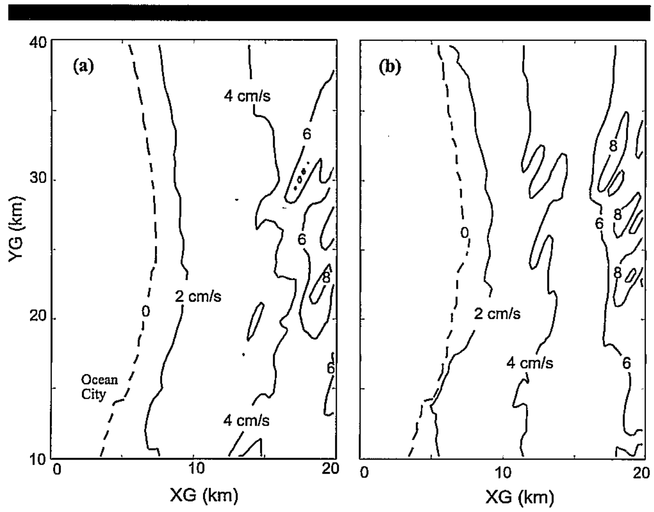


Figure 14. POM calculated contours of near-bed tidal current velocity (in cm/s) for a selected domain including Fenwick and Isle of Wight Shoals. (a) At maximum flood; (b) At maximum ebb. Zero contour line for tidal current is also the shoreline.

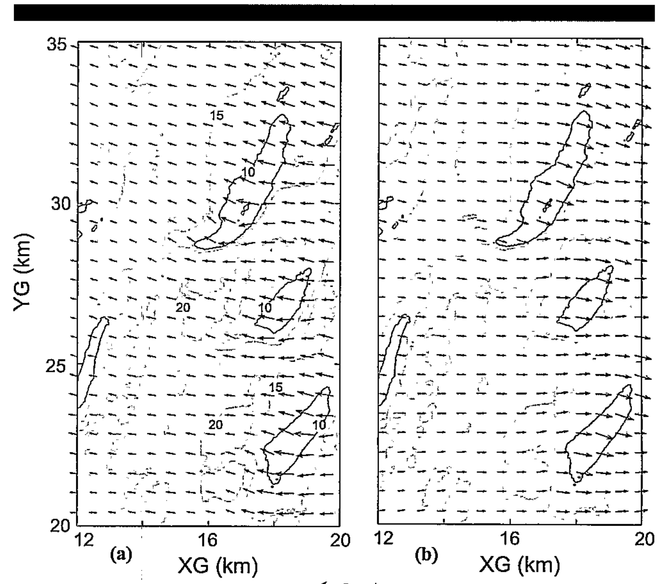


Figure 15. POM calculated near-bed tidal current velocity vectors for the selected domain at (a) maximum flood and (b) maximum ebb.

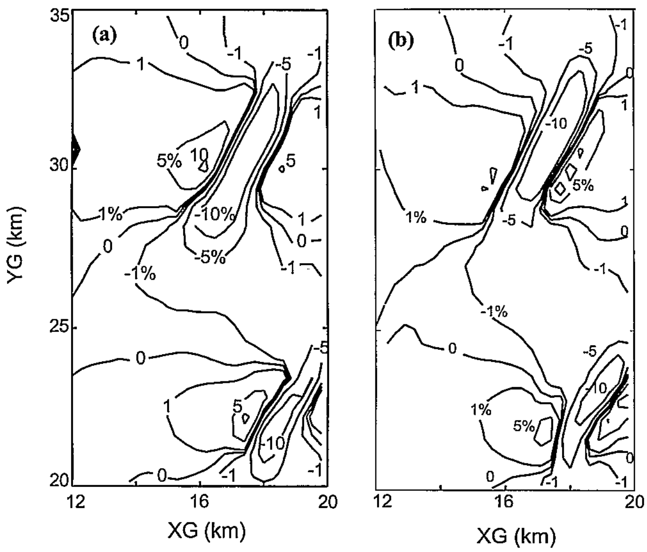


Figure 16. Difference (in %) in tidal current caused by sand mining at the modeled sites for (a) maximum flood and (b) maximum ebb.

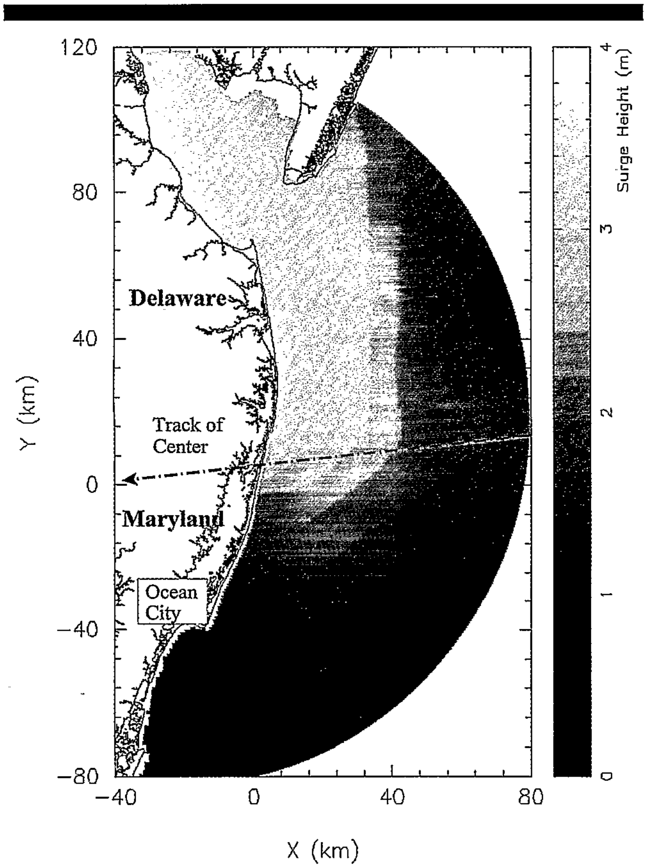


Figure 17. SLOSH model calculated maximum storm surge for a category 4 storm that moves across the shore.

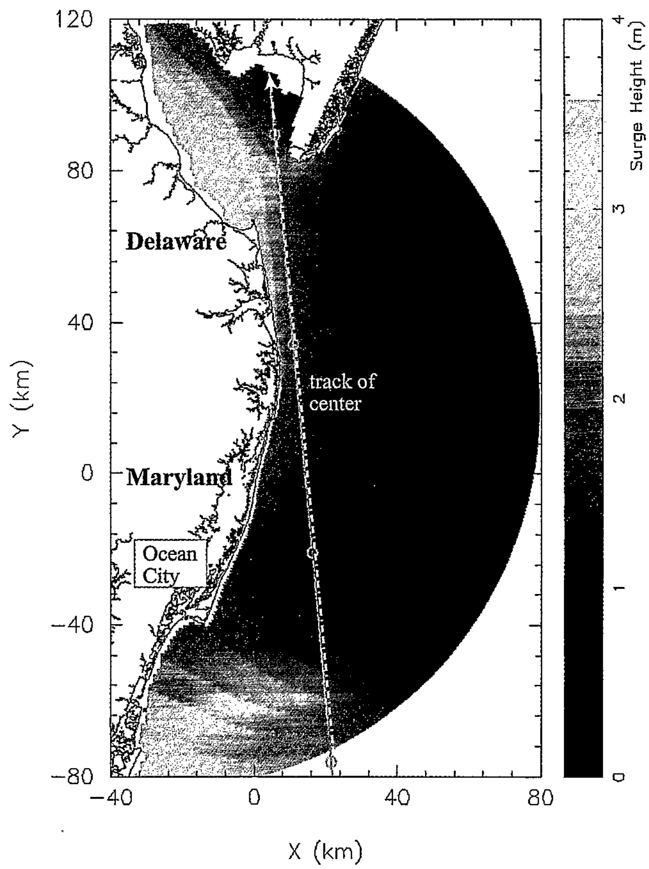


Figure 18. SLOSH model calculated maximum storm surge for a category 4 storm that moves parallel to the shore.

heights at this area may explain the relatively stable shoreline near the border.

This study indicates that the major change of wave height caused by cumulative sand mining at Fenwick and Isle of Wight Shoals is between the dredging site and the shoreline. The increase of local wave height can be as much as two times. The change of breaking wave height, on the other hand, is not so obvious except for the clear reduction of breaking wave height modulation (BHM) at the Maryland and Delaware border. The reduction of BHM at this location, however, is not necessarily a positive impact because it increases the breaking wave height at that location. As a consequence, more erosion and shoreline recession at that location might occur. Otherwise, the possible impact is not significant.

The SLOSH model with a category 4 storm that moves across the shore demonstrated that the possible change of storm surge caused by the modeled mining is only 0.1 cm which is negligible compared to the maximum surge of around 3 m.

The maximum near-bed tidal current is weak, on the order of 5 cm/s except at the shoals, where current velocity increases to around 8 cm/s. The postulated dredging at the shoals will reduce the maximum near-bed tidal current velocity (around 10%, *i.e.,* 1 cm/s). Immediately on the leeward side of tidal flow, the dredging increases the tidal velocity, up to 10%. These results indicate a negligible impact. For future studies, the possible impact on current and storm surge may be excluded.

ACKNOWLEDGMENTS

Sincere appreciation goes to the U.S. Minerals Management Service for financial support of this study under contract No. 14-25-0001-30740. This paper is contribution number 2548 of the Virginia Institute of Marine Science.

LITERATURE CITED

BERKHOFF, J.C.W.; BOOIJ, N., and RADDER, A.C., 1982. Verification of numerical wave propagation models for simple harmonic linear water waves. *Coastal Engrg.,* 6: 255–279.

BLUMBERG, A.F. and MELLOR, G.F., 1987. A description of a three-dimensional coastal ocean circulation model. *In: Three-dimensional Coastal Ocean Models,* Coastal and Estuarine Science, Vol. 4 (HEAPS, N.S. ed.), American Geophysical Union, Washington, D.C., 1–16.

CUTTER, JR. G.R.; DIAZ, R.J.; MUSICK, J.A.; OLNEY, J.; BILKOVIC, D.M.; MAA, J.P.-Y.; KIM, S.C.; HARDAWAY, C.S.; MILLIGAN, D.A.; BRINDLEY, R., and HOBBS, III C.H., 2000. *Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland, Final Report OCS Study* 2000-055, Prepared for Minerals Management Service, U.S. Dept. of the Interior, Virginia Institute of Marine Science, Gloucester Point, VA.

HEDGES, T.S., 1976. An empirical modification to linear wave theory, *Proc. Inst. Civil Engrg.,* 61(2), 575–579.

HOBBS, III, C.H., 2002. An investigation of potential consequences of marine mining in shallow water: An example from the middle Atlantic coast of the United States. *Journal of Coastal Research,* 18(1), 94–101.

JELESNIANSKI, C. P.; CHEN, J., and SHAFFER, W. A., 1992. *SLOSH: Sea, Lake, and Overland Surges from Hurricanes.* NOAA Technical Report NWS 48, Department of Commerce, USA, 71p.

KIRBY, J. T. and DALRYMPLE, R. A., 1991. *User's Manual, Combined Refraction/Diffraction Model, REF/DIR 1,* Version 2.3. Center for Applied Coastal Research, Department of Civil Engineering, University of Delaware, Newark, DE 19716.

KIRBY, J. T. and DALRYMPLE, R. A., 1994. *Combined refraction/diffraction model REF/DIF-1,* version 2.5, documentation and user's manual. CACR Report 94-22, Center for Applied Coastal Research, University of Delaware, Newark, Delaware, 171p.

MEINDL, E.A. and HAMILTON, G.D., 1992. Programs of the National Data Buoy Center. *Bulletin of the American Meterorological Society,* 73(7), 985–993.

MAA, J. P.-Y.; HOBBS, III C. H., and HARDAWAY, JR. C. S., 2001. A criterion for determining the impact on shorelines caused by altering wave transformation, *Journal of Coastal Research,* 17(1), 107–113.

MAA, J. P.-Y. and HOBBS, III C.H., 1998. Physical impact of waves on adjacent coasts resulting from dredging at Sandbridge Shoal, VA, *Journal of Coastal Research,* 14(2), 525–536.

MAA, J. P.-Y.; HSU, T.-W.; TSAI, C.-H., and JUANG, W. J., 2000. Comparison of wave refraction and diffraction models. *Journal of Coastal Research,* 16(4), 1073–1082.

MAA, J. P.-Y. and WANG, D. W-C., 1995. Wave transformation near Virginia coast: the 1991 Halloween Northeaster, *Journal of Coastal Research,* 11(4), 1258–1271.

MAA, J. P.-Y. and KIM, C.-S., 1992. The effect of bottom fiction on breaking waves using RCPWAVE model. *Journal Waterway, Port, Coastal and Ocean Engineering,* 118(4), 387–400.

MURTY, T. S., 1984, Storm surges-meteorological ocean tides, *Canadian Bulletin of Fisheries and Aquatic Sciences,* 212, 897p.

PORTER, D. and STAZIKER, D.J., 1995. Extensions of the mild-slope equation. *Journal Fluid Mechanics,* 300, 367–382.

RADDER, A.C., 1979. On the parabolic equation method for water wave propagation. *Journal Fluid Mechanics,* 95(1), 159–176.

SMITH, E. R., 1988. *Case Histories of Corps Breakwater and Jetty Structures,* Technical Report REMR-CO-3. Coastal Engineering Research Center, Dept. of the Army, Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi, 133p.

SUH, K.D.; LEE, C., and PARK, W.S., 1997. Time-dependent equations for wave propagation on rapidly varying topography. *Coastal Engineering,* 32, 91–117.

Journal of Coastal Research	20	1	149–154	West Palm Beach, Florida	Winter 2004

Regional Management Strategies for Federal Offshore Borrow Areas, U.S. East and Gulf of Mexico Coasts

Jacqueline Michel

Research Planning, Inc.
1121 Park Street
Columbia, SC 29201, U.S.A.
jmichel@researchplanning.com

ABSTRACT

MICHEL, J., 2004. Regional management strategies for federal offshore borrow areas, U.S. east and Gulf of Mexico coasts. *Journal of Coastal Research,* 20(1), 149–154. West Palm Beach (Florida), ISSN 0749-0208.

With the increased demand for Federal sand and gravel resources on the outer continental shelf, the Minerals Management Service (MMS) is developing strategies for environmentally sound and fiscally responsible management of the resource. A process is needed for planning, decisionmaking, and coordination among stakeholders. Two workshops were conducted in Texas and New Jersey to solicit input from Federal, State, and local government representatives, university researchers, and private companies on key issues. Based on the results of the workshop, it was recommended that sand management task forces be established in each state, starting with those states that can provide a strong technical and administrative lead and have a high level of interest in accessing Federal borrow sites. Sand management task forces would be responsible for planning, coordinating, and facilitating the use of OCS sand for beach nourishment and coastal restoration projects. MMS's responsibilities include taking the lead in the design and funding of long-term monitoring studies of the impacts of dredging OCS sand, sponsoring workshops on technical and policy issues, and providing a clearinghouse for dissemination of studies and findings on actual environmental impacts, focusing on key issues such as cumulative impacts.

ADDITIONAL INDEX WORDS: *OCS sand and gravel, sand resources.*

INTRODUCTION

The Minerals Management Service (MMS) sand and gravel/ marine minerals program is responsible for the environmentally responsible management of Federal Outer Continental Shelf (OCS) sand and gravel resources. MMS's mission is to make timely, streamlined, and environmentally sound and fiscally responsible decisions about access to OCS sand resources. MMS has the authority to negotiate, on a noncompetitive basis, the rights to OCS sand, gravel, and shell resources for shore protection, beach or wetlands restoration projects, or for use in construction projects funded in whole or part by or authorized by the Federal government.

Between 1995 and 2002, MMS conveyed over 19 million cubic yards of OCS sand for ten projects (DRUCKER *et al.,* this volume). MMS anticipates that, as the demand for sand for shoreline protection increases, OCS sand and gravel will become an increasingly important resource. It should be noted that projects are initiated by the beneficiaries of the resource; MMS does not propose leases for OCS sand resources.

MMS has cooperative sand evaluation programs with ten States (Alabama, Delaware, Florida, Louisiana, Maryland, New Jersey, North Carolina, South Carolina, Texas, and Virginia) to identify and evaluate OCS sand resources as potential sources for future beach nourishment projects. The program was started in 1992 in response to requests by the states to begin looking at the OCS for future sand supplies for beach nourishment. Geological task forces, consisting of members from MMS, State agencies, and other Federal agencies as appropriate, provide oversight of the program. The geological task forces conduct a thorough assessment of beach sand needs for the next 15–20 years, prioritizing the beaches in greatest need, gathering geological and geophysical information offshore of the highest-priority beaches, and determining if sufficient volumes of suitable sand are available. Benthic biological surveys and computer-generated wave modeling studies are conducted for the best sand sites to assess the potential for impacts to the benthos and coastline if the sand is removed.

MMS has contributed about $5,000,000 to the cooperative program since 1992, with the states matching that amount, mostly as in-kind contributions. Thus, the average outlay to each State has been around $50,000 per year. The status of these State inventory studies and available reports are posted on the MMS web site (www.mms.gov/offshore/).

MMS expects that some OCS sand resources will be long-term sources of borrow material for coastal erosion management because nearshore sand sources are diminishing and the renourishment cycles for beaches or coastal areas require quantities of sand that are not currently available from State sources. In addition, MMS is concerned that severe coastal storms might trigger the need for access to large sand inventories for immediate/emergency repair of beaches and coastal damage. MMS has developed guidelines for those interested in obtaining leases to develop OCS sand resources (GIORDANO *et al.,* 1999). As steward for these resources, MMS must

12 received and accepted in revision 6 June 2003.

ensure that any use of OCS sand resources will not adversely affect the marine, coastal, and human environments. Under the National Environmental Policy Act, an environmental assessment or impact statement (prepared by either MMS or another Federal Agency) is used to evaluate whether or not to issue a lease. MMS has taken an active role in identifying the potential environmental impacts of dredging OCS sand by conducting baseline studies of selected OCS regions and funding research on specific areas of concern. As of 2002, MMS has funded over $7 million for environmental studies. Table 1 lists the studies funded by MMS under this program; the studies are available at www.mms.gov/intermar/environmentalstudiespage.htm.

Most of the research to identify OCS sand resources has focused on bathymetric highs, described as sand shoals, ridges, and banks (see discussion on the characteristics of offshore ridges and shoals in HAYES and NAIRN, this volume). It appears that, because of their distance from shore (outside of state waters, thus greater than 4.8 kilometers offshore for most states) and water depth (typically 10–20 meters), these features appear to be isolated from the sediment budget of the littoral system by large distances and muddy areas (the latter indicating the absence of a sand transport pathway), though this will not always be the case. Their isolation from the active littoral system reduces the possibility of interrupting a sediment supply pathway to the shoreline, but it also prevents replacement of sand removed during dredging. Thus, OCS sand should be considered as a potentially nonrenewable resource that needs careful management and use.

Now, in the early stages of resource utilization, is the time to establish the mechanisms for long-term management of this resource. MMS has identified the need to involve Federal, State, and local governments and other stakeholders in an overall planning process to manage the Federal offshore borrow sites in an environmentally responsible and cost-effective manner over the long term. There are numerous jurisdictions, authorities, and consultations that must be addressed. Multiple entities may wish to access an OCS borrow site repeatedly over time, on a long-term, even continual basis, yet currently, each OCS dredging project is considered on a project-specific basis. Important objectives of the MMS program are the cost savings and value-added benefits that can be achieved through regional management, including opportunities reduce the time and costs for permitting and planning. Repeated use of sites brings up questions about potential long-term, cumulative impacts that need to be addressed, and monitoring responsibilities need to be resolved among multiple users of the resource.

STUDY APPROACH

MMS conducted a study to determine the feasibility of developing regional OCS sand management strategies; the study results (MICHEL, 2001) has been published as a MMS OCS report. The first step of the study was to identify two areas where pilot studies could be conducted to solicit input from stakeholders on how to best manage the Federal OCS sand and gravel resources. The two areas would represent different physical and biological settings, technical issues, en-

Table 1. *Environmental studies on OCS sand resource issues funded or supported by MMS.*

Site-Specific Environmental Baseline Studies
Environmental Investigation of the Use of Shoals Offshore Delaware and Maryland by Mobile Benthos and Finfish Species (Site-specific/Generic) Final Report January 2005
Field Testing of a Physical/Biological Monitoring Methodology for Offshore Dredging and Mining Operations (Generic/Site-Specific, being conducted at Sandbridge Shoal, offshore Virginia via Cooperative Agreement with VIMS). Final Report 2004
Environmental Surveys of Potential Borrow Areas Offshore Northern New Jersey and Southern New York and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Draft report Spring 2003. Final Report Summer 2003
Environmental Survey of Potential Borrow Areas on the East Florida Shelf and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Final Report Fall 2002
Collection of Environmental Data within Sand Resource Areas Offshore North Carolina and the Environmental Implications of Sand Removal for Coastal and Beach Restoration. Final Report Summer 2002
Surveys of Sand Resource Areas Offshore Maryland/Delaware and the Environmental Implications of Sand Removal for Beach Restoration Projects. OCS Study MMS 2000-055
Environmental Surveys of OCS Sand Resources Offshore New Jersey. OCS Study MMS 2000-052
Environmental Survey of Identified Sand Resource Areas Offshore Alabama. OCS Study MMS 99-0052
Use of Federal Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware and Virginia. OCS Study MMS 99-0036
Environmental Studies Relative to Potential Sand Mining in the Vicinity of the City of Virginia Beach, Virginia. OCS Study MMS 97-0025
Wave Modeling/Shoreline Erosion
A Numerical Modeling Examination of the Cumulative Physical Effects of Offshore Sand Dredging for Beach Nourishment—New Jersey, Virginia, North Carolina, Florida. Final Report Winter 2001
Wave Climate and Bottom Boundary Layer Dynamics with Implications for Offshore Sand Mining and Barrier Island Replenishment, South-Central Louisiana. OCS Study MMS 2000-053
Wave Climate Modeling and Evaluation Relative to Sand Mining on Ship Shoal, Offshore LA, for Coastal and Barrier Island Restoration. OCS Study MMS 96-0059
A Methodology and Criteria to Assess the Impact of Sand Volume Removed in Federal Waters on the Offshore Wave Climate. OCS Study MMS 99-0046
Generic Studies Applicable to all Offshore Marine Mineral Efforts
Model Development or Modification for Analysis of Benthic and Surface Plume Generation and Extent During Offshore Dredging Operations. Final Report 2002
Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-Term Impacts of Offshore Dredging Operations on the Marine Environment. OCS Report MMS 2001-089
Integrated Study of the Biological and Physical Effects of Marine Aggregate Dredging. Final Report Summer 2002
Study of the Cumulative Effects of Marine Aggregate Dredging. OCS Study MMS 99-0030
Marine Aggregate Mining Benthic and Surface Plume Study. OCS Study MMS 99-0029
Impacts and Direct Effects of Sand Dredging for Beach Renourishment on the Benthic Organisms and Geology of the West Florida Shelf. OCS Report MMS 95-0005
Marine Mining Technologies and Mitigation Techniques. A Detailed Analysis with Respect to the Mining of Specific Offshore Mineral Commodities. OCS Report MMS 95-0003
Synthesis and Analysis of Existing Information Regarding Environmental Effects of Marine Mining. OCS Report MMS 93-0006

vironmental concerns, interested parties, and agency policies on the issues. New Jersey was selected as a State with a strong beach nourishment program and nourishment projects primarily co-funded by the U.S. Army Corps of Engineers (USACE). Texas was selected as a State that was just starting a state-wide program (the 1999 Coastal Erosion Planning and Response Act) and where, historically, beach nourishment projects were funded mostly by local government agencies. Key agencies and staff in each area were identified and contacted to discuss their perspectives on what kind of management strategies would be most appropriate. The next step was to conduct a one-day workshop in each area and identify the key issues and concerns about OCS sand use. The participants in each workshop are provided in MICHEL (2001).

During the Texas workshop, it was made clear that any coordinated management effort should include both Federal OCS and State sand resources, especially since inshore sand resources will be exhausted first because of the costs of going long distances offshore. The State should take the management lead because of their authorities and ability to work locally. The first step should be development of comprehensive inventory of sand needs and sources. Without this information, there is no basis for developing management strategies. The plan should include an adaptive management approach that uses monitoring and routine re-appraisal to redirect efforts and priorities. There was a concern that the process should not become so big and cumbersome that it slows down beach nourishment projects or becomes a bureaucracy with unproductive meetings. Finally, cost sharing at the Federal, State, and local levels will be needed in all phases of data collection, monitoring, and management.

The results of the New Jersey workshop showed that an adequate base of funding provides a good support structure for successful planning. New Jersey's program has funds (provided by an additional hotel tax in coastal counties) to support dedicated staff, long-term data collection, and coordination among stakeholders. It was recognized that good geological data identifying sand sources and volumes and a sand budget identifying long-term needs are required to begin the planning process. New Jersey has developed and implemented a long-term plan for data collection, finding that task forces or working groups are effective when members have funding to work the project, are personally involved in the work, and know there is a long-term commitment to the program. Therefore, the regional management effort should be formalized through cooperative agreements. However, there is a need to integrate monitoring study results and data interpretation, so that consensus can be reached on findings, and future monitoring requirements can be modified to reflect the most current understanding of the types and duration of impacts. New understandings of impacts learned from monitoring studies need to be incorporated into resource management decisions. Therefore, long-term monitoring is required for 50-year projects because it is not possible to predict potential future impacts (see discussion of potential impacts in NAIRN *et al.*, this volume) over that period. The types of monitoring will change over time, reflecting information and understanding gained from on-going studies. It was recommended that MMS, with its broader perspective, should be the clearinghouse for environmental impact studies of OCS borrow sites.

MMS specifically considered the Regional Sediment Management (RSM) demonstration programs being conducted by the USACE. The objectives of the RSM demonstration programs are to 1) implement regional sediment management practices, 2) improve economic performance by linking projects, 3) develop new engineering techniques to optimize/conserve sediments, 4) determine bureaucratic obstacles to RSM, and 5) manage in concert with the environment (USACE, 2002). Because of their emphasis on the littoral zone, the RSM demonstration programs will not address all of the issues of concern to MMS in its charge of environmental management of OCS sand resources. OCS sand would be considered as a resource that could contribute to the sand budget along a shoreline. As the RSM demonstration programs expand, they could provide both funding and administrative resources for some of the activities that apply to both USACE and MMS objectives. In particular, increased cost effectiveness through better coordination among projects and stakeholders is a major objective of the RSM demonstration programs.

A FRAMEWORK FOR MANAGING OCS SAND RESOURCES

Based on discussions with MMS, agency representatives, and other stakeholders, it is clear that MMS needs a strategy for managing offshore sand and gravel resources in the public's trust. The question is, how should the resource be managed? There are multiple agencies with overlapping jurisdictions, differing objectives, limited staff resources, and highly variable technical skills. Decisions are not made solely on policy, technical, or economic considerations, but also include assessment of the relative importance and the magnitude of trade-offs among impacts and benefits. Not all beach nourishment projects are driven by the economics of tourist visitations or protection of private development. Sand placement on shorelines is also driven by the need to protect important coastal habitats, fishery resources, and wildlife. For example, in Texas, beach nourishment has been proposed to protect the valuable wetlands of the McFadden National Wildlife Refuge. Each State faces a different combination of issues, and resource managers strive to consider all costs and benefits.

Elements of a Regional Management Strategy

To be effective, the management strategy should be a formalized process for planning, decisionmaking, and coordination among all stakeholders. Ad-hoc committees do not have the necessary authorities. Therefore, a high level of commitment is required by each organization and the individuals assigned to participate in the process, so they are involved on a long-term basis. The organization has to provide time, funding, and recognition for participation. The management team members should be pro-active, identifying potential problems and data gaps, developing study plans and collecting data needed to address the problems, then using the results to propose and implement needed solutions and reach conclusions. There should be a mechanism for sharing of information among stakeholders, through open meetings where issues can be raised and discussed. There needs to be a mechanism for setting goals and priorities and resolving issues through discussion, data collection and interpretation, and consensus building.

Goals and Activities for Regional Management of OCS Sand

The goals should be specific and agreed upon at the beginning of the process. MMS's goals are to avoid or minimize the environmental impacts to OCS sand borrow sites that may represent long-term sources of sand for coastal communities; reduce the time and costs to efficiently access OCS borrow sites; promote coordination among beach nourishment/coastal restoration projects to maximize cost-effectiveness; and allow for adaptive management by learning from past projects to better manage future projects. It is important to evaluate the current process for planning, implementing, and coordinating beach nourishment projects, then identify problem areas and set priorities for working on solutions.

Based on discussions with local, state, and federal stakeholders involved in beach nourishment projects, the following issues are identified as key sand management activities:

—Compile inventory of projected sand needs from all entities in the region of interest, based on analysis of the sediment budget for the total system. This analysis is critical to a state-wide assessment of the long-term sand needs and priorities.

—Compile inventory of known sand resources available, including both nearshore and offshore sand borrow sites. MMA has coordinated such studies to assess OCS sand resources through establishment of geological task forces in ten states, to assist them in this activity. This work involves new geophysical surveys, coring, and data analysis of previous offshore studies.

—Identify critical data gaps (environmental/resource) and recommend actions to address these gaps. In New Jersey, this data gap analysis has led to focused studies to inventory new potential sand sources.

—Develop guidelines for sand resource allocation (volume available versus short- and long-term needs). The objective is to preclude future "sand wars", as well as define appropriate uses of available sand resources.

—Develop and keep updated a master schedule of proposed sand dredging plans.

—Evaluate strategies for permit streamlining. There has been little work in this area.

—Develop procedures for accessing sand under emergency conditions. No work has been done in this area, to-date.

—Establish monitoring requirements and recovery end-points.

—Develop techniques for dredging that maximize use of the site and minimize impacts, by testing different methods (*e.g.*, dredging in strips that leave undisturbed areas to promote more rapid recruitment of benthic communities).

—Identify time windows that are best/worst time for dredging to protect sensitive species.

SPECIFIC RECOMMENDATIONS FOR OCS SAND MANAGEMENT

Considering all of the information obtained during this study, the following recommendations can improve the planning process for managing OCS sand resources.

Regional management of sand resources is feasible and essential to the MMS goals for managing OCS sand resources in a cost-effective and environmentally sound manner. The expected increase in demand for OCS sand will trigger a need to manage the resource using a regional approach. Now that there are multiple potential users for sand from a single site, resource allocation becomes an issue. Frequent use raises concerns about the ability of the ecosystem to recover between dredging events, as well as long-term cumulative impacts. Coordination among users could reduce all types of costs, from mobilization to monitoring. Other Federal agencies, States, and local governments clearly look to MMS to provide leadership and guidance on both policy and technical issues associated with use of OCS sand for beach nourishment. They also expect to be active participants in decisions about any restrictions or costs associated with accessing OCS sand resources.

Generally, the "region" should consist of a single State. States differ in the types of beach erosion problems, approaches to solve them, amount of data available, level of state involvement and commitment, *etc.* It would be an added level of difficulty to engage more than one state in the process. The exception will be for specific borrow sites that straddle state lines, which would have to be handled on a case-by-case basis.

Regional management efforts should start in those States that can provide a strong State Lead and have already identified a need for OCS sand resources. MMS is limited by the small size of the sand and gravel/marine minerals program. They cannot take on the administrative burdens of coordination and logistics for each individual state that wants to use OCS sand resources. Furthermore, it would be more cost effective to work with agencies that have the resources and commitment to develop a successful approach that will be a model for future efforts. For example, the success of the early coordination efforts of the geological Task Force in New Jersey is already recognized as a model that should be followed for biological assessments there. Another factor is the degree of interest in accessing OCS sand resources. Because of the high costs of handling sand over long distances, inshore sources of sand are considered to be more economically feasible. However, there other factors that might out-weigh the cost factor, such as not interfering with the littoral transport system, environmental concerns about continual dredging in the nearshore region, and changes to wave conditions resulting from increased depths nearshore.

MMS should build on existing geological "Task Forces" in each State, letting them evolve into a State/MMS Sand Management Task Force. MMS has already established task forces or State/MMS cooperatives to collect geological data and identify promising OCS sand resources in nine states. These established relationships can be the basis for expanded responsibilities of a Sand Management Task Force (SMTF).

Compiling inventories of needs and sources is the first step in the process and needs to be completed before addressing other issues.

The relationship between the Sand Management Task Force and the USACE RSM demonstration programs will have to be addressed, depending on the stage of implementation in each region. The RSM demonstration programs presently emphasize collection of data on sediment budgets and focus on operational issues. The MMS objectives for cost effectiveness and efficiency match closely with those of RSM. There should be good cross-coordination between the two groups where they are both active.

MMS should expand its role in sponsoring and co-sponsoring workshops and developing synthesis documents and guidelines on technical and policy issues for managing offshore sand resources. MMS has already started this process with a special Sand Resources session at the January 2002 Gulf of Mexico Information Transfer Meeting. MMS could sponsor smaller, half-day or one-day meetings on specific topics where researchers involved in monitoring of the impacts of OCS sand dredging can informally discuss their results and work toward the development of findings and conclusions on the extent and duration of dredging impacts and rates of recovery of benthic communities and related biological and physical impacts (see NAIRN *et al.,* this volume). These meetings could be coordinated with other scheduled meetings or conferences. MMS could arrange for 1–2 experts to participate in the meetings, as appropriate for the selected topic.

MMS has traditionally emphasized publication of study results in peer-reviewed journals to provide scientific credibility to the study results. There should be parallel efforts to generate and disseminate in a timely manner non-peer-reviewed technical and policy documents that represent current approaches, guidelines, policies, findings, etc. MMS could take the lead on developing technical synthesis reports on the current state of knowledge on selected topics. These reports would be 2–5 page technical summaries on topics where there is general consensus on findings. Their production could be triggered by the completion of a major study, or the consensus reached at one of the smaller meetings discussed above. MMS could synthesize the guidelines developed by more advanced SMTFs and make them available on their web site as templates for use by others. This role of providing a mechanism for sharing of experience and building on previous efforts is appropriate for a Federal agency with a broader perspective and contact with multiple agencies. Through cooperative agreements, MMS can achieve significant cost effectiveness and value-added benefits, as demonstrated by the progress made in geological studies to identify and quantify OCS sand resources in the priority states.

MMS should become a clearinghouse for studies and findings on environmental impacts associated with offshore dredging relative to OCS/Federal borrow areas and use its web site to better disseminate this knowledge. MMS should take a leadership role in managing and coordinating environmental studies on the impacts of offshore dredging of OCS borrow sites. The costs of environmental monitoring of offshore areas are high, thus the study results need to be widely disseminated to all interested parties in a form that is useful to them. The NATIONAL RESEARCH COUNCIL (1990) report on Managing Troubled Waters: The Role of Marine Environmental Monitoring noted that "not only must data be gathered, but attention must also be paid to their management, synthesis, interpretation, and analysis" and "adequate resources are needed not only for data collection but also for detailed analysis and evaluation over the long term." MMS has followed these guidelines for their own studies, by producing and widely distributing reports at several technical levels (*e.g.,* executive summaries, technical summaries, non-technical summaries, detailed reports). Yet there is a need for better dissemination of all environmental monitoring data for offshore areas, and the Internet can be an effective means of accomplishing this goal. A well-designed and regularly updated MMS web site could achieve many of the MMS objectives, in terms of providing value-added benefits through sharing of information and findings among States. The MMS web site should become the best site for getting the most current, technical and policy information on offshore sand and gravel resources.

MMS should continue to play a lead role in the design and funding of long-term monitoring studies. Monitoring studies are expensive to conduct in offshore waters. There are never enough data to fully characterize all potential impacts. Of particular concern are potential long-term impacts associated with repeated dredging of a site. Therefore, monitoring programs have to be well-designed, cost-effective, and funded over long enough periods to produce definitive results. Funding is a key problem because no one agency or group has enough resources to fund monitoring programs. When there are multiple users of a site, responsibility for monitoring becomes even more complicated.

Monitoring costs need to be shared among the beneficiaries of the sand (State and local government sponsor), the managers of the resource (MMS), and other Federal agencies with an interest in the results of a monitoring effort. For instance, monitoring studies may provide valuable data for identifying essential fish habitat in the Federal OCS, thus the National Marine Fisheries Service should be involved in funding, study design, and interpretation. One of the more important functions of the State/MMS Sand Management Task Force will be to develop appropriate monitoring requirements and identify funding sources to support them. Without funds to support long-term monitoring of potential impacts, MMS will not be able to meet its responsibility to ensure that the OCS sand use does not adversely affect the marine and human environments.

MMS has already started work on improving monitoring program design. They funded a study to design a monitoring program that can be used to evaluate the potential physical and biological impacts resulting from the long-term use of OCS sand, and prepare protocols for the monitoring plan elements (MICHEL *et al.,* 2001; NAIRN *et al.,* this volume). They are cooperating with the Virginia Institute of Marine Science in a test of these protocols in 2002–2004. It should be noted that the proposed monitoring design includes post-dredging surveys at 1, 3, 5, and 7 years after the event (NAIRN *et al.,* this volume), thus monitoring may be required until impacts and recovery rates are better defined. Funding is needed not only for data collection and analysis, but also for long-term data management, interpretation, and synthesis, so the results can be used to support resource management decisions. MMS should assist in the development of data management strategies for the wealth of environmental data for the OCS being collected as part of the monitoring programs.

SUMMARY

Regional management of Federal sand and gravel resources will allow MMS to achieve its goals of environmentally sound management coupled with cost-effective permitting, planning, operations, and monitoring. Dredging of Federal borrow sites requires coordination among a wide variety of stakeholders. Sand management task forces provide a formal process under which key issues are identified, studies are designed and implemented to address these issues, and the results are formulated into technical and policy guidelines for future projects. Although MMS is the steward of these mineral resources, it is a partner in the process to develop best-management practices for dredging projects in Federal waters.

ACKNOWLEDGEMENTS

This effort was conducted under contract to the Minerals Management Service, Contract No. 14-35-0001-31051. Barry Drucker, the MMS Project Manager, contributed significantly to the project objectives. Carol Hartgen of MMS is acknowledged for her contribution and interest in promoting a management strategy for OCS sand resources. Rob Nairn of W.F. Baird & Associates Ltd. and Jay Johnson of Applied Marine Sciences, Inc. provided technical review and comments. The Texas and New Jersey workshop participants are acknowledged for their time and valuable input. This study greatly benefited from their insights and contributions.

LITERATURE CITED

DRUCKER, B.S.; WASKE, W., and BURNES, M.R., this volume. The U. S. Minerals Management Service's Outer Continental Shelf Sand and Gravel Program: Environmental Studies to Evaluate the Effects of Offshore Dredging Operations in Federal Waters.

HAYES, M.O. and NAIRN, R., 2002. Characteristics of OCS shelf sand ridges and shoals. This volume.

GIORDANO, A.C.; DRUCKER, B., and BASSIM, K., 1999. *Guidelines for Obtaining Minerals Other than Oil, Gas, & Sulphur on the Outer Continental Shelf.* Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 99-0070, 19p.

MICHEL, J.; NAIRN, R.; JOHNSON, J.A., and HARDIN, D., 2001. *Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-Term Impacts of Offshore Dredging Operations on the Marine Environment*: Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 2001-089, 116p.

MICHEL, J., 2001. *Examination of Regional Management Strategies for Federal Offshore Borrow Areas Along the United States East and Gulf of Mexico Coasts.* Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, OCS Report MMS 2001-090, 23 pp. + appendices.

NAIRN, R.; JOHNSON, J.A.; HARDIN, D., and MICHEL, J., 2002. Development and design of a biological and physical monitoring program for the evaluation of long-term impacts to the marine environment from offshore sand dredging operations in the U.S. Outer Continental Shelf. This volume.

NATIONAL RESEARCH COUNCIL, 1990. *Managing Troubled Waters: The Role of Marine Environmental Monitoring.* Washington, D.C.: National Academy Press, 125 pp.

U.S. ARMY CORPS OF ENGINEERS (USACE), 2002. Northen Gulf of Mexico Regional Sediment Management Program Demonstration Website (http://gis.sam.usace.army.mil/projects/RSM.

Journal of Coastal Research	20	1	126–137	West Palm Beach, Florida	Winter 2004

A Biological and Physical Monitoring Program to Evaluate Long-term Impacts from Sand Dredging Operations in the United States Outer Continental Shelf

Rob Nairn†, Jay A. Johnson‡, Dane Hardin‡, and Jacqueline Michel§

†W.F. Baird & Associates, Ltd.
627 Lyons Lane, Suite 200
Oakville, Ontario, Canada, L6J 5Z7

‡Applied Marine Sciences, Inc.
4749 Bennett Drive
Suite L
Livermore, CA 94550, U.S.A.

§Research Planning, Inc.
1121 Park Street
Columbia, SC 29201, U.S.A.

ABSTRACT

NAIRN, R.; JOHNSON, J.A.; HARDIN, D., and MICHEL, J., 2004. A biological and physical monitoring program to evaluate long-term impacts from sand dredging operations in the United States Outer Continental Shelf. *Journal of Coastal Research,* 20(1), 126–137. West Palm Beach (Florida), ISSN 0749-0208.

The Minerals Management Service (MMS) International Activities and Marine Minerals Division is charged with management of Federal Outer Continental Shelf (OCS) sand and gravel resources that would be used for beach nourishment to repair storm damage and protect against sea-level rise. To reduce environmental damage associated with long-term and large-scale use of these resources, a project was funded by MMS to design a comprehensive physical and biological monitoring program for sand-mining activities. An initial task of this project was performance of a literature review to determine where information gaps existed regarding the effects of sand mining and which physical processes and biological resources should be the focus of monitoring. Based upon the literature review and a conference with other investigators, the monitoring program was designed to include the following elements: benthic communities and their trophic relationships to fishes, marine mammals and wildlife (operational monitoring), sediment sampling and analysis, wave monitoring and modeling, bathymetric and substrate surveys, and shoreline monitoring and modeling. Protocols were developed for these elements to ensure consistency of methods among studies. The two primary physical impacts of concern are changes to the sea bed resulting in changes to the erosion and sedimentation processes along the shore and changes to the sea bed that would have a direct and significant impact on the biological environment. The most important biological impacts from dredging to be monitored in this program are changes in benthic secondary production and trophic transfer to fishes.

ADDITIONAL INDEX WORDS: *Sand resources, OCS, marine biological monitoring, marine physical monitoring, sand mining, benthic secondary production, trophic transfer, marine mammal monitoring.*

INTRODUCTION

Sand from nearshore coastal marine deposits has been frequently used for replenishing beaches in many, highly eroded, coastal areas of the United States, predominantly occurring along the East and Gulf Coasts of the U.S. Local and Federal agencies have relied on sand deposits in the territorial seas to restore the beaches and prevent further erosion, loss of property, and ecological damage. As these nearshore coastal deposits become depleted, sand sources located farther offshore on the Outer Continental Shelf (OCS) are being used. The Minerals Management Service (MMS) International Activities and Marine Minerals Division (INTERMAR) is charged with the responsibility for administering the Department of the Interior's role in mineral resource development other than oil, gas, and sulfur on the OCS. Between 1995 and 2001, MMS conveyed 14,600,000 cubic yards of OCS sand for ten projects.

MMS anticipates that OCS sand deposits will be needed as long-term sources of sand for coastal erosion management because there are diminishing supplies of onshore and nearshore sand. Long-term sources of sand are needed to address the effects of sea level rise and other natural and human-induced factors that lead to increased erosion. The renourishment cycles for beaches or coastal areas and the emergency repair of beaches from severe storms requires quantities of sand that currently cannot always be satisfied from state sources.

To prepare for an increased demand for OCS sand, the MMS has entered into cooperative agreements with ten coastal states to identify and study potential OCS borrow sites. They have also funded baseline marine biological and physical oceanographic environmental studies at select sites, and studied the potential impacts of sand dredging, including modeling studies, to determine the risk of shoreline erosion as a result of sand dredging. To date, coastal erosion management projects utilizing Federal OCS sand resources have been examined on a case-by-case basis. In the future, these resources will need to be managed on a long-term, large scale, system-wide basis to ensure that environmental damage will

10 received and accepted in revision 6 June 2003.

not occur as a result of continual and prolonged use. Sand sources that are to be used repeatedly may require additional biological and physical monitoring to ensure that unacceptable impacts to the marine and coastal environments do not occur. The MMS commissioned a study to design a long-term monitoring program that would evaluate the physical and biological changes that might occur as a result of using Federal OCS borrow areas, which is presented here. Readers are referred to MICHEL et al. (2001) for detailed sampling and analysis protocols for this program.

MONITORING PROGRAM GOALS AND ASSUMPTIONS

During the initial stages of the program, project goals and resource management questions that the monitoring program would address were developed. This effort was conducted with the assistance of MMS project personnel. Program goals included: to better understand the physical and ecological effects of sand dredging at the dredge site; and to obtain data or information that would be valuable for resource management decisions.

There were specific resource management questions around which the monitoring program was designed. First, is there a threshold above which continuous mining results in unacceptable damage/impairment to marine ecosystems? Second, are there operational methods that can be changed to reduce/eliminate negative impacts to physical or biological conditions? Third, does sand dredging result in predicted impacts? Fourth, are there impacts that were not predicted or anticipated? Fifth, do the predicted impacts occur and recover as expected?

Finally, to keep the focus of the monitoring program on locations where environmental impact assessments had indicated that sand dredging would be environmentally acceptable, the monitoring program design was based on several assumptions that concerned the type of dredging operations and locations where sand dredging would be allowed in the OCS. First, only beach replenishment type mining would be considered, in which only a small fraction of the material dredged is returned to the sea during dredging (less than 10 to 20% of what is taken on board). Second, dredging near environmentally sensitive (hard bottom, coral reefs, contaminated sediments) or culturally important locations would not be allowed by MMS; avoidable physical and biological impacts (critical habitats, locations and time periods) would be avoided. Third, the monitoring program would focus only on physical changes to habitat and community structure. Fourth, to determine the scale of monitoring efforts, it was assumed that the dredging projects subject to the monitoring protocols typically would involve removal of approximately 1,000,000 m^3 of sand.

The monitoring program had to be designed to address issues associated with the most common type of sand deposits identified by MMS, while also being applicable to other types of deposits. Ridge and shoal features represent the predominant morphology of the OCS sand borrow sites identified in MMS jurisdictions along the eastern seaboard of the U.S. Currently the only exceptions are identified deposits off the coasts of Florida and South Carolina. Nevertheless, it should be noted that the proposed protocols and monitoring program design are equally applicable to flat, shelf-type ecosystems where buried geological features can represent suitable sand and gravel borrow deposits. However, these deposits are more difficult to find and this may explain why most deposits identified thus far have been ridge and shoal features.

ENVIRONMENTAL IMPACTS FROM OCS SAND MINING

A comprehensive literature review was completed of the many studies of dredging in the continental shelf environment. As noted above, the MMS has sponsored many investigations of impacts along the Atlantic and Gulf coasts of the US and in the UK. Significant independent work on assessing impacts has also been completed in Florida, South Carolina, the UK, continental Europe and Hong Kong (MICHEL et al., 2001).

Following the completion of the literature review, those ecological resources (physical and biological) were identified that would have the greatest potential for being affected by offshore sand mining, both directly and indirectly. Impacts occurring as a one-time dredging event at a given location or as repeated dredging of an area over some time period were included. All physical and biological processes were initially considered.

Figure 1 illustrates the complex relationships between key physical and biological parameters that were identified during the literature review. Parameters are divided among one biological and three physical components, as well as geographic influences. Clearly, it would not be feasible to develop monitoring protocols to address all of the different processes and parameters represented in Figure 1. The challenge of developing the protocols was to take advantage of the interrelationships between processes in order to focus on some key indicator parameters, in addition to those that are most significant in nature. Table 1 presents a summary of the specific physical processes and biological communities potentially affected by OCS sand dredging, as identified during the literature review.

Impacts were defined as either direct or indirect. Direct impacts were defined as changes that occur as a primary response to the dredging process, without an intervening process (*e.g.*, removal of infauna). They generally extend from the area of extraction to the edge of the plume sedimentation footprint and/or extent of the plume itself in the water column. Indirect impacts were defined as changes that occur as a result of a secondary response to dredging activities (*e.g.*, change in fish populations because of the removal of infauna, changing the prey base), both within and outside the dredged area.

Geophysical Environment and Processes

There are three primary components of the physical environment: morphodynamics, seabed composition and oceanographic conditions. The term morphodynamics is used to describe the fluctuations and trends in changes to the elevation of the seabed and land surface extending from the vicinity of

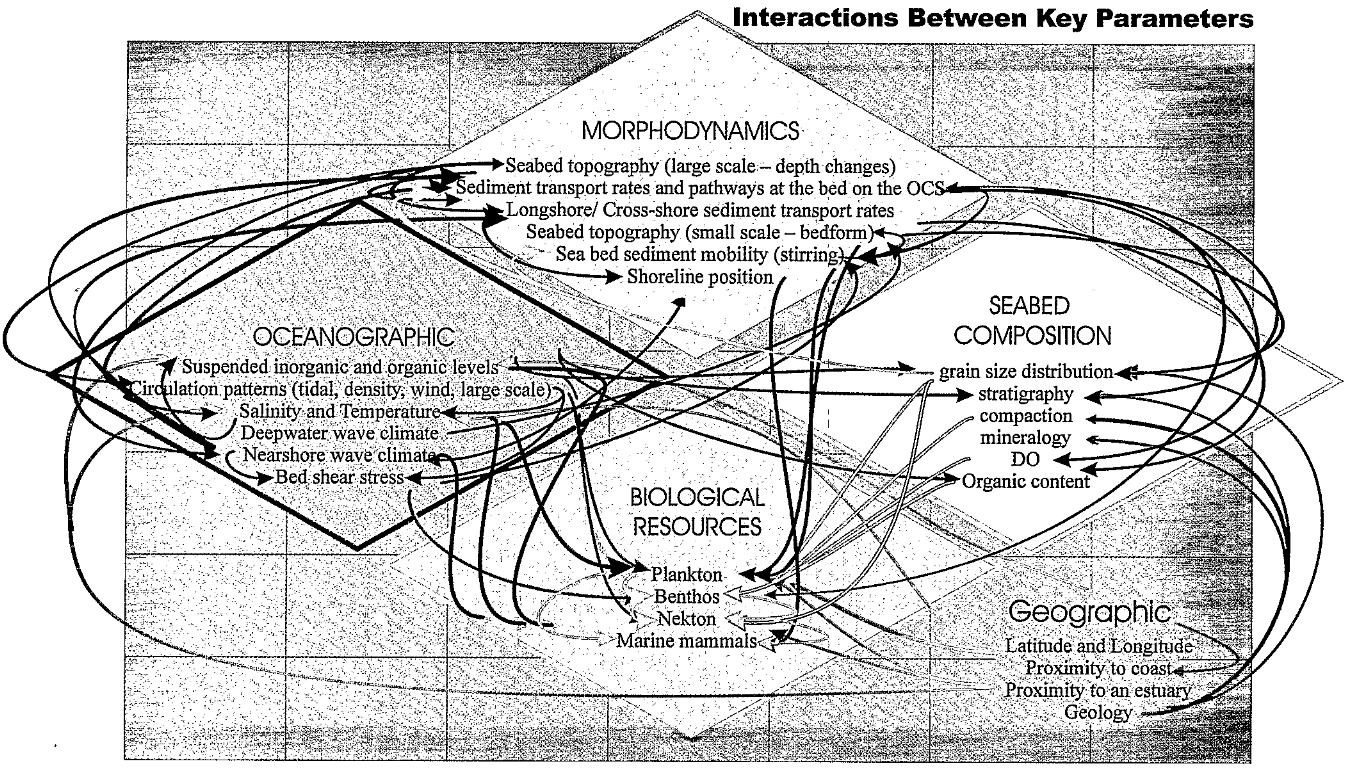


Figure 1. Interactions between physical and biological parameters.

the borrow deposit to the furthest onshore extent of the dynamic beach zone. These changes are a result of sediment transport processes, and may occur across a wide spatial scale, extending from individual sand grains, to bedform, to large-scale erosion and accretion, including shoreline change.

Seabed composition is the term used to address the temporal and spatial (three-dimensional) variability of the characteristics of the seabed including, but not limited to, grain-size distribution, stratigraphy, compaction, mineralogy, dissolved oxygen, and organic content. There are interrelationships between morphodynamics and seabed characteristics as the movement of sediment results in disturbance and change to the bed conditions and the sediment and larval deposition environment of the seafloor.

Finally, oceanographic conditions include a wide range of processes and properties associated with the water column including waves, currents (with a wide range of forcing functions), suspended sediment levels, water temperature, salinity and others.

Morphodynamic Impacts

The most apparent direct physical impact is the removal of substrate and the reduction in the elevation of the seabed. This may result in the creation of furrows or a pit or the removal of a bathymetric high such as the top of a shoal. Indirect morphodynamic impacts include subsequent changes to the seabed topography, seabed mobility, and shoreline change.

From a purely physical perspective, the only significant change of consequence is the potential indirect impact of dredging on shoreline change. For example, an increase in depth at a given location is not of direct importance to human activities, nor is a temporary sediment plume located in federal waters some distance from shore. Theoretically the shoreline change can occur in one of two ways: 1) through alterations to the wave transformation pattern, changing the waves that reach the shore, in turn modifying the sand transport-related processes and ultimately changing erosion and accretion patterns; and 2) by interrupting or modifying a sand supply pathway from or through the borrow area to the shore. A review of the currently identified OCS borrow deposits suggests that most, but not all, are immune from the second impact because they are isolated from the sediment budget of the littoral system by large distances and muddy areas (the latter indicating the absence of a sand transport pathway). Nevertheless, this will not always be the case. Careful consideration must be given on a site-specific basis to the possibility of interrupting a sediment supply pathway to the shoreline.

All other local physical changes and direct impacts caused by dredging are important only if they result in a biological impact, either directly or indirectly. From a morphodynamic perspective, the direct impacts consist of the depressions, furrows, and pits left by the dredging operations. Clearly, these can have an important impact on the benthic community. The indirect biological impacts derived from a change to morphodynamics may include long-term changes to depths within and beyond the dredge area, changing the mobility of the sediment due to a change in depth and/or wave conditions. Probably the biggest concern is the potential for ridge and shoal type features to deflate or be smoothed out where borrow deposits are accessed on an ongoing basis. This outcome could lead to large-scale impacts to biological communities that rely on the structure of these features and to possible shoreline impacts.

Impacts to Seabed Characteristics

Direct impacts to seabed characteristics include removal and disturbance of the substrate and exposure of an underlying layer with different characteristics (*i.e.,* grain size, reduced dissolved oxygen levels, and compaction), and changes in grain size of surficial sediments due to settling of fines from overspill plumes or sediment reworking. Indirect impacts include changes related to erosion and deposition. These changes to the seabed characteristics will only be significant where they result in biological impacts.

Oceanographic Impacts

The primary direct impact to the oceanographic conditions would be the elevated levels of suspended inorganic and organic solids in the overspill (at the point of discharge from the hopper dredge) and benthic (at the drag head) plumes. Indirect impacts include changes to the waves within and beyond the borrow area, changes to bed shear stresses and related seabed mobility due to changes to waves, and changes to near-bed current velocities driven by tides, wind, and large-scale phenomenon. Recent studies in the UK described by NEWELL *et al.* (1998) have found that the only detectable plume impact from a biological perspective is the direct sedimentation footprint and that this footprint is relatively limited in spatial extent (300 to 500 m from the borrow deposit). The potential biological effects of turbidity plumes on nekton include feeding impairment, a reduction in reaction distances (VINYARD and OBRIEN, 1976), reductions in the ability of visual predators to perceive and capture prey (BENFIELD and MINELL, 1996), and the clogging of gill cavities that results in retardation of normal respiration (BRUTON, 1985) and possible death (ROBINS, 1957). Based on the spatial and temporal extent of turbidity plumes from sand dredging operations, these impacts have been predicted to be insignificant (HAMMER, 2000). The investigations reported and referenced by NEWELL *et al.* (1998) pertain to heavily screened hopper dredge operations where there is a very significant overspill of sediment. Most sand dredging operations on the OCS will be non-screened (at least initially for beach nourishment borrow deposits) with much less overspill of sediment and the plume impact will be even less important than observed by NEWELL *et al.* (1998).

Biological Ecosystems

As illustrated in Table 1, the marine biological communities and associated habitats that were determined as being potentially affected by OCS sand dredging included: plankton, soft and hard substrate benthic communities, nekton, and marine mammals and wildlife.

As previously discussed, the MMS determined that hard substrate areas would be avoided by dredging activities or be surrounded by sufficient buffer zones to prevent dredge discharges from having any impact. In addition, since no sorting of dredged material would occur during beach replenishment dredging operations, the sediment plumes created by the dredge operations were determined to be very small and temporary. Consequently, effects to plankton, fish, and marine mammals should be minimal and of short duration (HARDAWAY *et al.,* 1998; HAMMER *et al.,* 1993).

Although short-term loss and changes in benthic community structure have been documented following sand dredging (BLAKE *et al.,* 1996; VAN DOLAH *et al.,* 1992), the ecological significance to the benthic community is uncertain. Studies investigating the recovery of benthic communities following dredging (BLAKE *et al.,* 1996; NEWELL *et al.,* 1998; VAN DOLAH *et al.,* 1992) have indicated that communities of comparable total abundance and diversity can be expected to recolonize dredge sites within several years. Although these recolonized communities may be similar in total abundance and species diversity, their taxonomic composition is often very different from pre- to post-dredging.

The key ecological question that remains to be answered is: Do the new benthic communities fill the same trophic function and provide the same energy transfer to higher trophic levels, as did the original communities? If they do not, then the potential long-term and cumulative ecological impacts of sand dredging may be far greater than predicted to date, a condition that may be unacceptable as more sites along the coast are dredged and others are dredged on a regular basis.

The potential direct effects to fisheries from sand dredging are unknown. Most of the environmental impact assessments prepared for OCS sand dredging indicate minimal or nonexistent impacts to fisheries (HAMMER, 1993; LOUIS BERGER GROUP, 1999). This assessment has been based on the determination that most of the fish inhabiting the potential dredge areas were characterized as wide-foraging or migratory, spending only part of their life cycle in the dredge borrow area. In addition, the ridge/shoal and shelf features identified as potential sand borrow areas are very large in geographic extent, extending over kilometers of seafloor, and the potential borrow area for each dredging event is relatively small. Therefore, the lost or altered habitat area, overall, would probably be minimal and very short-lived assuming that dredging technology is utilized that minimizes sediment plumes and sedimentation in surrounding areas.

We found that little is known or published on the ecological utilization of ridge/shoal features by fish. Whether these features provide critical habitat for spawning, overwintering, or foraging is relatively unknown. This information gap was identified as an area requiring further study, and the results from such a study could result in the modification of the proposed monitoring program.

Excluding the potential effects of lost essential habitat as a result of dredging, the greatest potential effect to the fish community utilizing a dredge borrow area is an alteration in trophic energy transfer from the benthos to the fish popula-

Table 1. *Summary of potential physical and biological effects of OCS sand mining for beach replenishment.*

	Physical or Biological Change	Effects/Impacts
Morphodynamics		
Direct	Creation of depressions and furrows (possibly ≥1 meter) from removal of substrate	Could result in changes to dredge site and shoreline geomorphology Potential change to benthos
Indirect	Change to seabed topography beyond immediate dredge area through induced erosion/deposition (created by changes to sediment transport processes and pathways)	Could result in impact (long-term) to shoreline geomorphology or the unraveling of a shoal/ridge feature Potential change to benthos
	Change to seabed mobility due to change in depth and in waves/currents (driving forces)	No known or identified significant physical impacts other than those that result in biological impacts. Potential change to benthos
	Change to shoreline evolution	Altered shoreline dynamics
Seabed Composition		
Direct	Removal (and disturbance) of substrate and exposure of underlying layer with different characteristics (grain size, DO, compaction and organic content). In some cases that may result in a positive impact where preferred substrates are exposed.	No known or identified significant physical impacts other than those that result in biological impacts. Potential change to benthos and indirectly to nekton and marine wildlife
	Change in grain size due to settling and deposition of sediment in overspill plume (inside and outside dredged area) and creation of trap for finer sediment.	No known or identified significant physical impacts other than those that result in biological impacts. Potential change to benthos (smothering and altered habitat)
Indirect	Changes in grain size, compaction, organic content and DO induced by indirect erosion/deposition	No known or identified physical impacts. Potential change to benthos and fish (altered habitat)
Oceanography		
Direct	Elevated levels of suspended inorganic and organic solids in the overspill and benthic plumes	Temporarily increased water column turbidity Minimal effect to plankton, marine mammals, marine wildlife and nekton
Indirect	Changes to wave climate over and inshore of the borrow area	Could result in changes to shoreline geomorphology (long-term) to or the unraveling of a shoal/ridge feature Potential change to benthos
	Changes to shear stresses related to alterations to the wave climate	No known or identified significant physical impacts other than those that result in biological impacts.
	Changes to near bed current velocities associated with tidal, density driven and large scale circulation	Could result in shoreline geomorphology impact (long-term)
Geography (location of the borrow deposit)		
Direct	None	No known or identified physical impacts
Indirect	None	No known or identified physical impacts
Plankton		
Direct	Short-term Increased turbidity from cutter head or dredge barge overspill	Limited reductions in primary and secondary productivity
Benthos		
Direct (Soft Bottom)	Loss or reduced suitability of habitat	Total removal/loss of infauna and epifauna at borrow site with recolonization by benthic organisms occurring within 1–5 years (possibly longer) to a community with comparable predisturbance abundance, diversity and biomass but different species composition and community structure
	Changes in nearfield habitat condition resulting from altered sediment particle size composition from cutter-head discharge or altered ridge morphology	Changes species composition and community structure (species present, diversity, abundance and biomass) in nearfield areas
Direct (Hard Bottom)	Increased deposition of advected suspended sediments, increased fluxes of suspended sediments during dredging	Burial of near-bottom organisms with potential changes in species composition and community structure, fouling of feeding and respiratory surfaces
Indirect (Soft Bottom)	Recolonization by an altered (different species composition and community structure) biological community	Altered productivity and energy transfer effects on the food chain; altered species composition of fish prey base
Indirect (Hard Bottom)	Recolonization by an altered (different species composition and community structure) biological community	Altered productivity and energy transfer effects on the food chain; altered species composition of fish prey base

Table 1. *Continued.*

	Physical or Biological Change	Effects/Impacts
Nekton		
Direct	Loss or reduced suitability of habitat	Removal of infauna and epifauna: 1) Loss of foraging habitat; 2) Loss of spawning habitat; 3) Loss of over-wintering habitat
	Increased turbidity and sedimentation	Low risk of gill clogging and burial
Indirect	Recolonization by an altered (different species composition and community structure) biological community	Altered foraging efficiency with resultant effects on individual size, weight, and fecundity
Marine Mammals & Wildlife		
Direct	Collisions during dredging operations and some noise disorientation.	Injury or death of animal; potential disorientation
	Loss or reduced suitability of habitat	Removal of infauna and epifauna: Change in foraging area and food
Indirect	Nearfield habitat changes	Removal of infauna and epifauna: Change in foraging area and food
	Increased turbidity and sedimentation	Reduced visibility resulting in reduced foraging efficiency and injury for visual predators

tion. As indicated above, if the post-dredging amount of energy being transferred to fish populations from the benthos is less than the pre-dredging energy transfer, then the potential long-term and ecological impacts of sand dredging may be far greater than predicted to date, and the level of impact may become unacceptable as more sites along the coast are dredged and others are dredged on a regular basis.

Direct and indirect impacts to marine mammals and other marine wildlife (*e.g.,* sea turtles and birds) were also assessed. The only identifiable direct effect from sand dredging is associated with the direct collision of marine mammals and turtles with the dredge ship or the entrainment of turtles in the suction dredge. Although such occurrences are very rare, U.S. environmental regulations mandate that any potential negative interactions with marine mammals and turtles should be prevented.

LONG-TERM MONITORING PROGRAM DESIGN

All of the identified OCS borrow sites share some common features. They are all in relatively shallow water, generally between 5 m and 15 m deep. The sites are mostly disconnected from coasts with respect to sediment transport pathways. The sites also fall into three morphologic categories: isolated ridges and swales, shoals, and shelves. Most of the sites that have been identified thus far fall into the ridges and swales category. These features are described in more detail in a companion paper included in this special issue (HAYES and NAIRN, 2004). It is noted that there are likely to be many other deposits discovered in the future that are associated with buried paleo channels and deltas. While more difficult to identify initially, these types of features may provide better quality sand, be located closer to shore, and may have less potential for impact when dredged. The monitoring program developed for the MMS is capable of addressing all types of borrow deposits.

Following the evaluation and assessment of physical and biological impacts that potentially result from OCS sand mining, six elements were selected for inclusion in the monitoring program. They included: sediment sampling and analysis, wave monitoring and modeling, bathymetric and substrate surveys, shoreline monitoring and modeling, benthic communities and their trophic relationships to fish, and marine mammals and wildlife.

Physical Monitoring Elements

Recognizing the fact that most physical impacts have the potential to become significant only when they result in unacceptable direct or indirect biological impacts or affect shoreline dynamics, inshore of the borrow deposit, the monitoring program needed to consider the biophysical interactions of the physical impacts. The review of possible physical impacts resulting from sand dredging indicated that for monitoring and modeling of physical parameters, only three physical changes needed to be considered. These included, changes to bathymetry, changes to waves and possible related shoreline changes, and changes to the seabed characteristics that may result in biological impacts. Based on these considerations, four physical monitoring and modeling protocols were developed to address these issues, which included bathymetric and substrate surveys, sediment sampling and analysis, wave monitoring and modeling, and shoreline monitoring and modeling.

The first two protocols primarily address the potential for biological impacts that may result from physical impacts. They essentially focus on tracking geomorphic changes to the borrow area and the surrounding seabed. For many of the currently identified OCS deposits, the potential impacts to the form of ridge and shoal features will be closely monitored. The bathymetric and substrate surveys protocol also provides a description of the form of the borrow deposit (and any indirect changes on adjacent seabed elevations) that is required as input to the Wave Modeling, the third protocol listed above.

The third and fourth protocols listed above address the potential for shoreline impacts that may be directly related to changes to the seabed elevations in the vicinity of the borrow deposit. Changes in seabed elevations may, in turn, influence the waves that reach the shore inshore of the borrow deposit,

Table 2. *Summary of requirements of the physical monitoring protocols.*

Protocol	Potential Impact	Objectives	Requirements: Monitoring	Requirements: Modeling
Bathymetry and Substrate	Changes to the morphology and substrate characteristics of the borrow deposit and surrounding area (particularly for ridges and shoals) and potential physical (waves and shoreline change) and biological impacts.	1. Determine the location and quantity of sand removed and change to bathymetry caused by dredging operations. 2. Quantify subsequent changes to bathymetry in the immediate vicinity of the borrow area. 3. Quantify potential changes to the overall borrow deposit feature (e.g. ridge or shoal if one exists)	1. Hydrographic Survey (single beam acoustic) plus Side Scan Sonar: or, 2. Hydrographic Survey with Multibeam technique; or, 3. LIDAR/SHOALS or other methods that are able to achieve specifications and requirements of the Protocol. Limitations of LIDAR/SHOALS for this application are detailed in Michel et al. (2001).	
Sediment	Changes in sediment texture and total organic content and subsequent biological impacts.	1. Define changes to texture caused by removal, sedimentation and indirect erosion/deposition processes. 2. Potential changes may serve the assessment of changes to morphology of features at the borrow deposit (e.g. ridges and shoals). 3. Determine changes in TOC to assess potential impact to benthic communities.	Collect sand samples at the location of benthic samples and test for grain size distribution (both sieve and hydrometer test or equivalent) and TOC method based on high temperature combustion.	
Waves	Change to wave transformation patterns over the dredged area with possible ultimate impact of shoreline change	1. Develop a continuous record of wave conditions starting from first access of borrow deposit. 2. Assess influence of initial changes to bathymetry. 3. Assess influence of subsequent (direct and indirect) changes to bathymetry.	Deepwater (or preferably directly offshore of the borrow site) wave data through combination of measured directional data and nondirectional data and available hindcast data.	Complete nearshore wave transformation modeling to transfer deepwater waves to the borrow deposit (if necessary), over the borrow deposit and into shore (ultimately for input to the shoreline change model).
Shoreline	Shoreline erosion directly attributable to dredging at the borrow deposit.	1. Document actual shoreline change (regardless of cause). 2. Assess the impact of dredging at the borrow deposit.	1. Beach and Nearshore Profile Surveys twice per year every 300 m. 2. Georegistered aerial photographs and digitized shoreline twice per year.	Apply GENESIS model or equivalent to assess longshore sand transport and related shoreline change with and without project prior to and after dredging commences (comparing to measured change in latter case).

and such changes to waves change longshore and cross-shore sand transport rates and the resulting shoreline dynamics. Because there are many other factors that may result in changes to shoreline dynamics, the Wave and Shoreline Protocols include two important and distinct features: 1) documentation of waves and shoreline change as a record of conditions; and 2) the need for modeling, in addition to monitoring, to attempt to isolate the direct influence of the changed bathymetry near the borrow area on waves and shoreline dynamics (*i.e.* from all the other possible factors that may influence these processes). While it is recognized that numerical modeling of these complex processes has many limitations, these techniques provide at least some insight into the processes and the potential for dredging to lead to shoreline changes. Recommendations for specific models, their limitations and background references are provided in MICHEL *et al.* (2001). Taken together with the field data derived from the monitoring and an understanding of the geomorphology of the area, the numerical model results provide the basis for evaluating the potential impacts of dredged borrow deposits on shoreline dynamics.

The four physical monitoring protocols are summarized in Table 2. This table provides the key potential impact, the monitoring objectives, and the monitoring and modeling requirements of each of the program elements. This table is provided as an overview only and the information is not intended to provide a complete guideline for the monitoring requirements. Detailed procedures are contained in MICHEL *et al.* (2001).

Detailed monitoring of the plumes generated during dredging operations at the overspill point and the draghead has not been included as a requirement because the primary concern is the extent of the sedimentation footprint, not the impact of the temporary plume itself. The extent of the sedimentation footprint will be documented by the sediment sampling program where the substrate has changed significantly with respect to grain size. *A priori* knowledge of the extent of the footprint would be useful to develop the spatial boundaries for the monitoring programs. This is the focus of a Plume Model development and testing project currently being undertaken by MMS in FY02. The Plume Model will also be useful for assessing future aggregate dredging operations that often rely on heavy screening that produces much larger plumes.

Biological Monitoring Parameters

Based on the potential direct and indirect effects to marine biota from sand dredging activities, the biological monitoring elements of the MMS OCS sand mining monitoring program focused on benthic communities and their trophic relationships to fish, and marine mammal and wildlife interactions with dredging operations. The biological monitoring program design further focused on long-term rather than short-term impacts and ridge and shoal type ecosystems, because of their greater micro-habitat and geomorphological complexity. The proposed protocols and monitoring program design are equally applicable to flat, shelf-type ecosystems where buried geological features can represent suitable sand and gravel borrow deposits.

Potentially, the most obvious biological effect of sand dredging operations is the complete removal of soft bottom habitat along with resident benthic organisms within the dredge area. Such removal affects not only the benthic communities, but also the fish assemblages that rely on the benthos for food. In addition, the potential small- and large-scale changes to seafloor geomorphology (*e.g.,* substrate type and composition, surface texture, water circulation, nutrient distribution) due to altered wave patterns and sediment transport in the vicinity of the dredging operation (Figure 1) may also affect benthic community structure and trophic energy flow.

The recommended approach for monitoring biological change, therefore, involves measuring trophic energy transfer between the benthos and representative species of the fish population. This approach facilitates the monitoring of changes over a very wide area of potential impact, as well as changes resulting from the sand dredging operations, regardless of the origin of the habitat change (*e.g.,* direct removal of sand or potential changes in habitat sediment composition following geomorphological changes in the ridge and shoal or shelf structure). In addition to measuring trophic energy transfer effects, limited community structure and composition information would be gathered on the benthos and fish. This focused approach has the added benefit of improving cost effectiveness.

Monitoring dredging effects on trophic transfer would be accomplished through sampling benthic and fish communities for the numbers and species of organisms present. Numerically dominant and recreationally or commercially important species would receive additional investigation. These species would be analyzed for stomach contents to determine their utilization of benthic organisms. The utilized benthic species would be analyzed for their estimated secondary production using models developed over the past 20 years (MASLIN and PATTEE, 1981; MORIN and BOURASSA, 1992; TUMBIOLO and DOWNING, 1994). The amount of benthic production that is transferred to fishes would be estimated using accepted trophic transfer efficiencies and differences between dredged and reference areas in the benthic production that is transferred to fishes will be determined statistically. Stable isotope analyses also will be performed on benthic prey species and fishes to determine whether altered secondary production and trophic transfer associated with dredging affects the trophic level at which fishes feed.

Stratification is an important strategy for sample allocation that would be used to improve the ability of the biological monitoring program to detect impacts. Strata would be identified based upon factors that are known to affect the distribution and abundance of organisms in the target communities. Pre-dredging samples would be collected from within strata (*i.e.,* areas) that are as physically homogeneous as possible. Impacts and recovery would be inferred by differences in temporal trends or changes in biological similarity (*e.g.,* secondary production) between dredged and control areas within strata.

Several factors are known to affect the distribution of benthic species and these should be considered in determining the pre-dredging strata. Sediment grain size and organic content are among the most important factors controlling the distribution of benthic organisms (BROWN *et al.,* 2000; GROVE and PROBERT, 1999; MANCINELLI *et al.,* 1998; MCLACHLAN, 1996; PEARSON and ROSENBERG, 1987; ROSENBERG, 1995). These factors, which vary with depth, also can be affected by bottom topography and water motion (TANAKA and DANG, 1996). The selection of strata for benthic sampling should be based on site-specific evaluations of these factors, as well as the morphology of the sand deposit to be dredged. Sand ridges should be divided into strata of offshore ridge slope, ridge crest, nearshore ridge slope, and swale bottom, at a minimum. If the ridge is large enough or nearby seabed features are near enough and large enough to affect lengthwise heterogeneity in the sediment grain size and organic content, then additional strata should be designated. If sufficient data to designate strata are not available prior to the pre-dredging sampling, then additional sampling will be necessary to obtain these data. Although fish are more mobile than benthic organisms and may move between strata, they should be sampled within the same strata defined for the benthos. Maintaining consistent strata for benthic communities and fish assemblages will improve the ability to correlate benthic organisms with fish.

To provide a balanced statistical design, defined strata should be present in both the dredged area and the control areas. The control area should be near the dredged area to ensure similarity of factors such as depth and wave regime, but removed far enough to minimize dredging effects. The ideal proximity between dredged and control areas will depend on site-specific conditions, such as depth and the amount of area being dredged. Delineation of strata and subsequent sampling should ensure the same sample density in both dredged and control areas. To satisfy this requirement, the areas of sampling strata in dredged and reference areas should be approximately equal. Moreover, there should be assurance that reference areas will not be subjected to dredging before the completion of monitoring at that site.

The sampling design involves collection of samples before and after each dredging operation over multiple years (years 1, 3, 5, and 7) in areas that were physically similar before dredging. Because initial successional processes may affect the rate and process of long-term recovery in dredged areas, the first post-dredging survey should be conducted one year following dredging. In addition to the pre-dredge survey, a baseline survey may also be required if sufficient data are not available for strata delineation.

The principal purpose of the baseline survey would be to obtain sufficient information about the borrow site and adjacent areas to effectively delineate benthic habitats. This baseline survey can be accomplished using Sediment Profile Imaging (SPI) equipment (CUTTER and DIAZ, 2000a; CUTTER *et al.,* 2000b) or benthic grabs. The effort can be combined with baseline geophysical data gathering efforts. At a typical ridge/shoal feature, this effort would include delineating the seaward flank of the feature, the landward flank and the ridge top, at a minimum, at both dredge and control locations. For a shelf feature, depth stratification may be more important.

As far as possible, sampling should be conducted in the same season for both pre-dredging and post-dredging sampling. Benthic communities exhibit strong seasonal patterns (OTT and FEDRA, 1977; SARDA *et al.,* 1999; VALLETT and DAUVIN, 1999) and maintaining seasonal consistency of sampling reduces the effects of season on detection of long-term trends and recovery from dredging. It is suggested that summer is the best time to conduct sampling (ALDEN *et al.,* 1997). These investigators found that summer sampling provides the greatest power for detection of trends and that differences in benthic response between reference and degraded sites are greatest in summer. Nevertheless, temporal proximity of sampling to dredging is more important than blindly requiring sampling to be conducted in the summer. Benthic sampling can be done concurrently with fish sampling or during a separate survey leg.

Scientific rigor should be incorporated into the monitoring program through several approaches. First, as mentioned above, sampling sites should be distributed among strata based on environmental variables known to influence communities. This will reduce within-treatment variation and improve statistical power. Second, the sampling design should utilize statistical tests and interpretive criteria to minimize misidentification of dredging impacts. The recommended sampling design is amenable to comparisons of variation within and between treatments through analysis of variance (ANOVA) and also to various multivariate approaches. Using ANOVA, dredging effects would be ascribed to significant time and treatment interactions that correspond to a divergence between dredged and undredged areas at the time of dredging. Recovery would be ascribed to a reconvergence between dredged and undredged areas over time. Ancillary physical data and species data would provide variables for multivariate analyses. Third, while the objective of the biological monitoring protocols is to estimate changes in secondary production and trophic transfer from benthos to fishes and not detailed descriptions of the communities, numbers of replicate samples would be based upon statistical characteristics of the biological communities, such as minimization of standard error. Such an approach would ensure representative abundance estimates and descriptions of the communities for use in estimating changes in secondary production and trophic transfer.

In addition to monitoring effects on trophic energy transfer, the potential physical interactions and impacts to marine mammals and wildlife also would be monitored. This element of the monitoring program is addressed as an operational control and monitoring component, that occurs during the dredging operations. During dredging activities, marine wildlife observers would be placed aboard the dredge vessel or an ancillary craft to observe the presence of marine wildlife in the dredge area. The observers would document the behavior of marine wildlife in response to the dredging activities, and document any collisions or other negative interactions between the dredge vessel and support craft with marine wildlife.

Finally, concurrent with the sand dredging operations and for a period of 60 days after completion of sand dredging, marine wildlife observers would be in communication with federal, state and local agencies responsible for documenting marine wildlife strandings. Every reported stranding that occurs along the coastline adjacent to the dredging operations would be checked for possible correlation with animals observed during the dredging operation (species, size, unique body markings, etc.) and for possible new markings on the body that would suggest a collision with the dredging equipment.

A summary of the two biological monitoring protocols is presented in Table 3. This table provides the key potential impact, the objectives, and the monitoring and analysis requirements of each of the monitoring program elements. This table is provided as an overview only and the information is not intended to provide a complete guideline for the monitoring requirements, which are detailed in MICHEL *et al.* (2001).

ADAPTIVE MANAGEMENT

A key component of any long-term scientific study or monitoring program is the need to adapt the original study design and approach to reflect information and understanding gained during the execution of the program. For this reason, it was recommended that the MMS will establish a permanent scientific review/advisory board to oversee the implementation and future revision of the OCS long-term sand monitoring program and advise the MMS on the program components. Another important responsibility of the scientific advisory board would be to ensure the scientific validity and integrity of individual borrow site monitoring programs and their findings.

CONCLUSIONS

Review of the literature and assessment of the inter-relationships between biological and physical parameters and

Table 3. *Summary of requirements of the biological monitoring.*

Protocol	Potential Impact	Objectives & Justifications	Requirements: Monitoring	Requirements: Analysis
Benthos and Fishes; Trophic Transfer	1. Total removal/loss of infauna and epifauna at borrow site with recolonization by benthic organisms occurring within 1–5 years (possibly longer) to a community with comparable pre-disturbance abundance, diversity and biomass but different species composition and community structure 2. Altered foraging efficiency with resultant effects on individual size and weight. 3. Altered species composition of fish prey base; altered productivity and energy transfer effects on the food chain	1. To determine the effects of dredging activities on benthic communities and the transfer of energy from benthic communities to fishes. While overall abundances of benthic organisms have been shown to return to pre-dredging levels in some cases within year or two after dredging, species composition may be different and the ability of fishes to utilize such altered assemblages for prey is uncertain	1. Collect 0.10 m^2 benthic infauna samples from multiple strata at both impact and reference locations prior to dredging and in years 1, 3, 5 and 7 following dredging. Monitoring may cease when recovery has been documented 2. Collect stomachs from numerically dominant or recreationally important species from multiple strata both impact and reference locations prior to dredging and in years 1, 3, 5 and 6 following dredging.	1.a. Infauna taxonomy for comparison with fish gut contents analysis and for determining secondary productivity values. 1.b. Biomass measurements for determining secondary productivity values. 1.c. Carbon and nitrogen stable isotope measurements of key benthic prey species for fish. 2.a. Fish gut analysis for comparison with infauna taxonomy. 2.b. Carbon and nitrogen stable isotope measurements of fish muscle tissue.
Marine Mammals & Wildlife	Injury or death of animal; potential disorientation	1. To obtain site-specific marine wildlife observation and behavior data during OCS dredging events. This information will assist state and federal regulatory agencies in assessing the appropriateness of imposed marine mammal and wildlife protection mitigation requirements and guide any necessary revisions of future mitigation requirements. 2. To obtain and assess marine wildlife stranding data for potential relationships between stranded animals and animals observed during OCS dredging. This information will assist state and federal regulatory agencies in assessing whether there exist any obvious relationships between post-dredging marine wildlife strandings and the OCS dredging event 3. To provide a means for implementing environmental mitigation requirements designed to minimize potential hazardous interactions with marine mammals and protected wildlife during dredging events. (This is the only "operational control" monitoring program element included in the OCS and dredging protocols.)	1. Collect observation and behavior data onboard the dredging vessel for marine mammals and wildlife during OCS dredging events. 2. Collect marine mammal and wildlife stranding data for a 60-day period following dredging operations. 3. Implement imposed environmental mitigation requirements designed to minimize collisions or harmful interactions between marine wildlife and dredging equipment.	1. Compare observation data with stranded animal data and document marine wildlife behavior during dredging events. 2. Compare marine wildlife data with observation data collected during the dredging event as well as with stranding data recorded for comparable time periods during nondredging years.

processes indicated potential significant impacts of dredging on the outer continental shelf. The protocols were designed to monitor the significance of these key impacts.

The two primary impacts of concern for the physical environment are indirect and related to: changes to the seabed that would result in changes to the erosion and sedimentation processes along the shore; and changes to the seabed at or inshore of the dredge area that would have a direct and significant impact on the benthic biological communities and their trophic energy transfer to fishes.

Impacts to shoreline change will be very difficult to discern from the existing temporal and spatial variability in shoreline erosion and sedimentation. Therefore, the protocols are based on an approach that will develop the necessary information to explain the relative influence of the changes caused by dredging. The approach relies on the surveying of changes to the seabed in the vicinity of the borrow deposit together with monitoring of waves, wave transformation modeling, and shoreline change monitoring and modeling.

With respect to the possible influence on the biological communities, one of the greatest concerns identified was the impact that dredging may have on the maintenance of the future form of ridge and shoal features. Little is known about the processes that maintain these features on the outer continental shelf. The companion paper in this issue by HAYES and NAIRN (2004) discusses this issue. Where pronounced, the form of the ridge and shoal features provides for different habitat conditions in terms of sediment type and mobility and a related patchwork of different biological assemblages. The concern is that too much dredging off the crest of one of these ridges could result in dramatic deflation of the feature and the loss of habitat. The monitoring protocols have been designed to track the ongoing and long-term changes to the form and surface texture of these features resulting from single event and repeated dredging of these features. The developed protocols will provide an effective form of monitoring for all types of seabed morphology.

One potential physical impact that has not been directly targeted for monitoring as part of the protocols relates to the sediment plume generated by the hopper dredging operations. The sedimentation footprint of the plume, where discernible, will be elucidated through the sediment sampling program. There is general agreement in the literature that increased turbidity levels do not lead to significant impacts in typical outer continental shelf conditions. Where local conditions dictate, such as proximity to hard substrate that cannot tolerate any level of sedimentation, a more detailed assessment will be required. In all of the borrow sites identified to date, on the outer continental shelf of the Atlantic and Gulf coast of the U.S., this was not found to be an issue of concern. MMS is currently funding the development of a plume dispersion model specifically designed for the loading of hopper dredges to provide a tool to better define these impacts in the planning stages of projects. Once developed, the model will also assist in the development of the spatial layout of sediment and benthic sampling.

The most direct impact of sand dredging on biological communities involves removal of benthic biota. Previous studies have shown recovery, usually within three years, of the numbers of species and numbers of organisms, although the species colonizing dredged areas may differ from those that were present before dredging. The apparent absence of data for changes in trophic transfer from benthos to fishes associated with the altered, post-dredging benthic communities suggested the importance of monitoring the affects of changes in benthic secondary productivity on fish production.

Changes in fish production will be estimated by sampling benthic organisms within defined strata, both inside dredged areas and at nearby reference areas, before and after dredging. Published models will be used to estimate the secondary production of those benthic species that are important prey items for fishes, as determined by analysis of contemporaneous fish gut contents. Temporal changes in benthic secondary production that differ between dredged and reference areas will be converted to corresponding changes in fish production using accepted figures for the efficiency of trophic transfer. Changes in trophic transfer of benthic secondary production will be compared with stable isotope analyses to determine whether altered secondary production and trophic transfer affect the trophic level at which fishes feed.

A study design has been recommended that will utilize statistical tests and interpretive criteria to minimize misidentification of dredging impacts. Comparisons of variation would be made within and between treatments (*i.e.,* dredged and undredged) through analysis of variance (ANOVA). Dredging effects would be ascribed to significant time and treatment interactions corresponding to a divergence between dredged and undredged areas at the time of dredging in benthic secondary production and trophic transfer from the benthos to fishes. Recovery would be ascribed to a reconvergence between dredged and undredged areas over time.

LITERATURE CITED

ALDEN, R.W. III; WEISBERG, S.B.; RANASINGHE, J.A., and DAUER, E.M., 1997. Optimizing temporal sampling strategies for benthic environmental monitoring programs. *Marine Pollution Bulletin,* 34(11), 913–922.

BLAKE, N.J.; DOYLE, L.J., and CULTER, J.J., 1996. Impacts and Direct Effects of Sand Dredging for Beach Renourishment on the Benthic Organisms and Geology of the West Florida Shelf: U.S. Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA, *OCS Final Report MMS 95-0005,* 109p.

BROWN, S.S.; GASTON, G.R.; RAKOCINSKI, C.F., and HEARD, R.W., 2000. Effects of Sediment Contaminants and Environmental Gradients on Macrobenthic Community Trophic Structure in Gulf of Mexico Estuaries. *Estuaries,* 23, 411–424.

BRUTON, M. N., 1985. The effects of suspensoid on fish, *Hydrobiologia,* 125:221–241.

CUTTER, G.R. JR. and DIAZ, R.J., 2000a. Benthic Habitat Mapping and Resource Evaluation of Potential Sandmining Areas Offshore Maryland and Delaware, 1998–1999: Virginia Institute of Marine Science of the College of William & Mary, *MD/DE Draft Report,* 111p.

CUTTER, G.R. Jr.; DIAZ, R.J., and MUSICK, J.A., 2000b. Environmental Survey of Potential Resource Sites Offshore Maryland and Delaware: MMS Cooperative Agreement 14-35-0001-30807 through Virginia Institute of Marine Science of the College of William & Mary, *Final Report,* 66p.

GROVE, S.L. and PROBERT, P.K., 1999. Sediment macrobenthos of upper Otago Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research,* 33, 469–480.

HAMMER, R.M.; BALCOM, B.J.; CRUICKSHAK, M.J., and MORGAN, C.L., 1993. Synthesis and Analysis of Existing Information Regarding Environmental Effects of Marine Mining: Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA. *Report,* 392p.

HAMMER, R.M. Environmental Survey of Potential Sand Resource Areas; Offshore New Jersey: Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA. *Report,* 254 p.

HARDAWAY, C.S. JR.; MILLIGAN, D.A.; THOMAS, G.R., and HOBBS, C.H., 1998. Environmental Studies Relative to Potential Sand Mining in the Vicinity of the City of Virginia Beach, Virginia. Part 2: Preliminary Shoreline Adjustments to Dam Neck Beach Nourishment Project Southeast Virginia Coast: MMS Cooperative Agreement 14-35-0001-30807 through Virginia Institute of Marine Science of the College of William & Mary, *Final Report,* 72p.

HAYES, M.D. and NAIRN, R.B., 2004. Characteristics of OCS sand ridges and shoals. *Journal of Coastal Research.* this issue.

LOUIS BERGER GROUP INC., 1999. Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia: Contract No. 1435-01-98-RC-30820, Department of the Interior, Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, VA, 244p.

MANCINELLI, G.; FAZI, S., and ROSSI, L., 1998. Sediment structural properties mediating dominant feeding types patterns in soft-bottom macrobenthos of the Northern Adriatic Sea. *Hydrobiologia,* 367, 211–222.

MASLIN, J.L. and PATTEE, E., 1981. The production of the benthos of a small stream: Its assessment by the method of Hynes, Coleman and Hamilton. *Archiv for Hydrobiologi, Stuttgart,* 92, 321–345.

MCCLACHLAN, A., 1996. Physical factors in benthic ecology: Effects of changing sand particle size on beach fauna. *Marine Ecology Progress Series, Oldendorf,* 131, 205–217.

MICHEL, J.; NAIRN, R.; JOHNSON, J.A., and HARDIN, D., 2001. Development and Design of Biological and Physical Monitoring Protocols to Evaluate the Long-Term Impacts of Offshore Dredging Operations on the Marine Environment: U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. *OCS Final Report MMS 2001-089,* 116p.

MORIN, A. and BOURASSA, N., 1992. Empirical models of annual production and P/B rate for running water benthic invertebrates. *Canadian Journal of Fisheries and Aquatic Science,* 49(3), 532–539.

NEWELL, R.C.; SEIDERER, L.J., and HITCHCOCK, D.R., 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology,* 36, 127–178.

OTT, J. and FEDRA, K., 1977. Stabilizing properties of a high-biomass benthic community in a fluctuating ecosystem. *Helgol. Wiss. Meeresunters,* 30, 485–494.

PEARSON, T.H. and ROSENBERG, R., 1987. Structuring factors in marine benthic communities; organization of communities past and present. *In:* GEE, J.H.R. and GILLER, P.S. (ed.), *Feast and Famine.* Aberystwyth, United Kindom, pp. 373–395.

ROBINS, C.R., 1957. Effects of storms on the shallow-water fish fauna of southern Florida with records of fishes from Florida. *Bulletin of Marine Science in the Gulf and Caribbean,* 7(3), 266–275.

ROSENBERG, R., 1995. Benthic marine fauna structured by hydrodynamic processes and food availability. *Netherlands Journal of Sea Research,* 34, 303–317.

SARDA, R.; PINEDO, S., and MARTIN, D., 1999. Seasonal dynamics of macroinfaunal key species inhabiting shallow soft-bottoms in the Bay of Blanes (NW Mediterranean). Publications Elsevier, Paris. *Acta Oecologica,* 20(4), 315–326.

STONE, G.W., 2000. Wave Climate and Bottom Boundary Layer Dynamics with Implications for Offshore Sand Mining and Barrier Island Replenishment, South-Central Louisiana. *Report Submitted to MMS, 6 July 2000.*

STONE, G.W. and XU, J., 1996. Wave Climate Modeling and Evaluation Relative to Sand Mining on Ship Shoal, Offshore Louisiana: Coastal and Barrier Island Restoration. *OCS Study MMS 96-0059.*

TANAKA, H. and DANGL, V.T., 1996. Geometry of sands ripples due to combined wave-current flows. *Journal of Waterway, Port, Coastal and Ocean Engineering,* 122, 298–301.

TUMBIOLO, M.L. and DOWNING, J.A., 1994. An empirical model for the prediction of secondary production in marine benthic invertebrate populations. *Marine Ecology Progress Series. Oldendorf,* 114, 165–174.

VAN DOLAH, R.F.; WENDT, P.H.; MARTORE, R.M.; LEVINSEN, M.V., and ROUMILLAT, W.A., 1992. A Physical and Biological Monitoring Study of the Hilton Head Beach Nourishment Project. Unpublished report prepared by South Carolina Wildlife and Marine Resources Department for Town of Hilton Head, S.C.

VALLETT, C. and DAUVIN, J C., 1999. Seasonal changes of macrozooplankton and benthic boundary layer macrofauna from the bay of Saint-Brieuc (western English Channel). *Journal of Plankton Research,* 21, 35–49.

VINYARD, G.L. and O'BRIEN, J.W., 1976. Effects of light and turbidity on the reactive distance of bluegill (*Lepomis macrochirus*). *Journal of the Fisheries Research Board of Canada,* 33, 2845–2849.

Journal of Coastal Research	20	1	115–125	West Palm Beach, Florida	Winter 2004

Impacts of Marine Aggregate Dredging on Benthic Macrofauna off the South Coast of the United Kingdom

R.C. Newell†, L.J. Seiderer†, N.M. Simpson†, and J.E. Robinson†‡

†Marine Ecological Surveys Limited
Trewood Cottage
Steeple Lane
St. IVES
Cornwall TR26 2PF. U.K.

‡Benthic Ecology Research Group
Department of Biological Sciences
University of Plymouth
Drake Circus, Plymouth
Devon PL4 8AA. U.K.

ABSTRACT

NEWELL, R.C.; SEIDERER, L.J.; SIMPSON, N.M., and ROBINSON, J.E., 2004. Impacts of marine aggregate dredging on benthic macrofauna off the south coast of the United Kingdom. *Journal of Coastal Research,* 20(1), 115–125. West Palm Beach (Florida), ISSN 0749-0208.

A survey of benthic macrofauna in the vicinity of a coastal marine aggregate dredging site off the south coast of UK was carried out in 1999. The object of the survey was to determine impact of marine aggregate dredging on community composition, the extent of impact outside the boundaries of the dredge site, and the rate of recolonization and recovery of the fauna following cessation of dredging. Part of the site was intensively dredged by vessels at anchor whilst other parts were less intensively exploited by trailer dredger. The impact of dredging within the intensively exploited anchor dredge site was limited to the dredged area. Impacts included a suppression of species variety, population density and biomass, as well as differences in species composition compared with the surrounding deposits. In contrast, trailer dredging had no impact on community composition of macrofauna within the dredge site.

No suppression of benthic community structure was recorded beyond 100 m from the dredge site. Species variety, population density, biomass and body size of macrofauna was enhanced for as much as 2 kilometers in each direction along the axis of the tidal streams. Whether this reflects organic enrichment derived from the dredge site warrants further investigation.

The rate of restoration of biomass following dredging was slower than that recorded for species diversity and population density. The data for the North Nab study site allow a generalised recolonization sequence to be constructed for coastal deposits.

ADDITIONAL INDEX WORDS: *Environmental impact, recovery time and sequence.*

INTRODUCTION

Most studies on the impact of dredging on marine benthos show that dredging can result in a 30–70% reduction in species variety, a 40–95% reduction in the number of individuals, and a similar reduction in biomass in dredged areas (NEWELL *et al.,* 1998). Studies by KENNY and REES (1994, 1996) and KENNY *et al.* (1998) showed that initial colonization occurred within months of the cessation of dredging at an experimentally-dredged site off the coast of Norfolk, UK, but that restoration of biomass took several years.

Recent studies by VAN DALFSEN and ESSINK (1997), VAN DALFSEN *et al.* (2000), DESPREZ (2000) and SARDÁ *et al.* (2000) show that the process of recolonization and recovery in commercially-exploited sand borrow sites is a complex one involving initial colonization by fast-growing (*'opportunistic'*) species. In stable environments these are replaced and supplemented by a wider species diversity of slow-growing (*'equilibrium'*) species after cessation of dredging. In more disturbed habitats the community is dominated by opportunistic species which do not move towards an equilibrium community because of repeated environmental disturbance.

Previous studies have been mainly confined to impacts within dredge sites. The dredging process has, however, important potential impacts outside the boundaries of the dredge site. In some sites *in situ* gravel deposits are transferred in bulk into the hold for subsequent use as beach feed or for landfill (see HESS, 1971). In other areas the proportion of sand:gravel in the cargo is adjusted to suit customer requirements by a process of screening. This can involve return of significant quantities of sand overboard at sites of dredging (HITCHCOCK and DRUCKER, 1996; NEWELL *et al.,* 1999).

This material comprises a large inorganic particulate load and also contains significant quantities of organic matter (NEWELL *et al.,* 1999). Such material has a lower specific gravity than inorganic components of the dredger outwash and is detectable at distances of as much as 3.3 km downstream of a dredger during normal loading of a screened cargo off the Owers Bank, U.K. (HITCHCOCK and DRUCKER, 1996; HITCHCOCK *et al.,* 1998).

Material derived from the dredging process may also be

9 received and accepted in revision 6 June 2003.

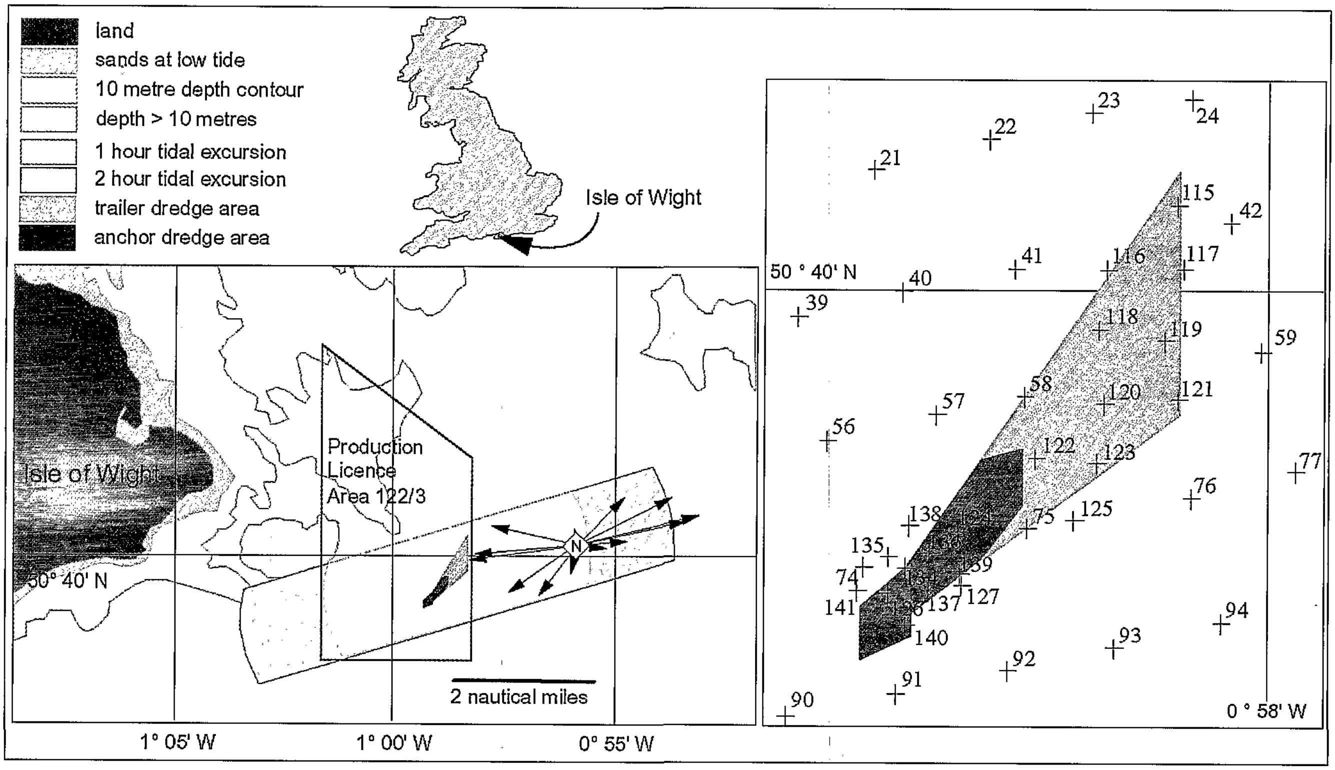


Figure 1. Map of the survey area showing the limits of the area surveyed (up to 2 hour tidal excursions) and the dredged site within the boundaries of the Production Licence Area. The enlarged map shows the anchor-dredge and trailer-dredge areas, together with the distribution of sampling stations within and adjacent to the dredged sites.

carried as a benthic plume for significant distances along the sea bed. DICKSON and REES (1998) reported the presence of a sediment plume at the sediment-water interface over 8 kilometers from a dredge site on the east coast of the U.K. Similar benthic boundary plumes have been reported even for unscreened cargoes at the Owers Bank off the south coast of U.K (HITCHCOCK *et al.,* 2002).

Study Objectives

Our study was undertaken to determine the following key questions in relation to marine aggregate mining in a commercially-worked Licence Area:

- Is there an impact of marine aggregate mining on key features of benthic biological community structure including species diversity (S), population density (N), biomass (B) or body size (B/N)?
- How far beyond the immediate limits of the dredged area do such impacts extend?
- What is the nature and rate of the recolonization and recovery processes in a commercially-dredged area?

Study Site

A small heavily-exploited aggregate area to the east of the Isle of Wight, off the south coast of the U.K., known as the North Nab Production Licence Area 122/3 was selected as a study area. The boundaries of the Licence Area are shown in Figure 1, together with the strength and direction of the tidal streams and the broad boundaries of the area surveyed. Areas which have been exploited for gravel within the boundaries of Licence Area 122/3 are also shown in Figure 1.

The total amount of marine aggregates dredged from this small area is quite low at 150,000 tonnes per year, but the amount removed per unit area is probably amongst the highest on the south coast of the U.K. The area had been exploited for almost 10 years prior to the survey, so any impact of intensive dredging on the benthos at this site should be apparent.

The material is not significantly screened, but of the approximately eleven Licence Areas on the south coast of the U.K., nine involve non-screened cargoes.

The North Nab study area is therefore representative of the majority of the Licence Areas on the south coast of the United Kingdom, in contrast with those of the southern North Sea which are generally heavily-screened.

The North Nab site has the further advantage that both anchor-dredging from a stationary dredger and trailer-dredging have been used to exploit the sea bed deposits in adjacent locations within the boundaries of the Licence Area (see Figure 1). The survey could therefore be used to assess the impact of the two principal methods of aggregate exploitation on macrofaunal communities. The results also allow some comparisons of the nature of the recolonization processes and rates of recovery in relation to anchor-dredging and trailer-dredging.

MATERIALS AND METHODS

Positions of the Sampling Stations

A survey of benthic macrofauna at a total of 131 sampling stations in the vicinity of the North Nab Production Licence Area 122/3 was carried out between 13th and 16th March 1999. Additional samples were collected on 7th September 1999. Positions were fixed with a Trimble 4000 SSI with a 300 DCI Differential Global Positioning System (dGPS) using Trimble Hydro Version 6.05 receiving in WGS 84 and converting to OSGB 36. The position of the grab on the vessel was offset and the accuracy of the positions was calibrated in port to within 2 meters.

The sampling stations were chosen to quantify the benthos both within the dredging areas and in zones potentially affected by deposition, as well as in control zones well outside any area of potential impact of dredging activity. The dredge history of sites within the survey area was obtained from records held by United Marine Dredging Ltd. who operate North Nab Production Licence Area 122/3.

The tidal excursion for tidal diamond N at latitude 50°40.1′N; 00°56.3′W on British Admiralty Chart No 2045 shows that tidal streams close to the eastern boundaries of the dredging area comprise a main tidal stream of up to 1.8-knots at 078° on the Spring flood and 1.6-knots at 252° on the ebb (see Figure 1). The positions of the sampling stations extend approximately 3 nautical miles to the east of the eastern boundary of Area 122/3, and a similar distance to the west of the western boundary of the Licence Area.

These sampling stations cover a potential zone of impact associated with deposition of material from dredging activities in the extraction area. They allow comparison with *control* sites outside any likely impact of dredging activity, as well as with areas directly impacted by extraction of marine aggregates from within the boundaries of the dredging area.

Collection and Extraction Procedures

Samples were taken with a 0.2 meter^2 Hamon Grab. Use of this grab has the advantage that loss of material by *wash-out* from the jaws experienced with conventional grabs is reduced (see HOLME and MCINTYRE, 1984; SIPS and WARDENBURG, 1989; KENNY and REES, 1994; VAN MOORSEL, 1994). The samples also allow strict comparison with the results of surveys elsewhere using a similar grab.

The samples were released from the grab onto a 1 millimeter mesh sorting tray, the contents of which were transferred to 10 litre buckets and preserved in formalin for subsequent separation and identification. The biological material collected includes both infauna and sessile epifauna. Separation of this macrofauna was carried out in the laboratory by elution with a large volume of tap water through a 1 millimeter mesh sieve, and by careful manual separation of the residual fauna from the remaining sediment. The macrofauna was then preserved in methanol for subsequent identification and enumeration. A reference collection of key taxa was retained for future reference.

Biomass Determination

The blotted wet weight of the main faunal groups was measured. These data were then used to estimate total biomass as ash-free dry weight (AFDW) in grams using conventional conversion factors for each of the faunal groups. These were Polychaeta = wet weight × 0.155, Crustacea = wet weight × 0.225, Mollusca = wet weight × 0.085, Echinodermata × 0.08; Miscellaneous Groups including Porifera and Bryozoa = wet weight × 0.155 (ELEFTHERIOU and BASFORD, 1989).

Particle Size Analysis

One factor which affects community composition of the benthos is sediment type (see PEARSON and ROSENBERG, 1978; WESTON, 1988; CLARKE and MILLER-WAY, 1992), although other factors including the consolidation of the deposits is also important (see SEIDERER and NEWELL, 1999; NEWELL *et al.*, 2001).

Sub-samples of sediment were taken for particle size analysis. The material was sieved over the range 125 millimeters down to 0.075 millimeters. Results were expressed using conventional Wentworth Classification to give percentage composition of each particle size. These data were then used as an input to similarity analysis of sediment composition in the survey area using multi-variate techniques. The results of analysis of sediment composition are reported separately (see HITCHCOCK *et al.*, 2002).

Analysis of Invertebrate Community Structure

The statistical methods used to analyse the structure of the invertebrate communities of the coastal sediments follow those of FIELD *et al.* (1982; see also CLARKE and WARWICK, 1994). The Plymouth Routines in Multivariate Research (PRIMER) version v5 software (CLARKE and GORLEY, 2001) was used for analyses of community structure.

Comparisons between faunal groups were made using the ANOSIM sub-routine within the PRIMER software. The test used resembles a standard ANOVA test. A significance level of <1% was used to distinguish the groups from one another. The degree of separation of the groups was distinguished as a scale of R = 0 (groups indistinguishable from one another) to R = 1 (no similarity between the groups). The species that account for the similarity and differences between the faunal groups were identified using the SIMPER sub-routine within the PRIMER software.

RESULTS

Abundance and Variety of Benthos

In all, a total of 316 taxa were recorded. The assemblage as a whole was dominated by Polychaeta and Crustacea, although hydroids, Mollusca and Bryozoa were also important at some sampling sites.

Table 1. *Comparison of survey data recorded for the vicinity of a worked site at North Nab Production Licence Area 122/3 with the results of surveys of the macrofauna of unexploited deposits in U.K. coastal waters.*

Site	Total Taxa	Mean Species Per 0.2 m²	Mean Individuals Per 0.2 m²	Biomass gAFDW Per 0.2 m²	N	Source
St. Catherine's Isle of Wight	270	37 ± 22	918 ± 1166	5.59 ± 8.97	52	MESL, 1996a
Folkestone, Kent	343	37 ± 25	595 ± 777	4.95 ± 23.6	70	MESL, 1996b
Orford Ness, Suffolk	223	30 ± 20	949 ± 4056	3.18 ± 9.7	60	MESL, 1997b
North Norfolk	—	36	1488	5.66	-	Recalculated from Kenny *et al* 1998
Lowestoft, Norfolk	112	9 ± 5	134 ± 272	1.49 ± 3.49	60	MESL, 1997a
West Channel	229	20.78 ± 14.79	77.97 ± 89.09	1.47 ± 2.45	91	MESL, 1999a
West Bassurelle	294	44.04 ± 18.84	186.44 ± 109.95	2.41 ± 2.85	100	MESL, 1999b
North NAB	316	26.77 ± 14.96	199.52 ± 244.08	2.11 ± 4.36	131	This study

MESL = Marine Ecological Survey Limited
gAFDW = grams ash-free dry weight according to (ELEFTHERIOU and BASFORD, 1989)

Table 1 shows the total number of taxa, mean number of species, mean number of individuals and mean biomass recorded in the North Nab survey site compared with values recorded from non-dredged coastal deposits in U.K. waters. Values recorded for the North Nab survey area are generally similar to those recorded for non-dredged deposits elsewhere in U.K. coastal waters. In general, biomass values of 1.5–5.0 grams AFDW per 0.2 meter² have been recorded for unexploited deposits. This compares with an average value for the biomass in the vicinity of the North Nab Production Licence Area 122/3 of 2.11 grams AFDW per 0.2 meter². Dredging within the Production Licence Area does not appear to have had a marked effect on species variety, population density or biomass of benthic organisms in the survey area as a whole.

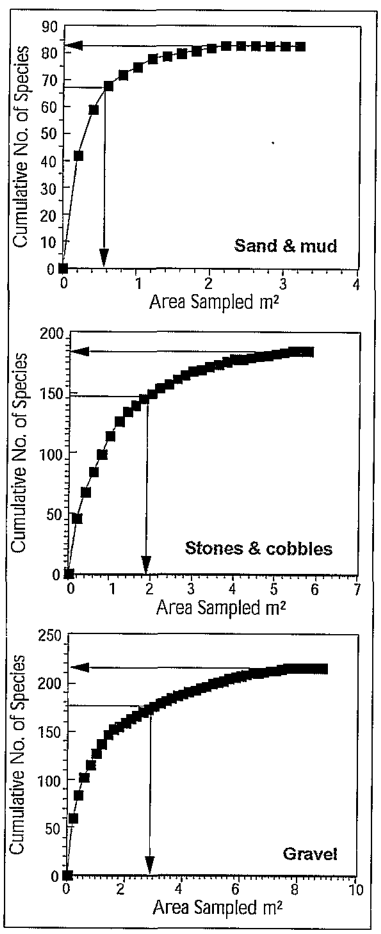


Figure 2. Species area curves for the macrofauna in the three main types of sediments that were identified in the survey area.

Impacts on Community Structure

One of the difficulties in the analysis of benthic communities is that there is a wide variability between replicate samples taken close together in the survey area. This reflects the patchiness of many components of marine communities and the fact that the 0.2 meter² sample of the sea bed deposits is small compared with the spatial separation of the macrofauna.

Figure 2 shows a series of *species area curves* for the macrofauna in the three main types of sediments that were identified in the survey area. The species recorded in each of a series of samples of 0.2 meter² have been plotted as a cumulative curve showing additional taxa recorded as a function of area sampled (meters²) in repeated replicates for each of the three types of sediment.

Figure 2 shows that the total number of species, as judged from the point at which no further taxa were discovered despite further replicate sampling of 0.2 meter², was 82 in sands and muds of the survey area. The corresponding value for coarse gravel was 185 taxa and that for the other gravel deposits was as high as 215 taxa. This increase in biodiversity probably reflects the habitat heterogeneity of gravels compared with sands and muds. These results are of importance because they suggest that removal of the coarse fraction, and rejection of sands by overboard screening may result in a reduction of species diversity in sea bed deposits.

A second feature of interest is that the *area sampled* required to identify at least 80% of the taxa that actually occur in the deposits is clearly related to sediment type. In the case of sands and muds that are dominated by one or a few taxa, only 0.4–0.6 meter² of sea bed (*i.e.* 2–3 replicate samples of 0.2 meter²) are required to discover at least 80% of the species

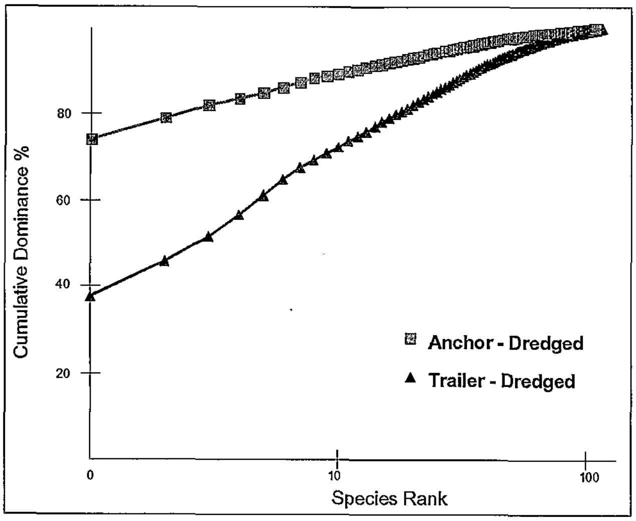


Figure 3. *K*-dominance curves for the macrofauna in combined anchor-dredged sites (squares) and trailer-dredged sites (triangles).

present in the deposits, even when as many as 82 taxa are present. Similar results have been obtained for sands and muddy deposits of the eastern English Channel by NEWELL *et al.* (2001).

Where the deposits comprise a larger species variety such as occurs in coarse gravel, an area of sea bed of up to 2.0 meter^2 (*i.e.* 10 replicate samples of 0.2 meter^2) are required to define 80% of the species present. Finally, in mixed sandy gravels of the survey area, an area of sea bed of at least 2.6 meter^2 (*i.e.* 13 replicate samples of 0.2 meter^2) are required to satisfactorily identify 80% of the taxonomic diversity of the sediments.

When sufficient samples are pooled to give a reliable estimate of species diversity, the data show that dredging for marine aggregates at North Nab Area 122/3 has an impact on the relative contribution of different species comprising the benthic macrofauna community. Figure 3 shows *k*-dominance curves plotted for combined trailer-dredged sites and for combined anchor-dredged sites within the Production Licence Area. *K*-dominance curves show the relative contribution of each component species to the total complement in the community (see LAMBSHEAD *et al.,* 1983).

Anchor dredged sites were heavily dominated by one species. In contrast, the sediments within the trailer dredged site had a relatively low dominance by one or a few species, and a more uniform species composition typical of undisturbed environments. This suggests that within the heavily exploited anchor-dredged site typical benthic macrofauna had been replaced by large numbers of mobile opportunistic species that are able to rapidly recolonise sediments following episodic disturbance.

Multi-variate Analysis of Community Composition

Figure 4 shows a group average sorting dendrogram and the corresponding two-dimensional multidimensional scaling (MDS) ordination for the infauna of deposits in the immediate vicinity of the dredge site. This shows a graded change in fauna which may comprise three groups or communities. These evidently have some common characteristics, indicated by the lack of clear separation in the MDS ordination. The groups have been designated Group A, Group B and Group C in Figure 4.

Analysis of similarity shows that faunal groups A, B and C are all significantly different from one another at the 1% level. However, whereas Groups A and B are very dissimilar ($R = 0.956$), as are Groups A and C ($R = 0.933$), Groups B and C are less dissimilar to one another ($R = 0.491$).

The species that account for the similarity within each of the three faunal groups identified above may be summarised as follows:

Group A: Characterised by polychaetes including *Notomastus* sp (22.9% of the similarity), *Cirratulus filiformis* (15.4%) and *Capitella* sp (13.7%).

Group B: Characterised by a wide range of species each making a small contribution to the percentage similarity of the group. They include *Pomatoceros* sp (7.4%), *Sabellaria spinulosa* (6.3%), *Distomus variolosus* (5.5%), *Ampelisca brevicornis* (5%), *Crepidula fornicata* (4.8%), *Cirriformia tentaculata* (3.9%), *Typosyllis prolifera* (3.9%), *Nucula nucleus* (3.7%), *Unicola crenatipalma* (3%), *Lumbrinereis latreilli* (2.9%), *Notomastus* sp (2.8%) and *Euclymene* sp (2.5%).

Group C: Characterised by *Distomus variolosus* (19.9%), *Crepidula fornicata* (13.8%), *Pomatoceros* sp (9.3%) and *Sabellaria spinulosa* (8.5%).

There is also a relatively large group of stations where the macrofauna communities have a relatively low level of similarity with one another and with faunal groups that occur elsewhere in the survey area. This may reflect disturbance of the benthos in dredged deposits. A similar disruption of community structure and low similarity levels of the macrofauna following dredging has been recorded for an experimentally-dredged site in the southern North Sea by KENNY and REES (1994, 1996).

Other groups of sites in the North Nab study site where the fauna was poorly-classified corresponded with deposits bordering mixed sands and reefs. The distribution of the main faunal communities close to the dredge site identified by multi-variate analysis of community composition of macrofauna is shown in a map of the survey area in Figure 5.

The concentration of poorly-classified communities within the dredge sites suggests that there is an impact of dredging on community composition close to the site of anchor dredging. The relatively uniform distribution of faunal Group C, both within the trailer-dredged site and in the surrounding deposits suggests, however, that any impacts on the community composition based on an analysis of species variety and population density, are confined to the intensively-exploited anchor dredge site.

Impacts Outside the Boundaries of Dredged Areas

The results show that there was no suppression of species diversity, population density or biomass of benthic macrofauna outside the immediate boundaries of the dredged sites in

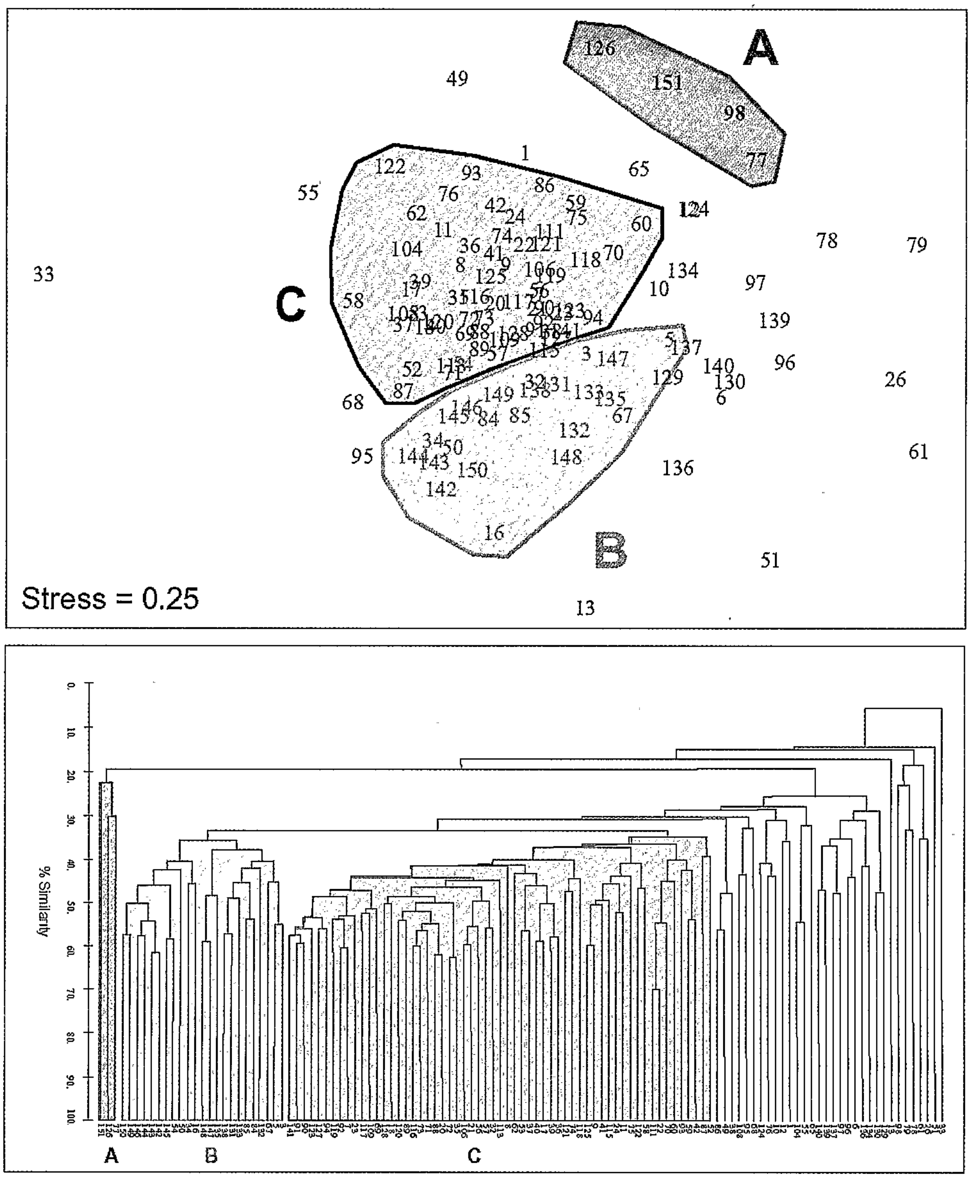


Figure 4. Group average sorting dendrogram and two-dimensional MDS-ordination for the macrofaunal communities at each of the stations in the survey area. The boundaries of the three main groups, or communities of macrofauna identified by multi-variate analysis are indicated. The high stress reflects the heterogeneous macrofauna recorded from the deposits.

the North Nab survey area. There is, however, clear evidence of a zone of enhanced biomass outside the boundaries of the dredge site extending along the axis of the tidal stream for a distance of up to 2 kilometers.

Table 2 shows mean values for number of species (*S*), population density (*N*), biomass (*B*) (grams AFDW) and body size (*B*/*N*) (grams AFDW) of benthos recorded from a total of 131 samples of 0.2 meter^2 in the North Nab survey area (from Table 1). Also shown are mean values for stations occurring within a zone extending for 600 meters across, and for 2 kilometers along the axis of tidal streams from the North Nab dredge site.

This shows that the stations within a zone of probable transport of material from the dredge site (near-site stations) had a higher species richness of 39.8 species compared with 26.8 species per 0.2 meter^2 for the survey area as a whole. The population density of macrobenthos in the near-site stations was 523.3 individuals per 0.2 meter^2 compared with 199.5 for the survey area as a whole. Biomass was 8.84 grams AFDW per 0.2 meter^2 compared with 2.11 grams AFDW for the survey area as a whole. Finally the mean body size was 0.0220 grams AFDW for the near site stations compared with 0.0103 grams AFDW for the macrobenthos of the whole survey area.

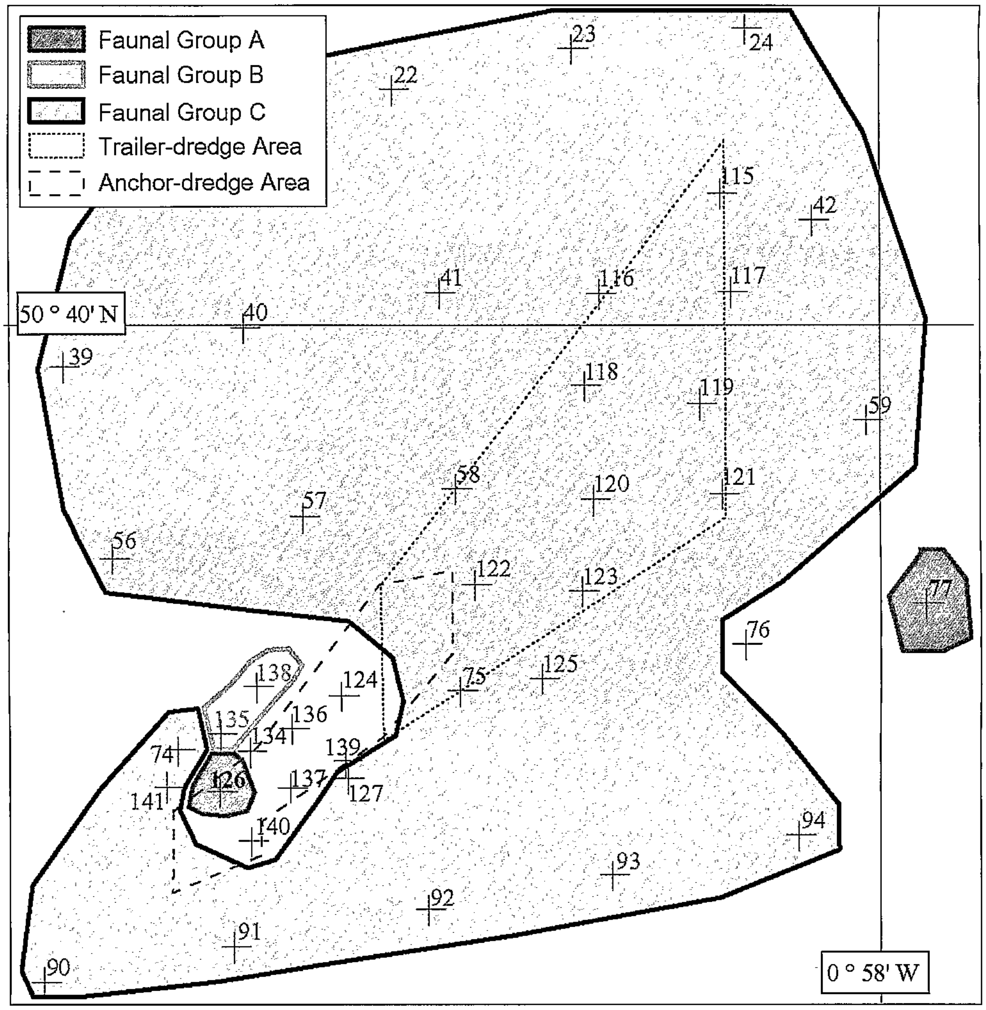


Figure 5. Map of the survey area showing the distribution of macrofaunal types in the deposits within and immediately adjacent to the dredged areas. Note the poorly classified (heterogeneous) communities within the anchor-dredged area, and the similarity of the communities within the trailer-dredged area compared with those in the surrounding deposits.

That is, the near site stations had a macrofaunal assemblage which was approximately 148% higher in species variety, 262.3% higher in population density, 419% higher in biomass and 213% higher in average body size of the individuals. These results are similar to the enhancement in benthos reported by POINER and KENNEDY (1984) close to a site of dredging in Queensland, Australia. They attributed this to release of organic matter from sediments disturbed by dredging. The possibility that this zone of enhanced species richness, population density and biomass of benthic macrofauna surrounding the dredge site may reflect organic enrichment from the dredge site warrants further investigation.

Impacts of Dredging within the Dredged Site

Impacts on Population Density, Species Variety & Biomass

Anchor-Dredged Site: Impacts of dredging on species variety, population density and biomass of macrofauna within anchor-dredged and trailer dredged sites are of interest because the data can be related to the known dates at which dredging had taken place at particular sampling sites. This gives information on the immediate impact of dredging on the benthic macrofauna and can also be used to estimate the rates of restoration of species diversity and population density within deposits following cessation of dredging.

Table 3 shows that the population density at Station 126 was reduced by 87% compared with average values for the survey as a whole. This site was close to an area being dredged at the time of our survey on 13.03.99. An 88% reduction in population density was recorded at Station 139, despite the fact that this site was last dredged 178 days prior to our survey. In contrast, a reduction of only 16% in the population density was recorded at Station 134, despite the fact that records show that this station was dredged only 7 days previously.

In general the results show that anchor dredging has a

Table 2. *Showing the values for the species variety (S), population density (N), biomass (B), and body size (B/N) of the benthic macrofauna. Values are shown for all stations in the survey area and for near-site stations in a zone extending up to 2 Km along the axis of dispersion of material within the tidal stream for the North Nab dredge site.*

	No. of Species (S) Per 0.2 m²	No. of Individuals (N) Per 0.2 m²	Biomass (B) gAFDW Per 0.2 m²	Body Size (B/N) gAFDW Per 0.2 m²
All Stations				
Mean	26.8	199.5	2.11	0.0103
S.D.	15	244.1	4.36	0.0148
N	131	131	131	131
Near Site Stations				
Mean	39.8	523.3	8.84	0.022
S.D.	15.6	389.2	7.26	0.0196
N	23	23	23	23
% Increase	148	262.3	419	213.5

gAFDW = grams ash-free dry weight according to (ELEFTHERIOU and BASFORD, 1989)

significant impact on population density of the benthos, although the exact level of suppression recorded depends on whether the samples coincided with the middle of a dredge pit, and the number of days elapsed since dredging took place.

These data showing a reduction of the population density of macrobenthos in dredged areas agree with results reported in the literature for various sediment types (see NEWELL *et al.*, 1998). A reduction of 70–80% in the number of individuals has been reported for commercially exploited sands and gravels (DESPREZ, 1992, 2000; VAN MOORSEL, 1994). A smaller reduction of 46% was reported for sands in Moreton Bay, Queensland, by POINER and KENNEDY (1984) and a value of 60% for sands in Hong Kong waters (MORTON, 1996).

The data for the North Nab site also show high population densities of benthos within approximately 100 meters from the dredge sites. This suggests that where the cargo is loaded without significant losses overboard, impacts on the macrobenthic population density is confined to the immediate area of the dredge site.

Impacts on species variety in general parallelled those described for population density with a reduction of 11–66% in dredged areas (Table 3). Table 3 also shows that a major suppression of biomass of 80–90% occurred in previously dredged sites. Further, it is clear that this suppression persisted for periods in excess of 18 months after cessation of dredging.

Trailer-Dredged Site: Table 3 shows that recovery of the population density to within 30–60% of that in the surrounding deposits is achieved within 80 days. The time required for restoration of population density is not dissimilar to that for anchor-dredge sites.

Recovery of species diversity may occur somewhat faster within the narrow trailer-dredge tracks compared with the larger pits in the sea bed associated with anchor-dredging. A recovery of 86% of the species diversity can occur within 20 days after trailer dredging, and full recovery is achieved within approximately 80 days. Finally the biomass in trailer-dredged areas shows some recovery after 80 days, but is still suppressed by at least 80% compared with that in the surrounding deposits 80 days after cessation of dredging.

DISCUSSION

Inspection of records from operating dredgers allows some estimates of the time course and sequence of recovery in the initial phases of the recolonization process at the North Nab dredge site. Restoration of the species variety to within 70–80% of that which occurs in the surrounding deposits generally occurs within 100 days although at Station 134 restoration apparently occurred within only 7 days. This may reflect a sampling inaccuracy in that the grab sample may not have coincided with the centre of the dredge pit at that site.

The data summarised in Table 3 suggest that in general,

Table 3. *Table showing the date at which a series of stations in the North Nab Production Licence Area 122/3 were sampled for macrofauna, when the stations were last dredged and the elapsed time in days. The number of species (S), number of individuals (N), and the biomass (B), the body size (B/N) at each station is shown, together with the % reduction compared with average background values for all stations outside the dredge area.*

Station	Date Sampled	Date Last Dredged	Days Elapsed	Species (S) Per 0.2 m² No.	Species (S) %	Individuals (N) Per 0.2 m² No.	Individuals (N) %	Biomass (B) gAFDW per 0.2 m² g	Biomass (B) %	Size (B/N) mg	Size (B/N) %
Anchor-Dredge											
126	13.03.99.	—	—	11	−62	26	−87	0.257	−83	1	−86
134	08.06.99.	01.06.99.	7	21	−28	166	−16	0.606	−61	3.6	−49
141	08.06.99.	21.02.99.	107	22	−24	130	−44	0.149	−90	1.1	−84
139	08.06.99.	18.12.98.	178	21	−28	44	−88	0.04	−98	0.8	−89
124	13.03.99.	06.04.98.	312	10	−66	114	−42	0.964	−38	8.5	21
137	08.06.99.	15.07.98.	355	26	−11	330	69	2.106	36	6.4	−9
136	08.06.99.	09.05.99.	395	33	13	357	82	0.17	−89	1.5	−79
140	08.06.99.	25.11.97.	560	20	−31	153	−22	0.258	−83	1.7	−86
Trailer-Dredge											
118	13.03.99.	21.02.99.	20	25	−14	84	−57	0.594	−62	7.1	1
122	13.03.99.	23.12.98.	80	31	7	60	−69	0.235	−85	3.9	−44
123	13.03.99.	23.12.98.	80	30	3	105	−46	0.301	−80	2.9	−59
121	13.03.99.	21.12.98.	82	18	−38	124	−37	0.196	−87	1.6	−87
120	13.03.99.	19.12.98.	84	25	−14	358	83	2.1	36	5.9	−16

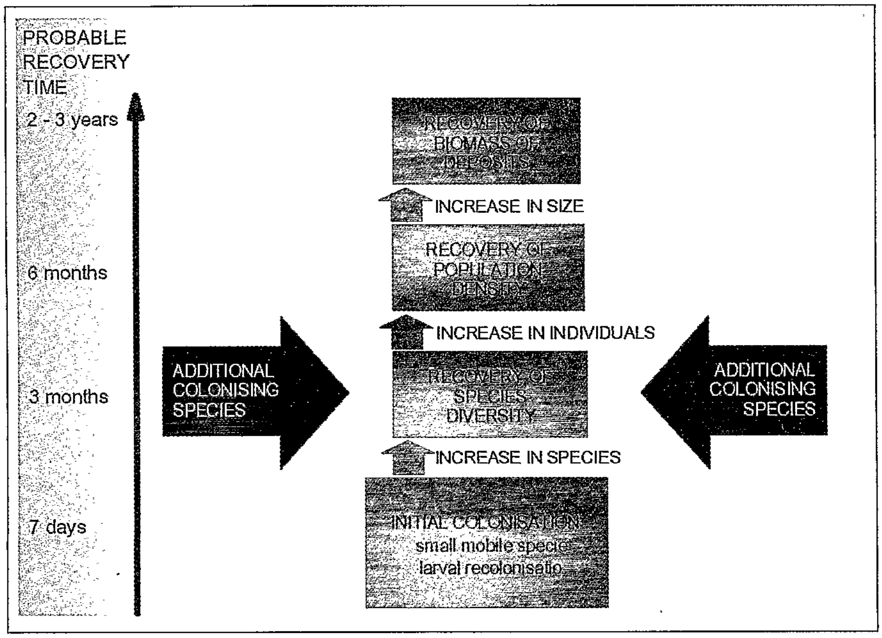


Figure 6. Generalised flow diagram showing the sequence of recovery of the macrofauna in coastal marine deposits in a *high energy* disturbed area following cessation of dredging.

population density is restored to within 60–80% of that in the surrounding deposits within 175 days after cessation of dredging. Station 134 again appears to be anomalous in that restoration of the population density to within 86% of that in the surrounding deposits evidently occurred within 7 days.

Finally, restoration of biomass by growth of individuals is far from complete even after 18 months. These data for the time taken for restoration of the biomass agree with those in the literature where recovery of biomass after initial recolonization by the macrofauna of sands and gravels has been reported to take 2–3 years (DESPREZ, 1992, 2000; KENNY and REES, 1994, 1996; NEWELL *et al.,* 1998; NEWELL *et al.,* 2002).

A generalised flow diagram showing the sequence of recovery of the macrofauna in coastal marine deposits following cessation of dredging is shown in Figure 6. It should be emphasised that whilst the sequence is likely to be similar in a wide range of deposit types, the absolute rates are likely to vary from the relatively rapid restoration of community structure noted above.

Where the deposits are stable, as in low-energy environments, or where the deposits are coarse, the biological community is represented by a higher proportion of long-lived and slow-growing species which have a slow rate of reproduction (for review, see NEWELL *et al.,* 1998). These components may take longer to recover both species variety and population density and for the biomass to be restored by growth of the individuals (see also VAN DALFSEN *et al.,* 2000).

CONCLUSIONS

This study has shown that aggregate dredging has an impact on community composition of the benthic macrofauna within the boundaries of an intensively-dredged site in coastal deposits off the south coast of U.K. Dredging at this site was associated with a significant suppression of population density, species diversity and biomass of benthic macrofauna. The community was dominated by one species within the boundaries of the intensively dredged site.

In contrast, there was little evidence of an impact on community structure outside the immediate boundaries of the intensively dredged site, including areas that had been lightly exploited by trailer-dredger. Macrofaunal communities outside the boundaries of the intensively dredged site had a relatively low dominance by one or a few species, and a more uniform species composition typical of undisturbed environments. This suggests that within the heavily exploited site, local infauna had been replaced by large numbers of mobile opportunistic species that were able to colonise sediments following episodic disturbance.

Although community structure of benthic infauna was apparently unaffected by dredging outside the immediate boundaries of the intensively dredged site, there was an enhancement of species diversity, population density, biomass and mean body size of the macrofauna in deposits surrounding the dredge site. The possibility that this reflects organic enrichment from the dredge site warrants further investigation.

The data also allow some estimates of the nature and rate of recolonisation processes in marine deposits following cessation of dredging. Recovery of species diversity to within 70–80% of that in the surrounding deposits was generally achieved within 100 days. Recovery of population density was achieved within 175 days. In contrast, restoration of biomass following growth of the individual colonising species was incomplete even 18 months after cessation of dredging.

ACKNOWLEDGMENTS

This study was supported by the United States Department of the Interior, Minerals Management Service Contract Number 14-35-01-99-CT-30980 to Coastline Surveys Ltd. U.K. and is reported in full in HITCHCOCK *et al.* (2002). We are grateful to Dr Andrew Bellamy of United Marine Dredging Limited for kindly providing us with information on dredging within the North Nab study site and for his assistance and co-operation during the course of this study.

LITERATURE CITED

CLARKE, D. and MILLER-WAY, T., 1992. An environmental assessment of the effects of open-water disposal of maintenance dredged material on benthic resources in Mobile Bay, Alabama. U.S. Army Engineer District, Mobile. *Misc Paper D-92-1.* 40p.

CLARKE, K.R. and GORLEY, R.N., 2001. *PRIMER v5: User Manual/ Tutorial.* Primer-E-Ltd., Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth PL1 3DH. U.K. 91p.

CLARKE, K.R. and WARWICK, R.M., 1994. *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation.* Natural Environment Research Council U.K. 144p.

DESPREZ, M., 1992. Bilan de dix années de suivi de l'impact biosédimentaire de l'estraction de graves marins au large de Dieppe. Comparaison avec d'autres sites. Rapport Groupe d'etude des Milieux Estuariens et Littoraux GEMEL, St Valery/Somme. Cited in: *Report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries.* ICES Report No CM 1993/E:7 Marine Environmental Quality Committee. pp. 51–67.

DESPREZ, M., 2000. Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel. Short and long-term post-dredging restoration. *ICES Journal of Marine Science.* 57, 1428–1438.

DICKSON, R.R. and REES, J.M., 1998. Impact of dredging plumes on Race Bank and surrounding areas (A908). CEFAS Lowestoft. Unpublished Final Report to MAFF, U.K. 15p.

ELEFTHERIOU, A. and BASFORD, D.J., 1989. The macrofauna of the offshore northern North Sea. *Journal of the Marine Biological Association of the UK.,* 69, 123–143.

FIELD, J.G.; CLARKE, K.R., and WARICK, R.M., 1982. A practical strategy for analyzing multispecies distribution patterns. *Marine Ecology Progress Series,* 8,37–52.

HESS, H.D., 1971. *Marine sand and gravel mining industry in the United Kingdom.* NOAA Tech. Rep. ERL 213-MMTCI. U.S. Dept. of Commerce, Boulder, Colorado 176p.

HITCHCOCK, D.R. and DRUCKER, B.R., 1996. Investigation of benthic and surface plumes associated with marine aggregates mining in the United Kingdom. *In: The Global Ocean-Towards Operational Oceanography. Oceanology International* Vol 2. ISBN 0-900254-12-2. pp. 220–234.

HITCHCOCK, D.R.; NEWELL, R.C., and SEIDERER, L.J., 1998. *Investigation of benthic and surface plumes associated with marine aggregate mining in the United Kingdom—Final Report.* Contract Report for the U.S. Department of the Interior, Minerals Management Service. Contract Number 14-35-0001-30763. Coastline Surveys Ltd. Ref. 98-555-03 (Final), 168p.

HITCHCOCK, D.R.; NEWELL, R.C., and SEIDERER, L.J., 2002. *Integrated report on the impact of marine aggregate dredging on physical and biological resources of the sea bed.* US Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Washington DC. (Contract No. 14-35-01-CT-30980).

HOLME, N.A. and MCINTYRE, A.D., (eds.), 1984. *Methods for the Study of Marine Benthos.* International Biological Programme Handbook. 2nd Edition. Blackwell, Oxford.

KENNY, A.J. and REES, H.L., 1994. The effects of marine gravel extraction on the macrobenthos: Early post-dredging recolonisation. *Marine Pollution Bulletin,* 28 (7), 442–447.

KENNY, A.J. and REES, H.L., 1996. The effects of marine gravel extraction on the macrobenthos: results 2 years post-dredging. *Marine Pollution Bulletin,* 32 (8/9), 615–622.

KENNY, A.J.; REES, H.L.; GREENING, J., and CAMPBELL, S., 1998. The effects of gravel extraction on the macrobenthos at an experimental dredge site off north Norfolk. UK. (Results 3 years post-dredging). *ICES CM 1998/V: 14,* 1–8.

LAMBSHEAD, P.J.D.; PLATT, H.M., and SHAW, K.M., 1983. The detection of differences among assemblages of marine benthic species based on an assessment of dominance and diversity. *Journal of Natural History,* 17, 859–874.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1996a. *Benthic Ecology of St Catherine's Licenced Dredging Area 407.* Report prepared for Oakwood Environmental, Wormley, Surrey. 62 pp.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1996b. *Benthic Ecology of West Varne Licenced Dredging Areas 432/1 & 432/2.* Report prepared for Oakwood Environmental, Wormley, Surrey. No SCS/ 432/1. 45 pp.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1997a. *Benthic Ecology off Lowestoft Dredging Application Area 454.* Report prepared for Oakwood Environmental, Wormley, Surrey. No. SCS/454/1. 48 pp.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1997b. *Benthic Ecology off Suffolk (Shipwash Gabbard) Dredging Application Area 452.* Report prepared for Oakwood Environmental, Wormley, Surrey. No SCS/452/1. 47 pp.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1999a. *Benthic Ecology south west of the Isle of Wight. Area 465/1 & 465/2 (West Channel).* Report prepared for Coastline Surveys Limited, Stonehouse, Gloucestershire. 39 pp.

MESL (MARINE ECOLOGICAL SURVEYS LTD.), 1999b. *Benthic Ecology: Areas 458 & 464 (West Bassurelle).* Report prepared for Oakwood Environmental, Wormley, Surrey. 39 pp.

MORTON, B., 1996. The subsidiary impacts of dredging (and trawling) on a sublittoral benthic molluscan community in the southern waters of Hong Kong. *Marine Pollution Bulletin,* 32(10), 701–710.

NEWELL, R.C.; SEIDERER, L.J., and HITCHCOCK, D.R., 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources in the sea bed. *Oceanography and Marine Biology: Annual Review,* 36, 127–178.

NEWELL, R.C.; HITCHCOCK, D.R., and SEIDERER, L.J., 1999. Organic enrichment associated with outwash from marine aggregates dredging: a probable explanation for surface sheens and enhanced benthic production in the vicinity of dredging operations. *Marine Pollution Bulletin,* 38(9), 809–818.

NEWELL, R.C.; SEIDERER, L.J., and ROBINSON, J.E., 2001. Animal: sediment relationships in coastal sediments of the English Channel off Folkestone, Kent. *Journal of the Marine Biological Association of the UK.,* 81, 1–9.

NEWELL, R.C.; SEIDERER, L.J.; SIMPSON, N.M., and ROBINSON, J.E., 2002. *Impact of marine aggregate dredging and overboard screening on benthic biological resources in the central North Sea: Production Licence Area 408, Coal Pit.* Marine Ecological Surveys Limited. Technical Report No ER1/4/02 to the British Marine Aggregate Producers Association (BMAPA). 72 pp.

PEARSON, T.H. and ROSENBERG, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: Annual Review,* 16, 229–311.

POINER, I.R. and KENNEDY, R., 1984. Complex patterns of change in the macrobenthos of a large sandbank following dredging. *Marine Biology,* 78, 335–352.

SARDÁ, R.; PINEDO, S.; GREMARE, A., and TABOADA, S., 2000. Changes in the dynamics of shallow sandy-bottom assemblages due to sand extraction in the Catalan Western Mediterranean Sea. *ICES Journal of Marine Science,* 57, 1446–1453.

SEIDERER, L.J. and NEWELL, R.C., 1999. Analysis of the relationship between sediment composition and benthic community structure in coastal deposits: implications for marine aggregate dredging. *ICES Journal of Marine Science,* 56, 757–765.

SIPS, H.J.J. and WARDENBURG, H.W., 1989. *The macrobenthic community of gravel deposits in the Dutch part of the North Sea (Klaverbank): Ecological impact of gravel extraction.* Bureau Waardenburg bv, Culemborg, Netherlands, 34p.

VAN DALFSEN, J.A. and ESSINK, K., 1997. *Risk analysis of coastal nourishment techniques in The Netherlands.* Ministry of Transport, Public Works and Water Management, National Institute for Coastal and Marine Management/RIKZ. Haren, The Netherlands. Report RIKZ-97.022, 98p.

VAN DALFSEN, J.A.; ESSINK, K.; TOXVIG MADSEN, H.; BIRKLUND, J.; ROMERO, J., and MANZANERA, M., 2000. Differential response of macrozoobenthos to marine sand extraction in the North Sea and Western Mediterranean. *ICES Journal of Marine Science,* 57,1439–1445.

VAN-MOORSEL, G.W.N.M., 1994. *The Klaver Bank (North Sea), Geomorphology, Macrobenthic Ecology and the effect of gravel extraction.* Rapport Bureau Waardenburg and North Sea Directorate (DNZ), Ministry of Transport, Public Works & Water Management, The Netherlands, 65p.

WESTON, D.P., 1988. Macrobenthos-sediment relationships on the continental shelf off Cape Hatteras, North Carolina. *Continental Shelf Research,* 8(3), 267–286.

Journal of Coastal Research	20	1	70–88	West Palm Beach, Florida	Winter 2004

Ship Shoal as a Prospective Borrow Site for Barrier Island Restoration, Coastal South-Central Louisiana, USA: Numerical Wave Modeling and Field Measurements of Hydrodynamics and Sediment Transport

Gregory W. Stone†, David A. Pepper‡, Jingping Xu§ and Xiongping Zhang†

†Coastal Studies Institute and Department of Oceanography and Coastal Sciences
Louisiana State University
Baton Rouge, LA 70803, USA

‡Present Address:
Department of Geography
University of Southern California
Los Angeles, CA 90089, USA

§U.S. Geological Survey
Menlo Park, CA 94025, USA

ABSTRACT

STONE, G.W.; PEPPER, D.A.; XU, J., and ZHANG, X., 2004. Ship Shoal as a prospective borrow site for barrier island restoration, coastal south-central Louisiana, USA: numerical wave modeling and field measurements of hydrodynamics and sediment transport. *Journal of Coastal Research,* 20(1), 70–89. West Palm Beach (Florida), ISSN 0749-0208.

Ship Shoal, a transgressive sand body located at the 10 m isobath off south-central Louisiana, is deemed a potential sand source for restoration along the rapidly eroding Isles Dernieres barrier chain and possibly other sites in Louisiana. Through numerical wave modeling we evaluate the potential response of mining Ship Shoal on the wave field. During severe and strong storms, waves break seaward of the western flank of Ship Shoal. Therefore, removal of Ship Shoal (approximately 1.1 billion m^3) causes a maximum increase of the significant wave height by 90%–100% and 40%–50% over the shoal and directly adjacent to the lee of the complex for two strong storm scenarios. During weak storms and fair weather conditions, waves do not break over Ship Shoal. The degree of increase in significant wave height due to shoal removal is considerably smaller, only 10%–20% on the west part of the shoal. Within the context of increasing nearshore wave energy levels, removal of the shoal is not significant enough to cause increased erosion along the Isles Dernieres. Wave approach direction exerts significant control on the wave climate leeward of Ship Shoal for stronger storms, but not weak storms or fairweather. Instrumentation deployed at the shoal allowed comparison of measured wave heights with numerically derived wave heights using STWAVE. Correlation coefficients are high in virtually all comparisons indicating the capability of the model to simulate wave behavior satisfactorily at the shoal.

Directional waves, currents and sediment transport were measured during winter storms associated with frontal passages using three bottom-mounted arrays deployed on the seaward and landward sides of Ship Shoal (November, 1998–January, 1999). Episodic increases in wave height, mean and oscillatory current speed, shear velocity, and sediment transport rates, associated with recurrent cold front passages, were measured. Dissipation mechanisms included both breaking and bottom friction due to variable depths across the shoal crest and variable wave amplitudes during storms and fair-weather. Arctic surge fronts were associated with southerly storm waves, and southwesterly to westerly currents and sediment transport. Migrating cyclonic fronts generated northerly swell that transformed into southerly sea, and currents and sediment transport that were southeasterly overall. Waves were 36% higher and 9% longer on the seaward side of the shoal, whereas mean currents were 10% stronger landward, where they were directed onshore, in contrast to the offshore site, where seaward currents predominated. Sediment transport initiated by cold fronts was generally directed southeasterly to southwesterly at the offshore site, and southerly to westerly at the nearshore site. The data suggest that both cold fronts and the shoal, exert significant influences on regional hydrodynamics and sediment transport.

ADDITIONAL INDEX WORDS: *Cold fronts, currents, inner shelf, storms, Gulf of Mexico.*

INTRODUCTION

Erosion of both barrier islands and wetlands in coastal Louisiana is occurring at rates largely unreported elsewhere around the globe (see reviews in STONE *et al.,* 1997; WILLIAMS *et al.,* 1997). Large-scale barrier island restoration will likely prove a major contributor to mitigating the wave field in Louisiana's bays and, therefore, reduce incident wave energy along fringing marshes resulting in a considerable reduction in wetland loss (STONE and MCBRIDE, 1998). Although billions of cubic meters of sand will be required for initial and recurring restoration, high quality sand is largely limited to isolated shoals or infilled fluvial channels on the inner shelf. One such deposit, Ship Shoal, lays at the 10-m isobath in south-central Louisiana adjacent a rapidly eroding barrier island complex, the Isles Dernieres (Figure 1). Here we summarize the results of a comprehensive program funded by the Minerals Management Service (MMS) and con-

6 received and accepted in revision 6 June 2003.

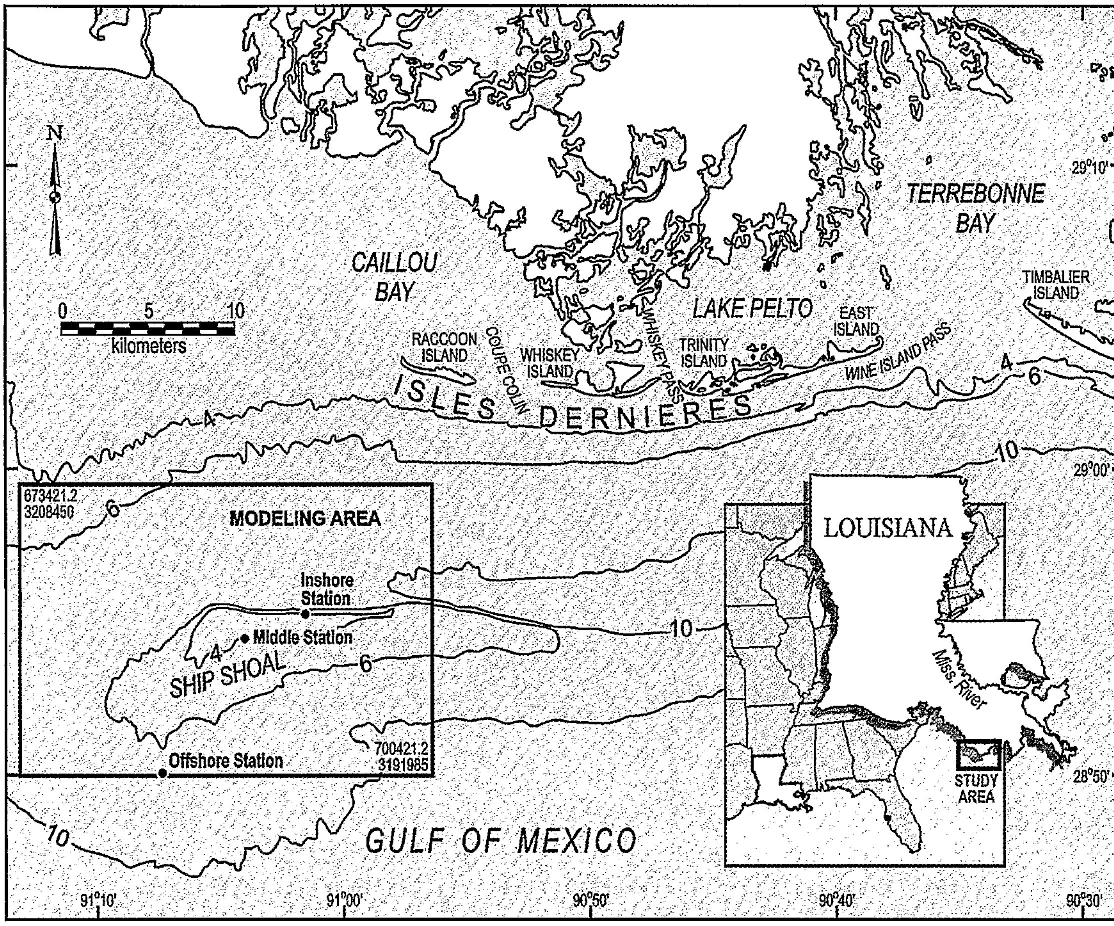


Figure 1. Map of the study site including the Isles Dernieres located in south-central Louisiana, and Ship Shoal on the 10-m isobath. The rectangle delimits the area modeled and the location of three sites where instruments were deployed.

ducted by scientists in the Coastal Studies Institute, Louisiana State University, to evaluate physical processes and sediment transport at Ship Shoal. The first part of the paper summarizes the extent of the problem and reviews the literature pertinent to barrier restoration and sand mining. The second part documents a detailed numerical wave modeling effort designed to assess the potential impacts of removing Ship Shoal through dredging on the wave field. The third part deals with a physical measurement program also funded by MMS which focuses on measuring bottom boundary layer parameters and sediment transport at the shoal. These data also provide an opportunity to compare in situ measurements with numerically derived wave information.

BACKGROUND

It is well established in the literature that barrier islands in south-central Louisiana (Figure 1) have been experiencing among the highest rates of shoreline retreat in the United States (McBride *et al.,* 1992; Stone and Penland, 1992; Williams *et al.,* 1992; Stone *et al.,* 1997; Williams *et al.,* 1997). The primary factors responsible for deterioration of these islands includes (1) eustatic sea-level rise; (2) compactional and geological subsidence; (3) wave erosion; (4) wind deflation; (5) reduction in sediment supply and (6) anthropogenic activity (*e.g.,* river diversion, dredging, levee building and maintenance). Historical erosion rates along the Isles Dernieres ranged from 4.8 m/yr (East Island) to 22.9 m/yr (Wine Island) over the last century or so (McBride *et al.,* 1992). Recent evidence indicates an apparent acceleration in erosion, approximating 213% over the last decade (Williams *et al.,* 1992). Based on these data, it is estimated that several of the islands will disappear within the next decade or two (McBride *et al.,* 1992; McBride and Byrnes, 1997; Stone and McBride, 1998). Given the recent impact of Hurricane Andrew and various tropical cyclones along this coast (Stone *et al.,* 1993; Stone *et al.,* 1995; Grymes and Stone, 1995; Muller and Stone, 2002), it is probable that this time period is less.

With the degradation of barrier systems, it is likely that mainland shoreline erosion and wetland loss will occur in response to a more energetic, local wave field (Penland and Suter, 1988; McBride *et al.,* 1992)—although, the critical

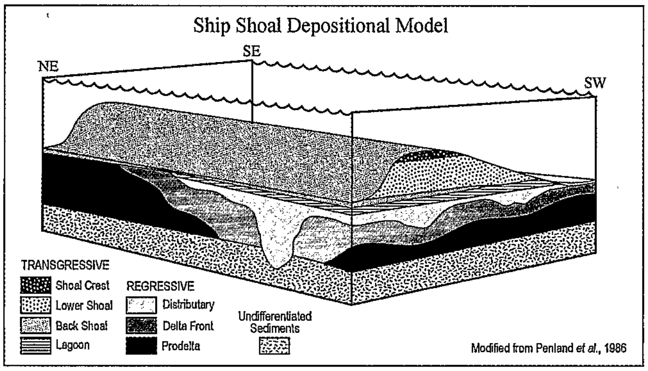


Figure 2. Depositional model of Ship Shoal showing the various transgressive and regressive facies and underlying undifferentiated sediments (modified from PENLAND *et al.*, 1996).

links have not yet been fully investigated (LIST and HANSEN, 1992; STONE and MCBRIDE, 1998). Recent data indicate that land loss in the Terrebonne Bay area averaged 0.86 km²/yr between 1932 and 1990 (BRITSCH and DUNBAR, 1993). Approximately 12 million m³ of sand would be required to restore the Isles Dernieres to a configuration indicative of the late 1800's. Several studies, funded largely by MMS, indicate the potential use of Ship Shoal (Figure 1) as a source of clean quartz sand (approximately 1.2 billion m³) for barrier island restoration along Isles Dernieres (MOSSA, 1988). Dredging of the material appears both technically and economically feasible (BYRNES and GROAT, 1991), and a detailed evaluation of the potential alteration of physical and sedimentary processes associated with using Ship Shoal as a source began in the mid 1990's. The data presented here build on the findings of MOSSA (1988), and BYRNES and GROAT (1991) which pertained to evaluating changes to wave refraction patterns, and qualitative assessments of the resultant wave energy distribution along the Isles Dernieres due to partial dredging of Ship Shoal.

SITE DESCRIPTION AND REGIONAL SETTING

The study site is located off the south-central Louisiana coast (Figure 1). The morphology of the study area is the product of a process combining relative sea-level rise with regressive (delta building) sequences, and transgressive (delta abandoning) sequences of the Mississippi River (PENLAND *et al.*, 1985; 1986; COLEMAN *et al.*, 1998). Over the last 7,000 years, the Mississippi River has built six major delta lobes (FRAZIER, 1967). Except for the Modern delta and Atchafalaya delta complexes, all other abandoned deltas have responded to the Holocene transgression by undergoing erosion, subsidence, sediment redistribution, and landward migration. Isle Dernieres, Timbalier islands, and Ship Shoal are all products of these processes. Ship Shoal is a transgressive sand deposit located 15 km offshore of Isles Dernieres near the 10 m isobath, and was formed by the erosion of a submerged barrier system. The shoal is approximately 50 km long, varies in width from 2 to 10 km as delineated by the 6 m isobath, and is comprised of well-sorted, clean quartz sand, and is the easternmost member of a group of Holocene inner shelf shoals located southwest of the Mississippi River delta plain (PENLAND *et al.*, 1986). Bathymetric comparisons covering a time span of over a century since 1853 indicate that Ship Shoal has migrated landward by approximately 1.5 km (PENLAND *et al.*, 1986; LIST *et al.*, 1997).

Table 1. *Sources of wave climate data.*

Sources	Lat. (N)	Long. (W)	Water Depth (m)
WIS 19	28.5°	91.0°	33
WIS 20	28.5°	90.5°	38
WIS 21	28.5°	90.0°	91
NDBC 42017	27.5°	90.5°	407
LATEX 16	28.9°	90.5°	21

PENLAND *et al.* (1986) identified seven major sedimentary facies in the study area and its vicinity based on lithology, texture, sedimentary structures, faunal assemblages and stratigraphic position. A block diagram illustrating shoal facies and depositional environment (PENLAND *et al.*, 1986) is shown in Figure 2. Of the seven facies, the first three are the most significant with regards to characterization of the surficial sediment and the environments of deposition. The first facies (shoal crest), representing the crest of Ship Shoal, is located within the upper 5 m of the shoal and is characterized as a very well-sorted, well-rounded 99% quartz sand that coarsens upward within the unit from 0.13 mm at the base to about 0.16 mm at the top. The second facies (lower shoal), which represents the central body or shoal front of Ship Shoal, is a 1.2 to 3.4 m thick, moderately sorted and very fine to fine (0.12 to 0.15 mm), sand that underlies facies 1. Facies 3 (back shoal) is characterized by poorly sorted, very fine sand (0.1 to 0.13 mm), with interbedded layers of silty clay. It represents the lower extent, or shoal base, of Ship Shoal. The shoal crest contains 112 million cubic meters of sand and resides within the zone of active fairweather and storm wave processes. Water depths over the shoal crest range from 2.7 m along the west to 7.0 m along the east. The shoal front and shoal base environments contain approximately 430 and 640 million m³ of sand respectively. Because these two facies are in deeper water, they are subjected to a lower wave energy environment.

MODELLING POTENTIAL CHANGES IN WAVE FIELD DUE TO SAND MINING

Numerical Models

Projects have yet to be designed for barrier restoration using Ship Shoal sand. Thus it remains unclear as to precisely how much sand would be required from Ship Shoal for future barrier restoration projects. Efforts to numerically model potential changes to wave processes as a consequence of shoal mining have largely focused on entire shoal removal. Several numerical models exist with the general capabilities of wave height prediction from deep water to the break point. These models define the wave field as monochromatic or single-period waves, one-dimensional spectral waves, two-dimensional spectral waves, or shallow water waves. As presented earlier, the objectives of wave modeling in this project are two-fold: (1) large-

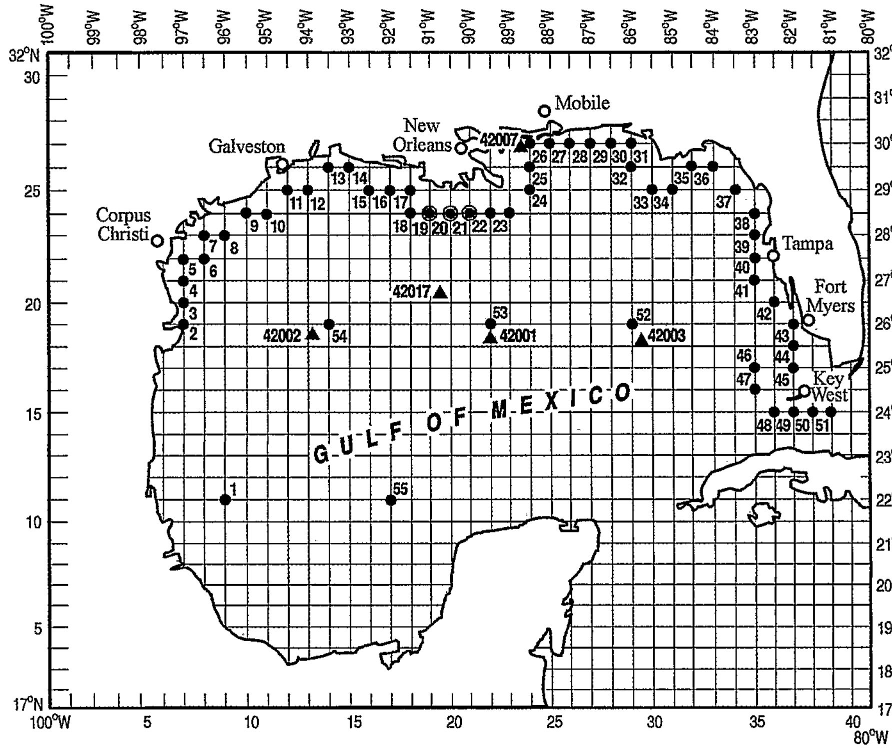


Figure 3. Distribution of Wave Information Study sites in the Gulf of Mexico represented by black circles. WIS 19, 20, and 21 were used in this study. Location of three National Data Buoy Center buoys are shown in black triangles. NDBC 42001 and 42017 were used in this study.

scale (or global scale) modeling that provides wave characteristics across the south-central Louisiana shelf, including the study area; and (2) local wave modeling that outputs higher resolution information (*e.g.* wave breaking) to evaluate the potential impacts of shoal removal on nearshore wave conditions. In this paper, we concentrate on the latter objective; the complete evaluation can be found in STONE and XU (1996), and STONE (2000). Additional model reviews may be found in HOLTHUIJUSEN *et al.* (1989); O'REILLY and GUZA (1993).

Model Selection

As discussed in STONE and XU (1996), and STONE (2000), four models (RCPWAVE, STWAVE, REF/DIF 1 and REF/DIF S were compared against the following criteria: representation (scale), efficiency, accuracy, spectral capability, computational grid size requirement, breaking criteria, and wind-wave generating ability. STWAVE had the highest composite score because of its spectral capability, inclusion of a wind-forcing function, high accuracy, and high efficiency. Given the objectives presented earlier, STWAVE was selected for use in this study.

Table 2. *Incident wave parameters used for deep water wave boundary conditions.*

Scenario	H_s (m)	T_p (s)	Approach Dir. (deg.)[1]	Description
1	6	11	−45,00, +45	Severe Storm
2	4	9	−45,00, +45	Strong Storm
3	2	6	−45,00, +45	Weak Storm
4	1	5	−45,00, +45	Fairweather

[1] −45 = southwest approach; 45 = southeast approach; 00 = south approach.

Boundary Conditions

Computational bathymetric grids and deep water wave conditions (directional amplitude and period weighted by frequency of occurrence) are necessary inputs for numerical modeling of surface wave behavior across the study site. Three different types of bathymetric grid were generated for application in this study. The grids differed in resolution, and underwent embedding of "local" (high resolution) in "global" (coarser resolution) grids. A quantitative inventory and assessment of the wave climate in the vicinity of the study area is presented in addition to quantification of wave parameters at the offshore boundary of the computational grids.

Deep Water Database for Winter Storms and Fairweather

Deep water wave inputs representing winter storms and fairweather conditions were obtained from three sources (Table 1): (1) 20 years (1956–1975) of hindcast data obtained from the Wave Information Study (WIS) (ABEL *et al.,* 1989; HUBERTZ and BROOKS, 1989); (2) National Oceanic and Atmospheric Administration (NOAA)'s National Data Buoy Center (NDBC) buoy 42017 (25.9°N, 89.7°W); and (3) Loui-

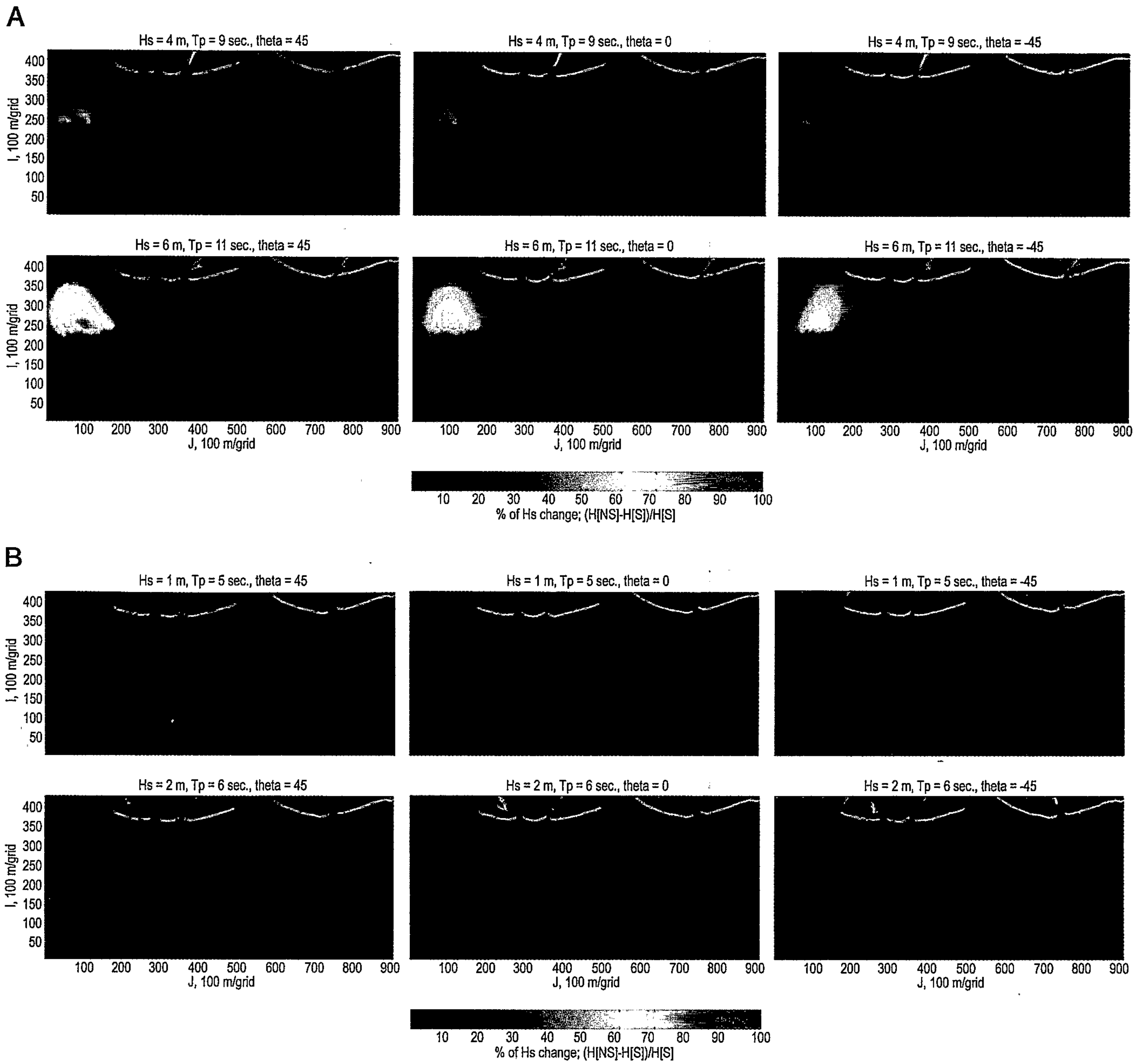


Figure 4. (A) Percentage increase in numerically derived significant wave height on comparing output with and without Ship Shoal in the computational grid. Upper panels represent moderate storm wave conditions for three directions of wave approach (southeast, south and southwest respectively). Lower panels represent percent increase in wave height using a deep water wave height indicative of a strong storm. The Isles Dernieres are located at the top of each diagram for reference.

Figure 4. (B) Percentage increase in numerically derived significant wave height on comparing output with and without Ship Shoal in the computational grid. Upper panels represent fair-weather wave conditions for three directions of wave approach (southeast, south and southwest respectively). Lower panels represent percent increase in wave height using a deep water wave height indicative of a weak storm. The Isles Dernieres are located at the top of each diagram for reference.

siana-Texas Shelf Physical Oceanography Program (LATEX) station 16 (28.9°N, 90.5°W; unpublished data supplied by Dr. Steven F. DiMarco, Texas A&M University).

Among the three sources, the WIS data set provides the most complete information. Statistics from three hindcast stations 19, 20, and 21 (Figure 3 for location) had shown an annual-mean significant wave height of 1.0 ± 0.2 m and mean peak period of 4.5–6.0 sec. The maximum wave heights from these stations exceeded 5 m, and the peak period associated with the largest wave exceeded 11 sec. The monthly mean

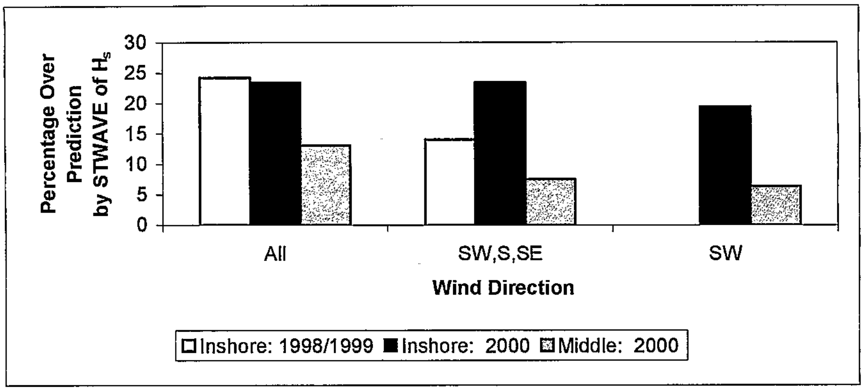


Figure 5. Summary of percent over prediction of H_s by STWAVE for all stations.

significant wave heights in winter (Dec.–Mar.) were 0.2–0.6 m higher than that of the rest of the year. The predominant wave directions were from the Southeastern quadrant (135.0°, 112.5°, and 90.0° for Stations 19, 20 and 21 respectively). The average directions associated with the largest waves were also mostly from this quadrant (125°, 117°, and 112° for the three stations). On summing the percentages of occurrence of wave directions in the range of 90°–180°, the percentages for the four stations are 76%, 85%, and 85% respectively.

Among the buoys that NDBC have administered within the Gulf of Mexico, 42017 (27.5°N, 90.5°W) is more significant for the purpose of the current project because of its close location to the study area (Figure 3). However, only 6 months (Apr.–Sep. 1989) of data were available from NDBC 42017. Although limited, the time series shows that the monthly mean significant wave heights ranged from 0.6 to 1.4 m and peak periods from 4.5 to 5.3 sec. A storm at the end of July, 1989 generated the maximum significant wave height of 5.1 m for the 6-month period. The peak period corresponding to the largest wave was almost 8 sec. The 12-month (Aug. 1991–Jul. 1992) time series from buoy 42001 (25.9°N, 89.7°W) showed that the monthly mean significant wave heights ranged from 0.6 to 1.8 m and monthly mean peak periods from 4.3 to 5.5 sec. The monthly mean significant wave heights, which also show a decreasing trend from winter to summer months, compared reasonably well with the WIS hindcast data. Wave direction was not recorded for either time interval.

LATEX station 16 (28.9°N, 90.5°W) is located within the general study area. The wave data, recorded by MiniSpec (Coastal Leasing, Inc.) directional wave gauges during a 6-month period (Dec. 1993 and Feb.–Jun. 1994), show that the monthly-mean wave heights varied from 0.3 to 1.3 m and wave period from 5.5 to 6 sec. The dominant wave directions agree with the previous data sets showing the contribution of southeasterly approaching waves. On synthesizing these data, four scenarios are presented which represent the respective deep-water wave conditions for fairweather through severe storms—excluding hurricanes (Table 2).

Change in Wave Field due to Shoal Removal

To quantify numerically, the control that Ship Shoal exerts on wave climate, the approach taken centered on removal of the entire shoal complex from the bathymetric grid. By comparing the wave fields obtained from running the wave model over these two grids, the significance of Ship Shoal in altering

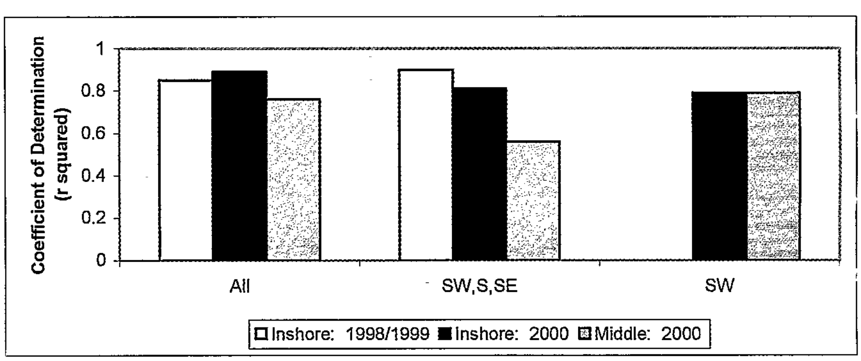


Figure 6. Summary of r^2 values for measured and modeled H_s for all stations.

Table 3. *Percentage of over prediction of H_s by STWAVE when compared to* in situ *measurements at two locations on Ship Shoal, based on 590 model runs.*

	1998/1999 Deployment (*inshore*)		2000 Deployment (*inshore*)		2000 Deployment (*Middle*)	
Wind Direction	Percentage	r^2	Percentage	r^2	Percentage	r^2
From: SW, S, SE	14.1	0.90	23.4	0.81	7.6	0.56
From: SW	No waves from this direction		19.4	0.79	6.4	0.79
All Data	24.2	0.85	23.4	0.89	13.1	0.76

wave climates under different conditions was examined. As much as a 6 m thick section of sand was removed at the west portion of the shoal, and the total volume of sand extracted from Ship Shoal was 1.1×10^9 m^3. A selection of graphs showing percentage change in significant wave height after shoal removal is presented in Figure 4. Interpretation of the data indicates that removal of Ship Shoal will alter wave propagation, dissipation and the wave energy distribution. The magnitude and spatial distribution of the alteration depend on the initial wave conditions. During severe storms (Scenario 1) and strong storms (Scenario 2), wave breaking occurs seaward of the western flank of Ship Shoal. Therefore, removal of Ship Shoal causes a maximum increase of the significant wave height by 90%–100% (*i.e.,* almost double the present value) in Scenario 1, and 40%–50% in Scenario 2, over the shoal and immediately adjacent to the lee of it. Wave breaking does not occur on the east flank of the shoal because of much deep water, and the magnitude of the wave height increase due to shoal removal is significantly less on comparison with that on the west flank. During weak storms (Scenario 3) and fair weather conditions (Scenario 4), waves do not reach breaking conditions over any part of Ship Shoal. On the west part of the shoal, the magnitudes of significant wave height increase due to shoal removal are considerably smaller, only 10%–20%. Wave height change on the east part of the shoal is minimal. Dissipation mechanisms are a combination of wave breaking over the shoal and bottom friction along deeper parts of the shoal.

The nearshore wave field is largely dependent on offshore wave conditions. Under high energy conditions in Scenario 1 and Scenario 2, removal of Ship Shoal results in higher breaking waves; however, the breaker zone is displaced between 0.5–1.0 km offshore. Ultimately, waves in the surf zone eventually attain the same energy level with and without the shoal, suggesting that shoal removal will not significantly change wave energy conditions along the Isles Dernieres. Un-

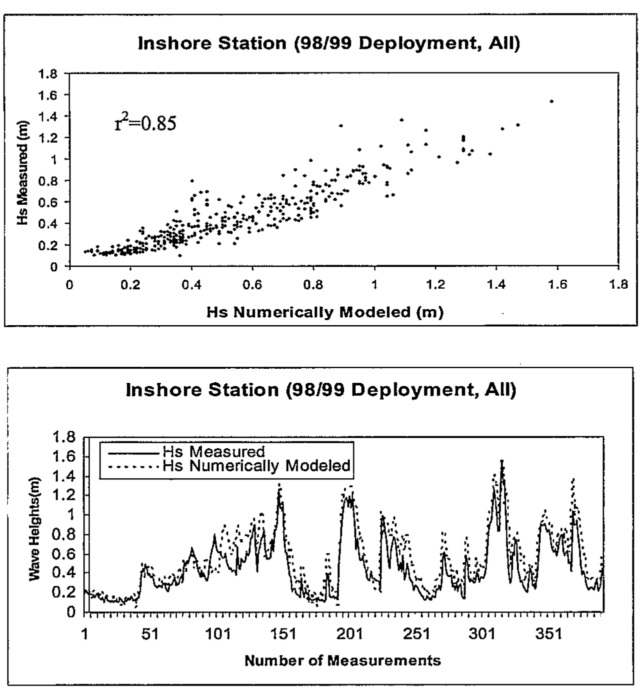


Figure 7. (upper) Scatter plot of significant wave heights for 1998/99 deployment for all wind directions at Inshore station. (lower) Comparison of measured and numerically modeled wave heights for all wind directions in 1998/99 deployment at Inshore station.

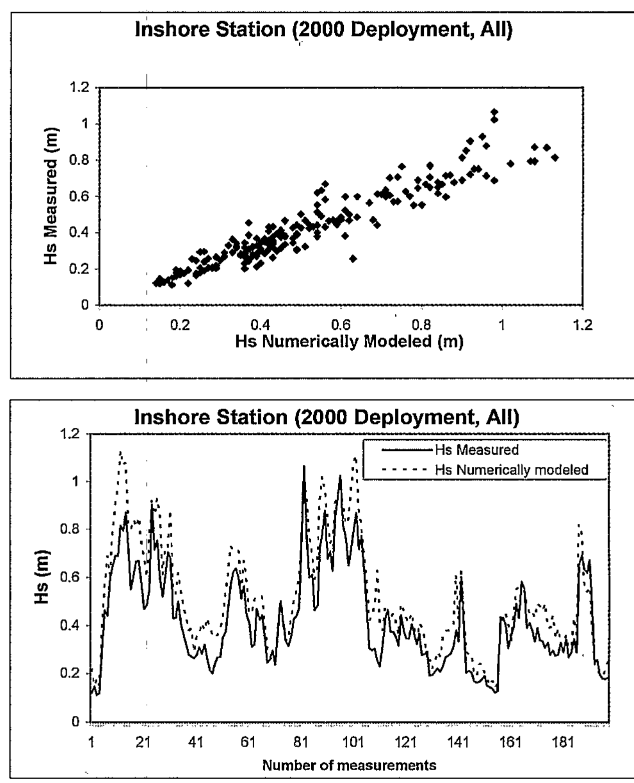


Figure 8. (upper) Scatter plot of significant wave heights for all wind direction at Inshore station for 2000 deployment. (lower) Comparison diagram of numerically modeled and measured wave heights for all wind directions at Inshore station for 2000 deployment.

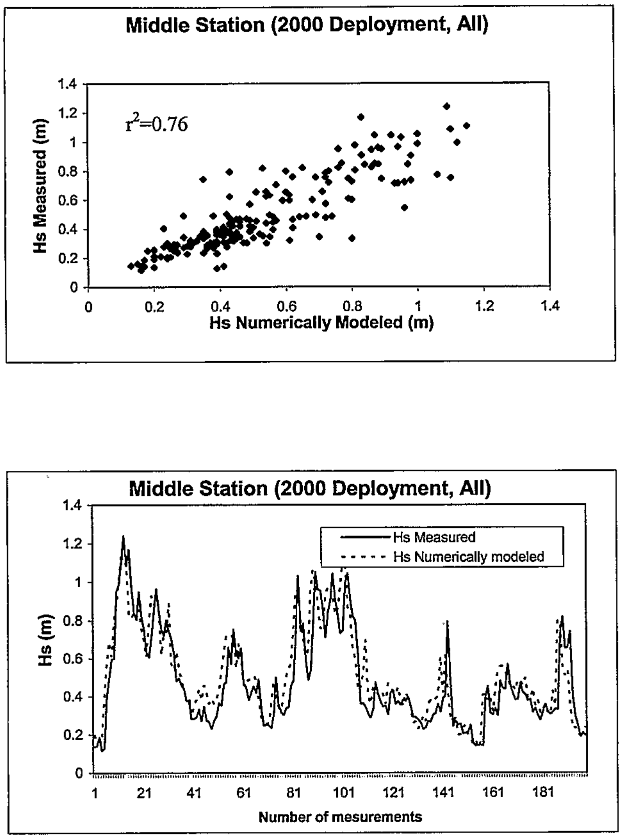


Figure 9. (upper) Scatter plot of Hs measured vs. Hs numerically modeled for 2000 deployment at Middle station. (lower) Comparison diagram of numerically modeled and measured wave heights for all wind directions at Middle station for 2000 deployment.

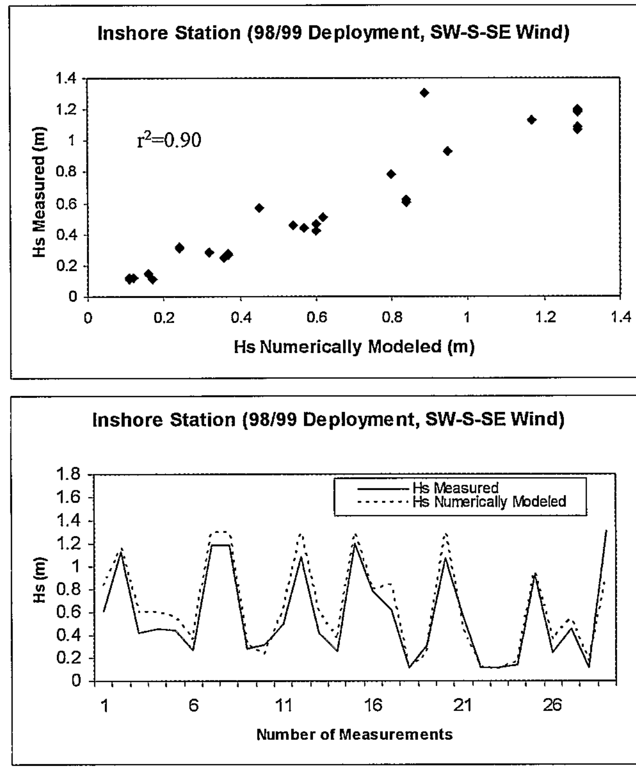


Figure 10. (upper) Scatter plot of measured and modeled H_s for wind blowing from southwest, south and southeast for 1998/99 deployment at Inshore station. (lower) Comparison diagram of numerically modeled and measured wave heights for selected southwest, south and southeast winds at Inshore station for 1998/99 deployment.

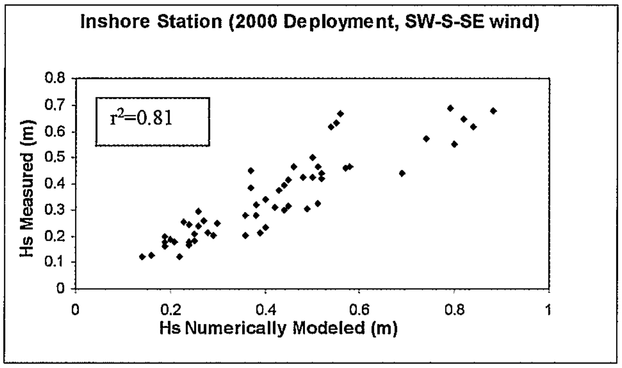
der weaker energy conditions in Scenarios 3 and 4, change in nearshore wave energy is even less noticeable particularly along the east flank of the study area.

Inclusion of a wind function increases wave height in all simulations. The magnitude of the increase is dependent on the deep water wave height and the slope of the shoreface profile. In Scenario 1, the surf zone is widened by almost 1.0 km whereas in Scenario 4, change is minimal. Removal of Ship Shoal results in a 50% increase in significant wave height. This is much larger than when wind forcing is neglected, *i.e.,* a 25–30% increase. The magnitude of wave height increase due to wind forcing over the east part of the shoal is as much as 0.8 m. Although the inclusion of the wind forcing function allows for an increase in wave height, the effects attributable to the removal of Ship Shoal are limited to the periphery of the leeward flank of the shoal, particularly along its western boundary. Changes in wave approach direction redistribute the increase in wave height in the lee of the shoal complex. This does not, however, change breaker wave heights in the nearshore along the Isles Dernieres.

Simulation of long wave propagation landward during Hurricane Andrew (STONE *et al.,* 1995) indicates near total wave energy dissipation, as opposed to breaking, over Ship Shoal. A much smaller percentage of low amplitude waves crossed the shoal complex. Peak wave energy dissipation rates occurred, however, seaward of Ship Shoal in approximately 25–30 m water depths.

Validation of STWAVE

The output from STWAVE (version 3) was tested for two bottom boundary layer field deployments conducted in 1998/1999 and 2000. Data from these deployments are presented below. Two stations were established for the first deployment (offshore and inshore on Figure 1) and a third station midway between the former during the 2000 deployment. For both deployments, wave information measured at the offshore station was selected as the input boundary condition for the model. The wind conditions for the 1998/99 deployment were obtained from Grand Isle, Louisiana, and a Terrebonne Bay site for the 2000 deployment. The input wave spectra (JONSWAP) were calculated by STWAVE from measured significant wave heights, peak wave period, wave direction and corresponding wind information. A range of 15 frequencies was applied over 35 approach angles. Peak, low, and high cut off frequencies were dependant on the individual measured wave parameters at the boundary station. Because STWAVE is a half-plane model (*i.e.,* wave energy can only



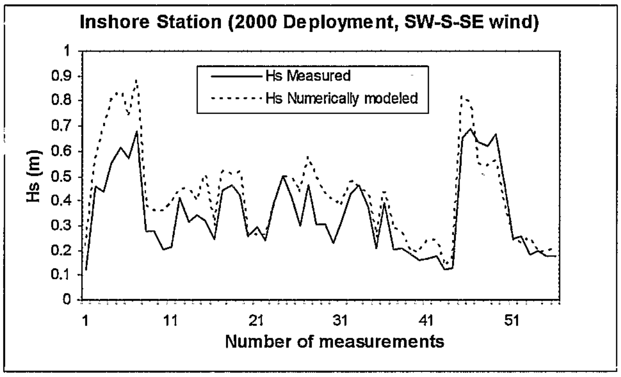
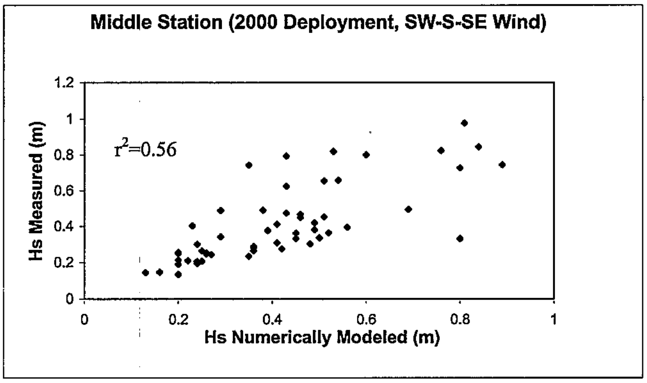


Figure 11. (upper) Scatter plot of Hs measured vs. Hs numerically modeled at Inshore station for southwest, south and southeast wind directions for 2000 deployment. (lower) Comparison diagram of numerically modeled and measured wave heights for southwest, south and southeast wind directions at Inshore station for 2000 deployment.



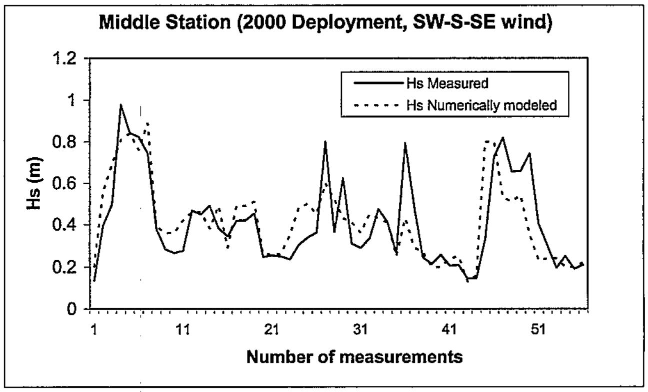


Figure 12. (upper) Scatter plot of Hs measured vs. numerically modeled Hs at Middle station for southwest, south and southeast winds foe 2000 deployment. (lower) Relationship between numerically modeled and measured significant wave heights at Middle station for southwest, south and southeast winds.

propagate from offshore to onshore or ± 87.5° from the grid × axis), wind generated waves from the north are neglected. The bathymetric grid at Ship Shoal had the dimensions 16.6 km by 27.1 km. As shown on Figure 1, the offshore station was located on the south side boundary of the modeling area, and the mid and inshore stations to the north. The bathymetric grid was generated from surveys conducted in the 1980's by the United States Geological Survey. Bathymetry for the west and northwest part of the study site was obtained from the National Ocean Service. The grid size is 166 by 271 with 100 m spacing. Measured wave and wind data were input to the model for both time series every 3 hr for the 1998/99 time series and 4 hr for the 2000 time series. A total of 590 models runs were conducted.

Comparison of Measured and Modeled Data

High r^2 values of 0.85 and 0.89 were obtained on regressing measured on numerically derived significant wave heights. The results are summarized in Figures 5 and 6 and Table 3. As shown in Figures 7 and 8, the measured and predicted values are in good agreement throughout the entire range of wave heights measured, 0.1 to 1.6 m. At both stations for each deployment, the model over predicts wave height by between 23 and 24% (Table 3). At the Middle station for the 2000 deployment, the r^2 value is 0.76 (Figure 9) for all wind directions and the percentage over prediction is 13% (Table 3) for H_s values ranging between 0.1 to 1.2 m.

Given that STWAVE does not account for waves generated and propagated from the north, input wave parameters of waves approaching from the southwest, south and southeast were extracted from the measured data sets and input to the model. For the 1998/99 deployment at the Inshore station, the r^2 value increased to 0.9 and the percentage over prediction of H_s decreased to 14.1% when compared to all data (*i.e.,* winds from all four quadrants) (Figure 10). For the 2000 deployment, however, the r^2 value decreased slightly to 0.81 and the percentage over prediction remained the same (23.4%) (Figure 11). Data obtained from the Middle station showed a marked decrease in over prediction from 13.1% down to 7.6% and a decrease in the r^2 value from 0.76 to 0.56 (Figure 12).

To test the model further, waves approaching from the southwest were extracted from the time series and used as

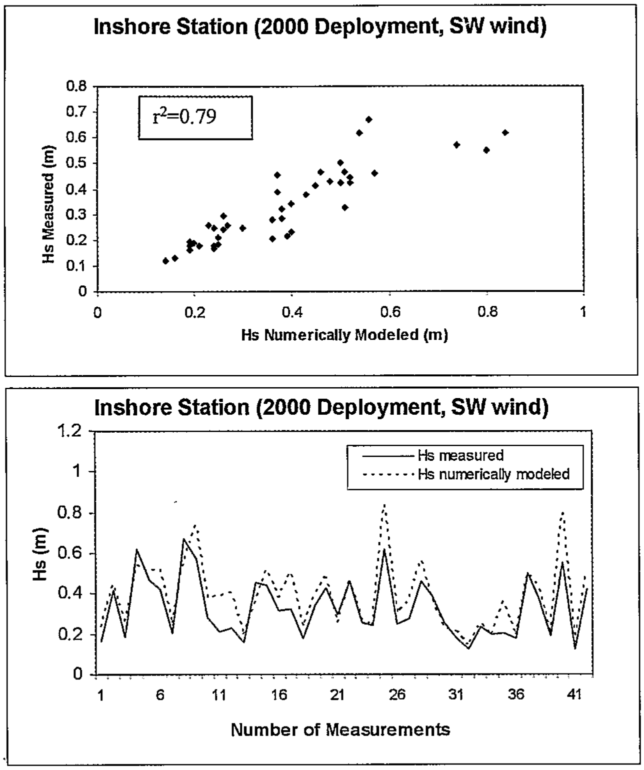


Figure 13. (upper) Scatter plot of Hs measured vs. Hs numerically modeled for south-west wind only at Inshore station for 2000 deployment. (lower) Relationship between numerically modeled and measured significant wave heights for south-west wind only at Inshore station.

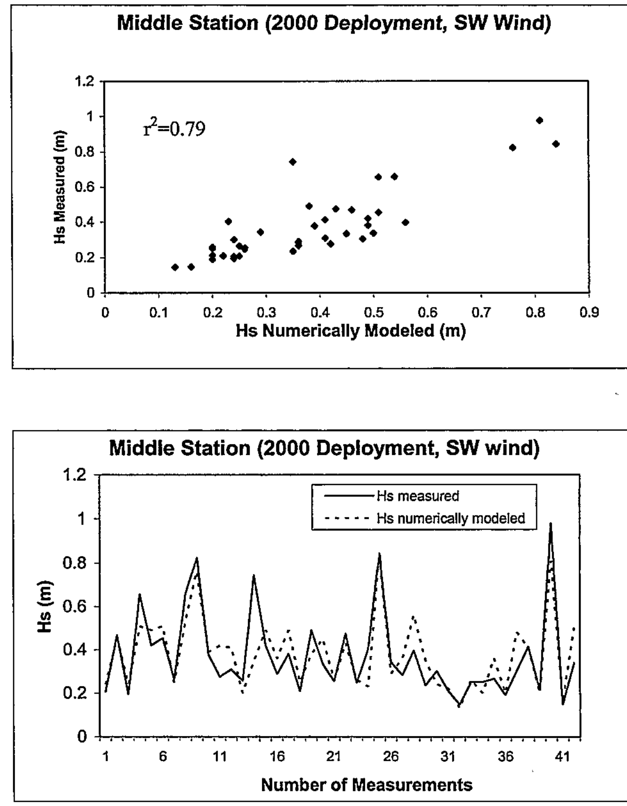


Figure 14. (upper) Scatter plot of Hs measured vs. Hs numerically modeled for south-west wind only at Middle station for 2000 deployment. (lower) Relationship between numerically modeled and measured significant wave heights for south-west wind only at Middle station.

input. This was done to test if the orientation of the instrumentation array (slightly southwest to northeast) and wave refraction effects across the seaward flank of Ship Shoal were of significance in the comparisons of data sets. During the 1998/1999 deployment waves did not approach from the southwest, a common phenomenon during winter months off the Louisiana coast. For the 2000 deployment at the Inshore station, the r^2 value decreased slightly when compared to SW, S and SE approaches from 0.81 to 0.79 (Figure 13). The percent over prediction in H_s decreased by 4% to 19.4%. At the Middle station, the r^2 value increased from 0.56 to 0.79, and the percent over prediction of H_s decreased by 1.2% to 6.4% (Figure 14).

CHANGE IN HYDRODYNAMICS AND SEDIMENT TRANSPORT

Field Measurement

In order to establish the role that Ship Shoal plays on regional hydrodynamics and sediment transport, two deployment sites were selected specifically to collect data from the seaward and landward sides of the shoal complex (Figure 1). Wind data were obtained from the Grand Isle C-Man station. Three bottom-mounted instrumentation systems were used, two of which (Systems 1A and 1B) were deployed a few meters away from each other at Site 1, while the other (System 2A) was deployed at Site 2. System 2A was retrieved on January 12, 1999, and the others remained at Site 1 until February 2, 1999. Due to memory constraints, however, System 1A ceased recording on January 20, 1999. All instrumentation was calibrated, prior to deployment, by the Louisiana State University Coastal Studies Institute Field Support Group.

The instrumentation consisted of two types of frame-mounted system, both of which included internal compasses, tilt and roll sensors, and a self-contained data recorder module. The primary components of Systems 1A and 2A (Figure 15) were SonTek® downward-looking Acoustic Doppler Velocimeters (ADV's) that measured seabed elevation, relative particulate concentration and three-dimensional currents 20 cm above the bed. System 1A sampled at 25 Hz for 81 secs every three hours. System 2A included a Paroscientific pressure sensor in addition to the ADV, and sampled at 4 Hz for 8.5 min every 3 hr.

System 1B (called WADMAS) included a Paroscientific pressure sensor, a sonar altimeter, and a vertical array of three co-located Seapoint optical backscatter sensors (OBS's) and Marsh-McBirney electromagnetic current meters (Figure 16). WADMAS thus measured water level, directional wave

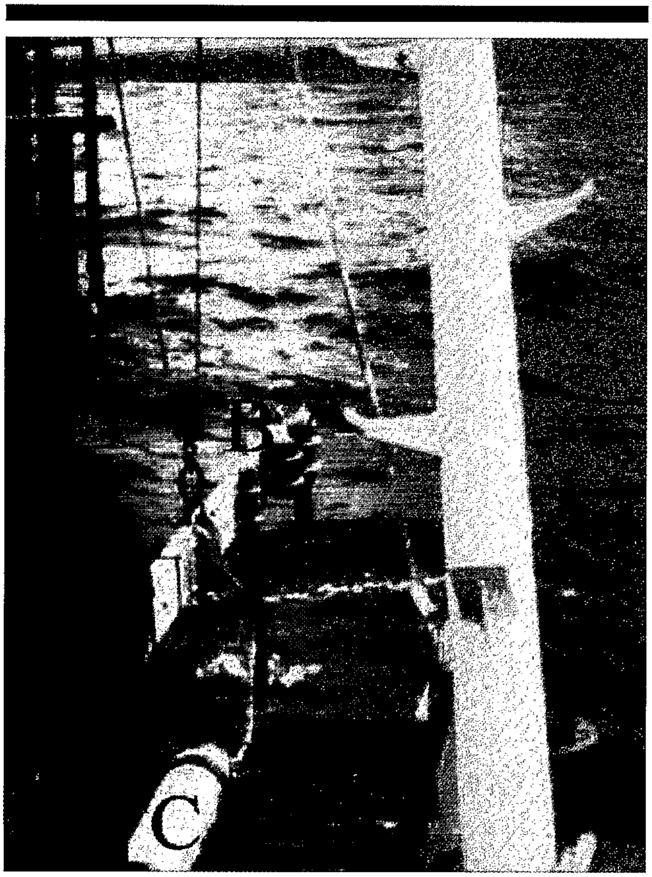


Figure 15. System 2A during deployment at Site 2. (A) Acoustic Doppler Velocimeter. (ADV) (B) Pressure Sensor. (C) Waterproof housing containing recorder module, compass and power supply. System 1A was identical except that it did not include a pressure sensor.

parameters, and seabed elevation, as well as current velocity and suspended sediment concentration at heights of 20, 60, and 100 cm above the seabed. The sonar altimeter collected one measurement every 15 min, while all other sensors sampled for 8.5 min per hour at a frequency of 4 Hz.

Hourly wind data for the deployment period were obtained from the National Oceanic and Atmospheric Administration (NOAA) station located on Grand Isle, Louisiana (GDIL1). Daily National Weather Service maps were also inspected to identify the occurrence of frontal passages. "Storm" winds associated with frontal passages are defined in this paper as those that exceeded one standard deviation above the mean wind speed for the study period, a value of 7.3 m s^{-1}. Pre-frontal winds were those that blew from a direction between 90 and 270° and occurred prior to the cold front passage. The post-frontal phase included the period subsequent to the frontal passage when wind direction was between 270 and 90°.

For a detailed description of field data analysis techniques, the reader is referred to PEPPER (2000); STONE (2000) and PEPPER and STONE (2002), PEPPER and STONE (in review). In summary, directional wave parameters were calculated from the pressure and current-meter data using the spectral method outlined by EARLE *et al.* (1995). Two methods were employed to calculate an initial value of shear velocity, depending on the instrumentation system from which the data were obtained. The Reynolds stress (RS), or eddy correlation, technique was used to calculate shear velocity and apparent bottom roughness from the ADV data (Systems 1A and 2A). The logarithmic profile method (LOG) was used to calculate bottom boundary layer parameters from the System 1B data. A method based on the GRANT-MADSEN model (1979, 1986) was also employed on calculating shear velocity during combined waves and current flows, owing to the model's widespread familiarity and high level of empirical verification (LARSEN *et al.*, 1981; CACCHIONE *et al.*, 1987; HUNTLEY and HAZEN, 1988).

Critical shear velocity of the bottom sediment (u_{*crit}) was calculated using a modified Yalin technique outlined by LI *et al.* (1996). This yielded a value of 0.81 cm s^{-1}, and because sediment at the study site was fairly uniform in size, it was assumed that this single value could be applied. The sediment suspension profile was represented using the standard ROUSE (1937) equation because it has been demonstrated to be a fairly accurate representation for sandy environments, even under combined wave and current flows (LYNCH *et al.*, 1997)

Suspended sediment transport is represented mathematically by time- and depth-integrating the product of the horizontal velocity of the fluid and the suspended sediment concentration. This is a complex problem in combined-flow regimes, owing to phase differences in velocity and concentration, and the possible occurrence of secondary flows including ejected vortices (AGRAWAL and AUBREY, 1992; OSBORNE and GREENWOOD, 1993; DAVIES, 1995). Results of this calculation are therefore very sensitive to the time-scale chosen. The method chosen here, labeled the time-averaged approach (TA), was to multiply the burst-averaged velocity and concentration profiles as calculated on the basis of the shear velocity. This approach has often been employed in wave-dominated environments (*e.g.* VINCENT *et al.*, 1981; KIM *et al.*, 1997) despite the fact that it assumes temporally-uniform values, a condition that may not be satisfied during unsteady oscillatory flow. The profiles were integrated both within and above the wave boundary layer (WBL) using:

$$Q_{sn} = \begin{cases} \dfrac{1}{t} \displaystyle\int_{z=\delta_w}^{z=\eta} \int_0^t uC_n \, dz \, dt & \text{for } z > \delta_w \\ \dfrac{1}{t} \displaystyle\int_{z=z_0}^{z=\delta_w} \int_0^t uC_n \, dz \, dt & \text{for } z < \delta_w \end{cases}$$

where η is the sea surface elevation. Bed load transport rate (Q_b) was calculated by using the combined wave-current shear stress as an input to the empirical formula of MEYER-PETER and MULLER (1948) as adapted by WIBERG *et al.* (1994):

$$1Q_b = 8\frac{(\tau - \tau_{crit})}{(\rho_s - \rho)g}$$

Bedload transport was assumed to occur in the same direction as that of the maximum shear stress (φ_{max}) within the WBL.

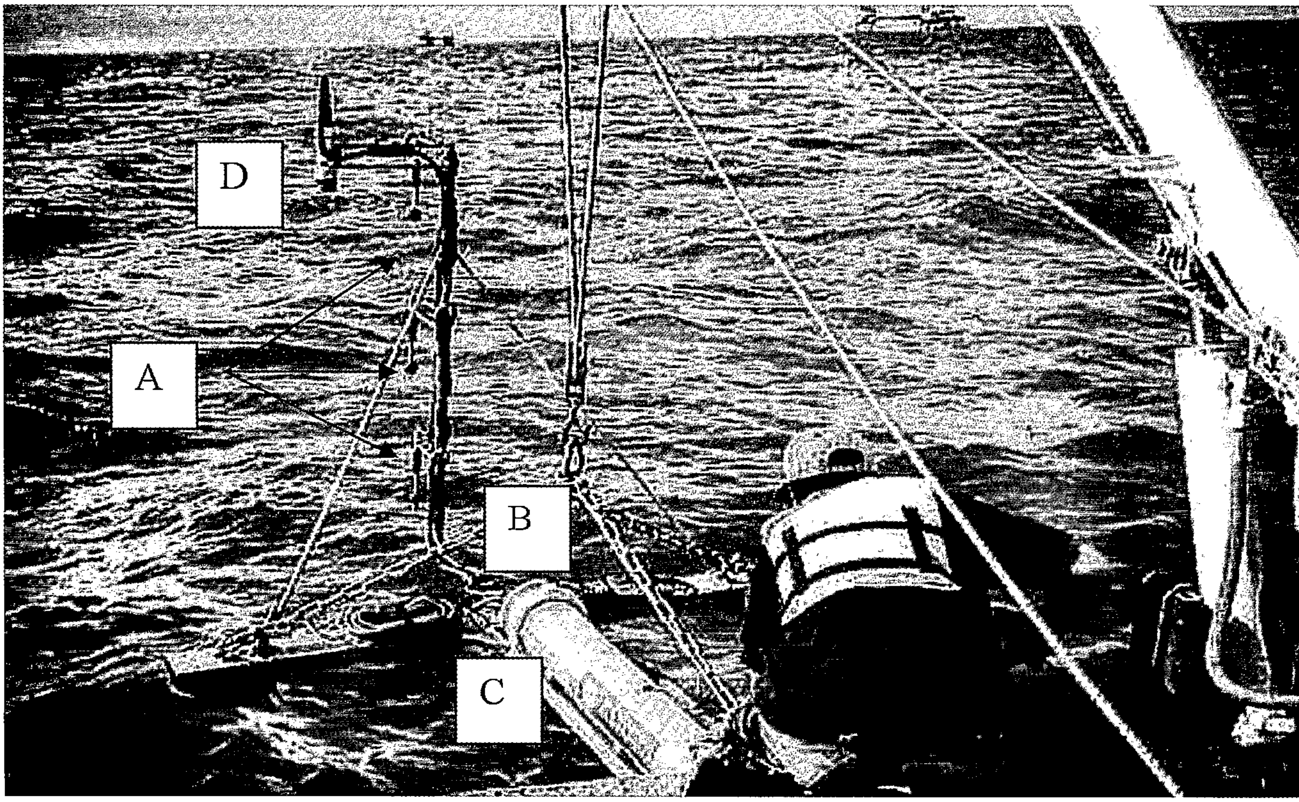


Figure 16. System 1B during deployment at Site 1. (A) Stacked array of co-located electromagnetic current meters and optical backscatter sensors. (B) Pressure Sensor. (C) Waterproof housing containing recorder module, compass and power supply. (D) Sonar altimeter.

Table 4. *Summary of hydrodynamic parameters recorded by the systems at Sites 1 and 2 during the deployment.*

Location System	Statistic	Site 1 (*offshore*) 1A (ADV)	1B (WADMAS)	Site 2 (*nearshore*) 2A (ADV)
Total Depth (m)	Mean	8.8	9.0	7.3
	Minimum	8.2	8.4	6.7
	Maximum	9.2	9.5	7.8
Hs (m)	Mean	n/a	0.61	0.45
	Minimum	n/a	0.07	0.10
	Maximum	n/a	2.80	1.53
Tp (s)	Mean	n/a	5.3	5.0
	Minimum	n/a	3.6	3.6
	Maximum	n/a	9.1	9.1
Orbital Velocity (cm s^{-1})	Mean	11.7	10.6	9.9
	Minimum	2.6	0.8	0.0
	Maximum	35.9	53.1	36.5
Current Speed (cm s^{-1}) (~0.2m above bed)	Mean	5.8	4.6	6.3
	Minimum	0.1	0.1	0.0
	Maximum	44.8	34.2	47.6
Current Speed (cm s^{-1}) (~1 m above bed)	Mean	12.4	8.0	13.9
	Minimum	0.1	0.1	0.0
	Maximum	72.4	53.2	62.3
Current Direction	Mean	245	240	292

Influence of Ship Shoal on Hydrodynamics and Sediment Transport

Table 4 is a summary of hydrodynamic parameters for the deployment. Points to note include the depth, which was 1.5–2.0 m deeper offshore (Site 1) than nearshore (Site 2), and the depth range, which was slightly greater than 1.0 m at both sites. Significant wave height and wave orbital velocity were higher at Site 1 than at Site 2, by 36 and 18%, respectively, which is consistent with the expectation that waves crossing Ship Shoal are attenuated as a result of bottom friction. Because of the attenuation of swell waves propagating northward across the shoal, peak wave period was 9% lower at the nearshore site, where locally-generated sea assumed a greater relative importance.

Differences in current velocity between sites were less expected and are less easily explained than differences in wave parameters. In contrast to wave energy, mean current speed was approximately 10% higher at Site 2 (nearshore) than Site 1 (offshore). Current direction had a strong westerly component at both sites, which is consistent with previous research (Crout and Hamiter, 1981; Murray, 1997; Jaffe *et al.*, 1997). However, the across-shelf current component was seaward at the offshore site and landward at the nearshore site (Figure 17). Since the two sites are separated by only a few kilometers and are subject to similar atmospheric and tidal

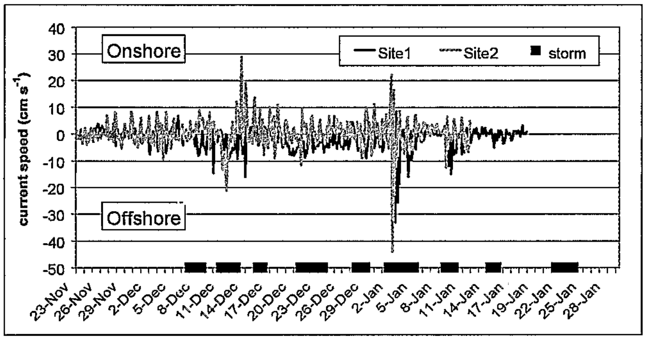


Figure 17. Across-shelf current flow during the deployment at Sites 1 and 2 (at ~20 cm above the bed) as measured by Systems 1A and 2A.

forcing mechanisms, this was apparently the result of flow modulation by Ship Shoal's bathymetry. A likely explanation is that the prevailing westward currents were steered downslope by gravity on opposite sides of the shallow shoal, resulting in southward flow at Site 1 and northward flow at Site 2. Although this is difficult to verify using the available data set, preliminary results from a recent deployment suggest that this interpretation is correct. Ship Shoal controls the regional hydrodynamics, a phenomenon that is presumably also significant on any inner shelf that includes submerged sand bodies or other prominent bathymetric features. Furthermore, this influences bottom boundary layer dynamics and sediment transport on the Louisiana inner shelf, a point that will be discussed further in the context of cold front passages.

Significance of Cold Front Passages

Nine cold front passages occurred during the deployment, or approximately one per week. Overall, mean wind speed and direction were 8.1 m s^{-1} and 354° (northerly) during storm periods and 3.8 m s^{-1} and 113° (southeasterly) during fair weather. Clockwise rotation (veering) of the wind from south to north was typical during frontal passages.

The cospectrum of across-shelf winds and currents (Figure 18) shows a positive peak at periods of 5 to 10 days (which is statistically-significant at a 90% confidence level). The phase spectrum (Figure 18) indicates that there was little phase difference between wind and current variability. The same was true of along-shelf winds and along-shelf currents, although the cospectrum was not statistically significant over most frequencies. Thus, southerly winds were generally coincident with northerly currents, and northerly winds were coincident with southerly currents, with cold-front passages apparently providing the major energy input.

Cold-front passages had a strong influence on inner-shelf hydrodynamics. Wave height increased steeply as did mean and oscillatory currents (Figures 19A and B). Mean and wave-driven flow speeds were similar overall, although each attained a relatively higher level at different times during the deployment, likely as a result of differing meteorological forcing mechanisms.

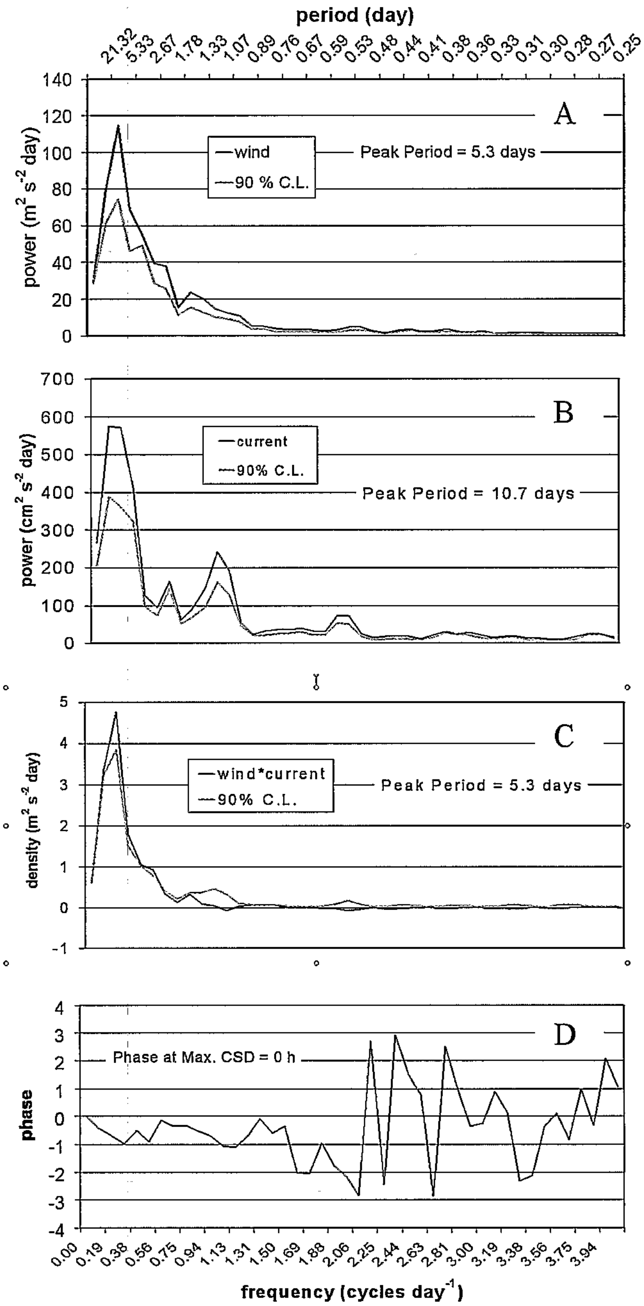


Figure 18. (A and B): Cospectrum of across-shelf wind and current. (C) Phase spectrum of wind and current. (D) CSD denotes cross-spectral density. The 90% confidence level (CL) is shown on plot s A, B and C.

Hydrodynamic differences between cold-front passages and fair weather led to differences in bottom boundary layer parameters and sediment transport, as summarized in Table 5. Episodic increases in current- and wave-current shear velocity were associated with storms, when values were generally at least 50% higher than those during fair weather conditions. Sediment transport predictions varied widely depending on the method used, and as such, they should be used

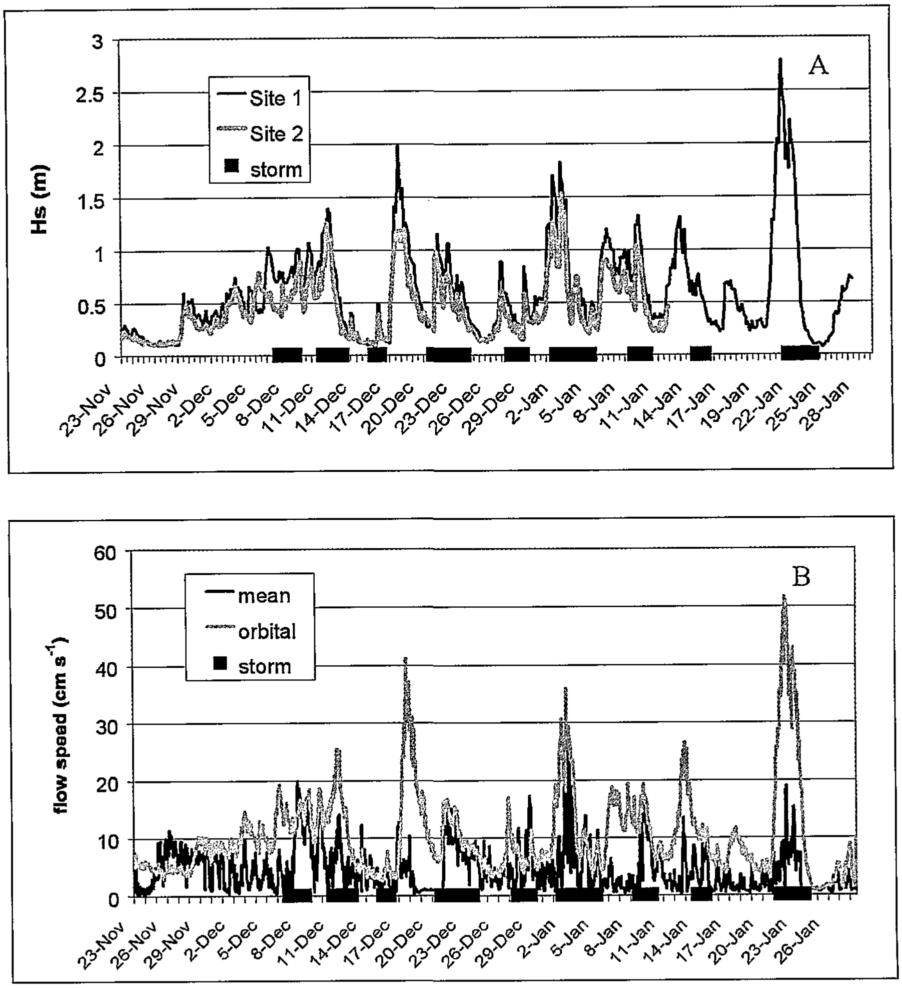


Figure 19. (A) Significant wave height at Sites 1 and 2 during the deployment period. (B) Mean and orbital (oscillatory) flow speed for Site 1. Trends were similar at Site 2.

primarily as relative estimates for the purposes of comparison. However, all estimates indicate that sediment transport in the across- and along-shelf directions was episodically increased by storms. It should also be noted, that rate of sediment transport during fair weather conditions was not predicted to be zero.

Sediment transport direction was especially variable as a result of the occurrence of different types of weather conditions. Predicted fair weather transport was westerly at Site 1, and easterly at Site 2, with the across-shelf vector tending to be onshore at both sites. Mean extratropical storm transport was offshore at both sites, with an easterly component

Table 5. *Summary of flow, bottom boundary layer (BBL), and sediment transport values during extratropical storms and fair weather conditions for Sites 1 and 2.*

	Flow Speed (cm s^{-1})		BBL Shear Velocity (cm s^{-1})		Sediment Transport (mg cm^{-1} s^{-1})			
					TA		MPM	
	Mean	Orbital	$u*_c$	$u*_{cw}$	Rate	Direction	Rate	Direction
Site 1								
Storms	7.5	11.4	1.7	2.7	549.1	139	97.8	145
Fair Weather	3.5	8.3	1.1	1.9	138.7	298	85.6	253
Site 2								
Storms	10.3	12.3	2.1	3.2	810.7	182	412.9	256
Fair Weather	5.1	9.2	1.6	2.5	584.8	50	325.0	17

Table 6. *Mean wave characteristics for the storm types as measured at Sites 1 and 2, respectively.*

Storm Type	Site 1			Site 2		
	Hs (m)	Tp (s)	Ub (cm s^{-1})	Hs (m)	Tp (s)	Ub (cm s^{-1})
1	0.80	4.11	12.7	0.60	3.8	12.58
2	1.06	5.82	19.1	0.66	5.0	14.29

at Site 1 and a westerly component at Site 2. However, there was considerable variability between individual cold front passages (PEPPER and STONE, 2002), and as such, a classification system was introduced.

Cold Front Classification

The classification system consisted of two end-member types on a continuum of regional cold front passages. It was determined that three cold front passages that occurred during this deployment fit into each of the two categories, and a summary of hydrodynamic and sediment transport measurements for each are presented here. More detailed results based on this classification system are discussed for two specific cold front passages by PEPPER and STONE (2002).

Type 1 storms, or arctic surges, have a weak pre-frontal phase followed by a fairly powerful post-frontal phase, during which northeasterly winds dominate. Type 2 storms are migrating cyclones dominated by a strong low-pressure cell, and have fairly strong southerly winds prior to the frontal passage, followed by strong northwesterly winds subsequent to it.

Table 6 shows wave characteristics at both sites for each of the storm types. Wave energy, as indicated both by wave height and near-bed orbital velocity, was highest at each site during Type 2 storms, followed by Type 1 storms. Wave period was considerably higher for Type 2 than for Type 1 storms.

Time series of significant wave height and peak wave period for representative Types 1 and 2 storms (Storms 6 and 7) are shown in Figures 20 and 21. Type 1 storms were characterized by an increase in significant wave height and an accompanying decrease in peak wave period associated with the onset of northerly post-frontal winds. On the other hand, wave response to Type 2 storms, as illustrated by data from Storm 6 (Figure 21), was more complex. The time series of significant wave height had two peaks, the lower of which occurred immediately prior to the frontal passage, while the higher occurred just subsequent to it. Maximum hourly significant wave height (H_s) during this event was 1.83 m and H_s exceeded 1.5 m for 10 hr around the peak of the storm. Peak wave period increased gradually to approximately 8 sec prior to the frontal passage, following which, it suddenly decreased to 3.76 sec. It then fluctuated between the high- and low-frequency values for 24 hr, at which point it leveled off at approximately 4 sec.

The directional characteristics of waves associated with various phases of the two storm types provide additional information regarding their dynamics and generating mechanism. Figures 22 and 23 are vector plots of non-dimensional wave direction during Types 1 and 2 storms, respectively. In both cases, wave direction was uniformly toward the northwest during the pre-frontal stage. Immediately following the passage of the front, however, wave direction differed between storm types—in the case of the Type 1 storm, there was an immediate shift to southerly waves, while wave direction during the Type 2 storm oscillated between northeasterly and southeasterly before ultimately aligning with the (northerly) wind direction approximately 24 h later. It should be noted that this does not indicate sudden (*i.e.* hourly) shifts in wave direction, but instead, minor changes in the relative energy level of the longer- and shorter-period wave bands. This is indicative of the continued importance of longer-period waves throughout the duration of Type 2 storms.

The storm types differed in terms of their associated wave characteristics. Type 2 storms appear to have had the most energetic wave field overall, particularly during the pre-frontal phase. Significant contributions to the energy spectrum resulted from both long-period northerly swell waves, and

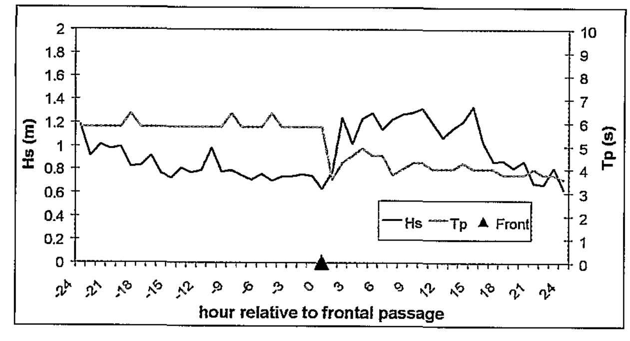


Figure 20. Significant wave height (Hs) and peak wave period (Tp) at Site 1 during a Type 1 storm (Storm 7).

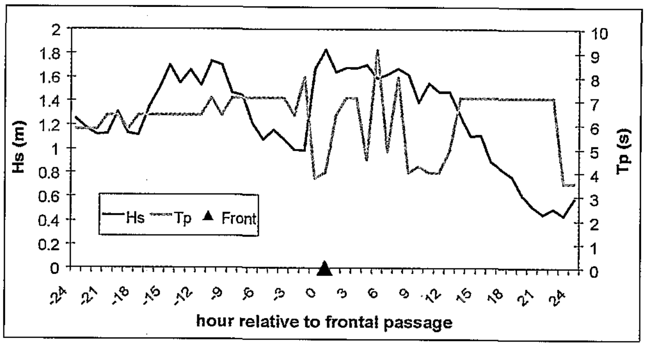


Figure 21. Significant wave height (Hs) and peak wave period (Tp) at Site 1 during a Type 2 storm (Storm 6).

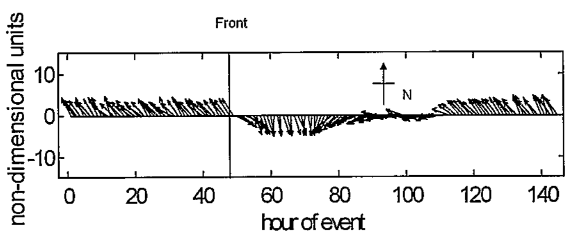


Figure 22. Non-dimensional wave direction during Storm 7, a Type 1 storm. The time of the frontal passage is indicated by the line at hour 48.

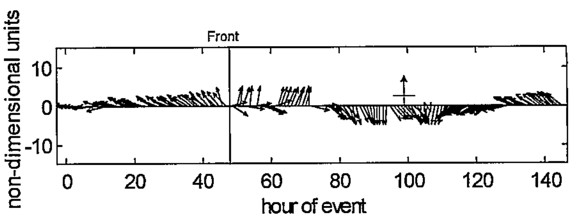


Figure 23. Non-dimensional wave direction during the Type 2 storm. The time of the frontal passage is indicated by the vertical line at hour 48.

short-period, southerly storm waves, both of which were present during the majority of the post-frontal phase. Type 1 storms, on the other hand, were dominated by short-period southerly waves subsequent to the frontal passage. As outlined above, Type 1 storms were characterized by weak southerly pre-frontal winds and energetic northerly pre-frontal winds, thus resulting in higher southerly post-frontal storm waves. In contrast, the strong southerly pre-frontal winds that accompanied Type 2 storms acted over a larger fetch than was present during periods of northerly winds, resulting in the generation of northerly long-period waves that were energetic enough to persist throughout much of the storm. This also explains the relative reduction in significant wave height and peak wave period at Site 2 during Type 2 storms, since northerly, and not southerly, waves are primarily influenced by attenuation across Ship Shoal at this site.

Table 7 shows mean currents for the storm types based on the field deployment data. Overall and post-frontal current speeds were highest during Type 1 storms, although during the pre-frontal phases, current speed was nearly twice high during Type 2 storms. Mean current direction during this phase was northwesterly for both storm types. The (stronger) post-frontal currents were southwesterly during Type 1 storms, and southeasterly during Type 2 storms, which is closely reflected in the overall current direction for these events. The absence of strong currents prior to the frontal passage was likely the result of the fairly weak winds that predominated during the pre-frontal phase of Type 1 storms. Similarly, the powerful southeasterly or southwesterly post-frontal currents observed immediately following the frontal passages were probably the result of strong, direct wind stress during the post-frontal phase.

Standard bottom boundary layer parameters for Site 1, calculated by applying the logarithmic profile (LOG) method to current data from System 1B, are presented in Table 8. The results obtained by applying the Reynolds Stress (RS) method to the 3-D current data from Systems 1A and 2A are not presented here, largely owing to the smaller data sets available, and the fact that general trends apparent from these systems were similar. Shear velocity was almost identical overall during Types 1 and 2 storms. During the 24 hours prior to the frontal passage, however, shear velocity was much higher for Type 2 than for Type 1 storms. Calculated shear velocity values were higher during the post-frontal than the pre-frontal phase for both types of storms, with Type 2 storms again being characterized by the highest values. Apparent bottom roughness was clearly highest during Type 2 storms. The reasons for this are unclear, although it is possible that high wave activity occurring during the pre-frontal phase of Type 2 storms created physical bed roughness elements such as wave ripples. These may have been absent, or at least less prominent, during the other storm type, and additionally, may have been washed out by strong post-frontal currents during Type 1 storms.

Table 9 summarizes the overall suspended and bed load transport estimates for Sites 1 and 2 during the three storm types, as estimated using the time-averaged (TA) and Meyer-Peter and Muller (MPM) methods, respectively. It is evident that at both sites, and according to both methods, Type 2 storms were responsible for the largest rates of sediment transport, while Type 1 storms had transport rates several times lower. Both suspended and bed load sediment transport direction ranged between southerly and westerly during Type 1 storms, depending on the prediction method used and the location. Transport had a stronger offshore component at Site 1, where the overall direction was nearly southerly, than at Site 2, where transport was predominantly westerly. Suspended sediment transport during Type 2 storms was toward the southeast; however, unlike Type 1 storms, there was a stronger offshore component at Site 2 than at Site 1. Bed load transport during Type 2 storms was southwesterly at Site 1, and southeasterly at Site 2. In summary, therefore, sediment transport rate during Type 1 storms was not as high as dur-

Table 7. *Mean current parameters for the storm types as measured at approximately 1 m above the bed by System 1B at Site 1.*

	Storms		Pre-frontal		Post-frontal	
Storm Type	Speed (cm s^{-1})	Direction	Speed (cm s^{-1})	Direction	Speed (cm s^{-1})	Direction
1	16.5	229	5.8	315	17.4	228
2	13.2	141	11.7	287	17.2	123

Table 8. *Current-induced and combined wave-current shear velocity (u^*_c and u^*_{cw}, respectively), and apparent bottom roughness (z_o) for the storm types at Site 1.*

	All Storm Conditions			Pre-frontal (24 h)			Post-frontal (24 h)		
Storm Type	u^*_c (cm s^{-1})	u^*_{cw} (cm s^{-1})	z_0 (cm)	u^*_c (cm s^{-1})	u^*_{cw} (cm s^{-1})	z_0 (cm)	u^*_c (cm s^{-1})	u^*_{cw} (cm s^{-1})	z_0 (cm)
1	1.51	2.55	1.66	0.63	1.15	3.37	1.52	2.57	1.63
2	1.52	2.55	4.11	1.23	2.43	4.09	2.01	3.22	4.07

ing Type 2 storms, and the mean direction tended to be southwesterly at Site 1 and westerly at Site 2, while during Type 2 storms, mean sediment transport was directed southeasterly at Site 1, and southerly at Site 2.

CONCLUSIONS

Ship Shoal mitigates the adjacent wave field off the Louisiana coast, particularly during storm conditions. The interaction of fairweather waves with the shoal is negligible. Removal of the shoal, however, for possible future barrier/coastal restoration efforts will not significantly influence wave conditions in the nearshore because the expected increase in wave energy is limited to the leeward flank of the shoal. The data presented indicate that STWAVE over predicts H_s by between 6 and 24%. Over prediction shows a general decrease when winds from the northern two quadrants are removed from the time series. Modeling waves propagating from the southwest to incorporate possible refraction across the shoal does not significantly alter either the over prediction percentage or r^2 value when compared to wave approaches from both southern quadrants. Overall, the model has predicted H_s satisfactorily over a broad spectrum of wave conditions for the northern Gulf of Mexico.

Hydrodynamic, bottom boundary layer, and sedimentary processes on the Louisiana inner shelf during the winter are characterized by episodic variability, largely as a result of the quasi-periodic cycle of recurring cold front passages. Specifically, these events are characterized by increases in wave height, oscillatory and mean current speed, shear velocity, and sediment transport. Waves tend to be higher and longer in period on the seaward side, whereas mean currents are generally higher landward, where they are directed onshore, unlike the offshore site, where seaward currents predominate. Sediment transport initiated by cold fronts is generally directed southeasterly to southwesterly at the offshore site, and southerly to westerly at the nearshore site. It is clear, therefore, that Ship Shoal exerts a significant influence on regional hydrodynamics and sediment transport.

End-member cold front types can be identified. Type 1 storms are arctic surges that are associated with southerly storm waves, and southwesterly to westerly currents and sediment transport. Type 2 storms are migrating cyclones that cause northerly swell that transforms into southerly sea, and currents and sediment transport that are southeasterly overall.

ACKNOWLEDGEMENTS

Funding for this work was obtained from the U.S. Minerals Management Service under contracts 14-35-0001-30660 and 14-35-0001-30660-19911b. We thank Dr. Don Resio (Coastal and Hydraulics Laboratory), and Dr. James Kirby (University of Delaware) for helpful discussion on STWAVE and REF/DIF S respectively. Cartographic assistance was obtained from Mary Lee Eggart, Kerry Lyle and Clifford Duplechin (Louisiana State University). We acknowledge the constructive criticisms offered by Drs. Nick Kraus and Alexis Lugo-Fernandez on an earlier draft of this manuscript. The Coastal Studies Institute's Field Support Group at LSU performed all array mount fabrication and deployment.

LITERATURE CITED

ABEL, C.E.; TRACY, B.A.; VINCENT, C.L., and JENSEN, R.E., 1989. Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956–1975. USAE Waterways Experiment Station, Vicksburg, MS, *WIS Report 19,* 33 p.

AGRAWAL, Y.C. and AUBREY, D.G., 1992. Velocity Observations Above a Rippled Bed Using Laser Doppler Velocimetry. *Journal of Geophysical Research,* 97(C12), 20249–20259.

BRITSCH, L. D. and DUNBAR, J. B., 1993. Land loss rates: Louisiana coastal plain. *Journal of Coastal Research,* 9, 324–338.

BYRNES, M.R. and GROAT, C. (eds.), 1991. Characterization of the Development Potential of Ship Shoal Sand for beach Replenishment of the Isles Dernieres. Final Report to the U.S. Minerals Management Service, 164 p.

CACCHIONE, D.A.; GRANT, W.D.; DRAKE, D.E., and GLENN, S.M., 1987. Storm-Dominated Bottom Boundary Layer Dynamics on the Northern California Continental Shelf: Measurements and Predictions. *Journal of Geophysical Research.* 92(C2), 1817–1827.

Table 9. *Sediment transport predicted with the TA and MPM methods for Systems 1A and 2A using the Reynolds stress technique for calculating shear stress.*

	Site 1				Site 2			
	TA		MPM		TA		MPM	
Storm Type	Q_b (mg cm^{-1} s^{-1})	Dir.	Q_b (mg cm^{-1} s^{-1})	Dir.	Q_b (mg cm^{-1} s^{-1})	Dir.	Q_b (mg cm^{-1} s^{-1})	Dir.
1	289.2	195	144.7	190	175.8	273	173.9	259
2	1095.6	120	388.1	118	1871.8	171	847.8	205

COLEMAN, J.M.; ROBERTS, H.H., and STONE, G.W., 1998. Mississippi River Delta: An Overview. *Journal of Coastal Research,* 14, 3, 698–716.

CROUT, R.L. and HAMITER, R.D., 1981. Response of Bottom Waters on the West Louisiana Shelf to Transient Wind Events and Resulting Sediment Transport. *Transactions of the Gulf Coast Association of Geological Societies,* 31, 273–277.

DAVIES, A.G., 1995. Effects of unsteadiness on the suspended sediment flux in co-linear wave-current flow. *Continental Shelf Research,* 15(8), 949–979.

EARLE, M.D.; MCGEHEE, D., and TUBMAN, M., 1995. Field Wave Gaging Program, Wave Data Analysis Standard. Vicksburg, Mississippi: *U.S. Army Corps of Engineers Instruction Report CERC-*95-1, 33p.

FRAZIER, D.E., 1967. Recent Deposits of the Mississippi River, their Development and Chronology. *Transactions of the Gulf Coast Association of Geological Societies,* 17, p. 287–311.

GRANT, W.D. and MADSEN, O.S., 1979. Combined Wave and Current Interaction with a Rough Bottom. *Journal of Geophysical Research,* 84(C4), 1797–1807.

GRANT, W.D. and MADSEN, O.S., 1986. The Continental-Shelf Bottom Boundary Layer. *Annual Review of Fluid Mechanics,* 18, 265–305.

GRYMES, J. and STONE, G.W., 1995. A review of the key meteorological and hydrological aspects of Hurricane Andrew. *In:* STONE, G.W. and FINKL, C.W., (eds.), Impacts of Hurricane Andrew on the Coastal Zones of Florida and Louisiana: 22–26 August 1992 *Journal of Coastal Research, Special Issue 21,* 6–23.

HOLTHUIJSEN, L.H.; BOOIJ, N., and HEBERS, T.H.C., 1989. A Prediction Model for Stationary, Short-Crested waves in Shallow Water with Ambient Currents. *Coastal Engineering,* 13, p. 23–54.

HUBERTZ, J. M. and BROOKES, R.M., 1989. Gulf of Mexico hindcast wave information. WIS report 18. *US Army Corps of Engineer, Waterways Experiment Station,* Vicksburg, MS.

HUNTLEY, D.A. and HAZEN, D.G., 1988. Seabed Stresses in Combined Wave and Steady Flow Conditions on the Nova Scotia Continental Shelf: Field Measurements and Predictions. *Journal of Physical Oceanography,* 18, 347–362.

JAFFE, B.E.; LIST, J.H., and SALLENGER, A.H., JR., 1997. Massive sediment bypassing on the lower shoreface offshore of a wide tidal inlet–Cat Island Pass, Louisiana. *Marine Geology,* 136, 131–149.

KIM, S.-C.; WRIGHT, L.D., and KIM, B.-O. 1997. The combined effects of synoptic scale and local-scale meteorological events on bed stress and sediment transport on the inner shelf of the Middle Atlantic Bight. *Continental Shelf Research,* 17(4), 407–433.

LARSEN, L.H.; STERNBERG, R.W.; SHI, N.C.; MARSDEN, M.A.H., and THOMAS, L., 1981. Field investigations of the threshold of grain motion by waves and currents. *Marine Geology,* 42, 105–132.

LI, M.Z.; WRIGHT, L.D., and AMOS, C.L., 1996. Predicting ripple roughness and sand resuspension under combined flows in a shoreface environment. *Marine Geology,* 130, 139–161.

LIST, J.H. and HANSEN, M.E., 1992. The Value of Barrier Islands: 1. Mitigation of Locally-generated Wind-Wave Attack on the Mainland. *USGS Open File Report* 92-7222, 18 pp.

LIST, J.H.; JAFFEE, B.E.; SALLENGER, A.H., and HANSEN, M.E., 1997. Bathymetric comparisons adjacent to the Louisiana barrier islands: Processes of large-scale change. *Journal of Coastal Research,* 13, 3, 670–678.

LYNCH, J.F.; GROSS, T.F.; SHERWOOD, C.R.; IRISH, J.D., and BRUMLEY, B.H., 1997. Acoustical and optical backscatter measurements of sediment transport in the 1988–1989 STRESS experiment. *Continental Shelf Research,* 17(4), 337–366.

MEYER-PETER, E. and MULLER, R., 1948. Formulas for bed-load transport. International Association for Hydraulic Structural Research, Meeting 2, Stockholm, Sweden.

MOSSA, J., 1988. Analysis of the Environmental Effects of Sand resource Utilization on the Louisiana Continental Shelf. Open-File Series No. 88-01. *Louisiana Geological Survey,* Baton Rouge, LA.

MULLER, R.A. and STONE, G.W., 2001. A climatology of tropical storm and hurricane strikes to enhance vulnerability prediction for the southeast U.S. coast. *Journal of Coastal Research,* 17, 4, 949–956.

MURRAY, S.P., 1997. An observaytional study of the Mississippi-Atchafalaya coastal plume: Final report. OCS Study MMS 98-0040. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, La. 513 pp.

MCBRIDE, R.A.; PENLAND, S.; HILAND, M.; WILLIAMS, S.J.; WESTPHAL, K.A.; JAFFE B., and SALLENGER, A.H. JR., 1992. Analysis of barrier shoreline change in Louisiana from 1853 to 1989. *In:* WILLIAMS, S.J. *et al.* (eds.), Atlas of Barrier Island Changes in Louisiana from 1853 to 1989. *USGS Miscellaneous Investigations Series* I-2150-A, 36–97.

MCBRIDE, R.A. and BYRNES, M.R., 1997. Regional variations in shore response along barrier island systems of the Mississippi River delta plain: Historical change and future prediction. *Journal of Coastal Research,* 13, 3, 628–655.

OSBORNE, P.D. and GREENWOOD, B., 1993. Sediment suspension under waves and currents: time scales and vertical structure. *Sedimentology,* 40: 599–622.

O'REILLY, W.C. and GUZA, R.T., 1993. A Comparison of Spectral Models in the Southern California Bight. *Coastal Engineering,* 17.

PENLAND, S. and SUTER, J.R., 1988. Barrier island erosion and protection in Louisiana: A coastal geomorphological perspective. *Transactions of the Gulf Coast Association of Geological Societies,* 38, 331–342.

PENLAND, S.P.; SUTER, J.R., and BOYD, R., 1985. Barrier Island Areas Along Abandoned Mississippi River Deltas. *Marine Geology,* 63, 197–233.

PENLAND, S.; SUTER, J.R., and MOSLOW, T.F., 1986. Inner-shelf shoal sedimentary facies and sequences: Ship Shoal, northern Gulf of Mexico, *In:* MOSLOW, T.F. and RHHODES, E.G., eds., Modern and ancient shelf clastics: A core workshop: *Tulsa, Oklahoma, Society of Economic Paleontologists and Mineralogists Core Workshop* No. 9, p. 73–123.

PEPPER, D.A., 2000. Hydrodynamics, Bottom Boundary Layer Processes, and Sediment Transport on the South-Central Louisiana Shelf: The Influence of Extratropical Storms and Bathymetric Modification. Unpublished Dissertation, Louisiana State University, Baton Rouge, 159 p.

PEPPER, D.A. and STONE, G.W., 2002. Atmospheric forcing of fine-sand transport on a low-energy inner shelf: south-central Louisiana, USA. *Geo-Marine Letters,* 22, 331–41.

PEPPER, D.A. and STONE, G.W., in review. Hydrodynamic, Bottom Boundary Layer and Sedimentary Responses to Two Contrasting Winter Storms on the Low-Energy Inner Shelf of the Northern Gulf of Mexico, *Marine Geology.*

ROUSE, H., 1937. Modern conceptions of the mechanics of fluid turbulence. *Transactions of the American Society of Civil Engineers,* 102, 463–554.

STONE, G.W., 2000. Wave climate and bottom boundary layer dynamics with implications for offshore sand mining and barrier island replenishment in South-Central Louisiana. OCS Study MMS 2000-053, 90 pp.

STONE, G.W. and PENLAND, S., 1992. Historic Shoreline Change along the Northern Gulf of Mexico. *In:* MAJUMDAR, S.K.; FORBES, G.S.; MILLER, E.W., and SCHMALZ, R.F. (eds.), Natural and Technological Disasters: Causes, Effects and preventive Measures, *The Pennsylvania Academy of Science.*

STONE, G.W. and XU, J., 1996. Wave climate modeling and evaluation relative to sand mining on Ship Shoal, offshore Louisiana, for coastal restoration and barrier island restoration. OCS Study MMS 960059, 170 pp.

STONE, G.W. and MCBRIDE, R.A., 1998. Louisiana barrier islands and their importance in wetland protection: Forecasting shoreline change and subsequent response of wave climate. *Journal of Coastal Research,* 14, 3, 900–915.

STONE, G.W.; XU, J.P., and ZHAN, G.X., 1995. Estimation of the wave field during Hurricane Andrew and morphological change along the Louisiana coast, *In:* Impacts of Hurricane Andrew on the Coastal Zones of Florida and Louisiana: 22–26 August 1992 *Journal of Coastal Research,* Special Issue 21, STONE, G.W. and FINKL, C.W. (eds.), 234–253.

STONE, G.W.; WILLIAMS, S.J., and BURRUSS, A.E., 1997. Louisiana's barrier islands: An evaluation of their geological evolution, morphodynamics and rapid deterioration. *Journal of Coastal Research,* 13, 3, 591–592.

STONE, G.W.; GRYMES, J.; ROBBINS, K.D.; UNDERWOOD, S.G.; STEYER, G.D., and MULLER, R.A., 1993. A chronologic overview of climatological and hydrological aspects associated with Hurricane Andrew and its morphological effects along the Louisiana coast, USA. *Shore and Beach,* 61, 2, 2–12.

VINCENT, C.E.; SWIFT, D.J.P., and HILLARD, B., 1981. Sediment transport in the New York Bight, North American Atlantic Shelf. *Marine Geology,* 42, 369–398.

WIBERG, P.L.; DRAKE, D.E., and CACCHIONE, D.A., 1994. Sediment resuspension and bed armoring during high bottom stress events on the northern California inner continental shelf: measurements and predictions. *Continental Shelf Research,* 14(10/11), 1191–1219.

WILLIAMS, S. J.; PENLAND, S., and SALLENGER, A. H., JR., 1992. Louisiana barrier island erosion study: Atlas of shoreline changes in Louisiana from 1853 to 1989. *USGS Miscellaneous Investigations Series I*-2150-A, 103 p.

WILLIAMS, S.J.; STONE, G.W. and BURRUS, A.E., 1997. A perspective on the Louisiana wetland loss and coastal erosion problem. *Journal of Coastal Research,* 13, 3, 593–594.

From: Frazer, Gary D
To: Shultz, Gina
Cc: Berg, Elizabeth A; Kodis, Martin; Gustavson, Angela; Niemi, Katie; BalisLarsen, Martha
Subject: Re: CBRA call with HNRC Majority
Date: Friday, November 22, 2019 9:52:39 AM
Importance: High

If OCL wants us to do a call, I'll participate and will want Katie Niemi or Dana Wright to join me. -- GDF

Gary Frazer
Assistant Director -- Ecological Services
U.S. Fish and Wildlife Service
(202) 208-4646

On Wed, Nov 20, 2019 at 4:10 PM Shultz, Gina <Gina_Shultz@fws.gov> wrote:

> Hi Liz,
> Gary is out today. He will be back tomorrow. We are still waiting for the Solicitor's office to provide answers to questions we have about implementation of the new M-opinion.
> Gina Shultz
> Deputy Assistant Director, Ecological Services
> U.S. Fish and Wildlife Service
> MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> 703-358-1985
>
> On Wed, Nov 20, 2019 at 3:45 PM Berg , Elizabeth <elizabeth_berg@fws.gov> wrote:
>
> > Hi Gary,
> >
> > I'm just checking in on this before we reach out to Lora.
> >
> > Thank you,
> > Liz
> >
> > On Thu, Nov 7, 2019 at 12:36 PM Kodis, Martin <martin_kodis@fws.gov> wrote:
> >
> > > Thanks Liz. To clarify, I don't think Lora is aware that there is a SOL memo, and the last direction I got from OCL was we shouldn't be sharing the memo outside DOI, so I didn't mention it to her. She is aware of the Van Drew letter, which is in the public domain.
> > >
> > > Marty
> > >
> > > On Thu, Nov 7, 2019 at 12:25 PM Berg , Elizabeth <elizabeth_berg@fws.gov> wrote:
> > >
> > > > Hi Gary,
> > > >
> > > > Lora Snyder, HNRC Majority, contacted Marty yesterday with questions regarding the CBRA SOL Memo. She is aware of the Secretary's letter to Van Drew, but has not seen the full SOL Memo. She did not have many specific questions beyond "can this be done without a solicitor's opinion to overturn the existing solicitor's interpretation?"

She also generally asked about what will change and what the effect will be on the ground.

OCL would like us to schedule a call with Lora to address her questions and asked us to identify a subject matter expert to participate in the call. Can you please advise?

Thank you,
Liz

--
Elizabeth Berg
Congressional and Legislative Affairs Knauss Fellow
U.S. Fish and Wildlife Service
Office: 703-358-2225
elizabeth_berg@fws.gov

--
Martin Kodis
Chief, Division of Congressional and Legislative Affairs
U.S. Fish and Wildlife Service

5275 Leesburg Pike
Falls Church, VA 22041

703-358-2241 ph
703-358-2245 fax

--
Elizabeth Berg
Congressional and Legislative Affairs Knauss Fellow
U.S. Fish and Wildlife Service
Office: 703-358-2225
elizabeth_berg@fws.gov

From:	Bohn, Cynthia
To:	Shaughnessy, Michelle
Cc:	Niemi, Katie
Subject:	Fwd: CBRA Coordination with Wilmington District for Carolina and Wrightsville beach projects relative to new Solicitor"s memo
Date:	Tuesday, December 3, 2019 5:47:23 PM

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

Sorry Michelle, I forgot you in my cc list. Hope to meet you soon. Cindy

---------- Forwarded message ---------
From: **Bohn, Cynthia** <cynthia_bohn@fws.gov>
Date: Tue, Dec 3, 2019 at 5:36 PM
Subject: CBRA Coordination with Wilmington District for Carolina and Wrightsville beach projects relative to new Solicitor's memo
To: Dana Wright <dana_wright@fws.gov>, Katie Niemi <katie_niemi@fws.gov>
Cc: aaron valenta <Aaron_Valenta@fws.gov>, Martha BalisLarsen <martha_balislarsen@fws.gov>, Phinney, Jonathan <jonathan_phinney@fws.gov>, Jack Arnold <jack_arnold@fws.gov>

Hi HQ folks:
I spoke with Jack Arnold (and Aaron Valenta, my supervisor) last night about what is the Regions' thoughts might be on how I should work with the Corps for Wrightsville and Carolina Beach renouishment/storm damage reduction projects. I expect them to call me in the morning in response to my email this afternoon. I shared a copy of the draft letter from Gary to the Corps with Jack in order to talk to Leo about what his wishes are for his Regions. I thought the letter did a good job of outlining what the CBRA legislative language is and what HQ is proposing with developing BMPs. He knows it is draft and that Martha may not have seen it yet and that it will be coming to the Regions for comments before it is sent to the Corps. We discussed various issues about using/not using the "Due to" box on the Interagency Template and about the fact that we don't know how to interpret some of the Solicitor's language yet. In my call with the Wilmington District tomorrow, I will talk to the Corps and find out what their timeline is, and what phase the project is in. I thought they were still in the planning phase, but their emails make it sound like it may be more in construction. I will also

try to find out what the project entails in the way of "structural vs. non-structural" and how they think that the project fits and is consistent with CBRA. I will not offer any "opinions" but discuss with you all first. I will check in with you all tomorrow. Thanks, Cindy

PS: Are we allowed to share the Solicitor's memo with the Corps? I think they already have it. c

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200g
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

From:	Bohn, Cynthia
To:	Williams, Larry O
Cc:	Arnold, Jack; Valenta, Aaron; Eversen, Michelle; Niemi, Katie
Subject:	Re: [EXTERNAL] RE: CBRA Coordination for the USACE Wrightsville Beach Validation and Carolina Beach BRER Projects
Date:	Wednesday, December 4, 2019 11:04:35 AM
Importance:	High

I spoke with Jack and Aaron last night and got some direction from them. I had a call with the Corps this morning and I will fill you all at lunch if you like. c

Cynthia Bohn
Regional Coastal Program Coordinator
Coastal Barrier Resources Act Regional Coordinator
USFWS
1875 Century Blvd, Room 200
Atlanta, GA 30345
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Tue, Dec 3, 2019 at 9:00 PM Larry Williams <larry_williams@fws.gov> wrote:

> Cindy,
> I know we need to discuss this, and I'd like to ensure we have sufficient time. Unfortunately tomorrow we will all be in the workforce planning meeting. Perhaps we can discuss it a bit before or after Jack's lunch, but I expect we'll need to schedule a longer discussion later.
>
> Larry
>
> Sent from my iPhone
>
> On Dec 3, 2019, at 4:00 PM, Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:
>
> I folks, if possible, could I have a discussion with one or all of you on how to go forward with CBRA determinations for these projects specifically and other projects in our Regions? I will be here tonight until 5 or so and in the office tomorrow morning until after Jack's lunch. Thanks, Cindy
>
> Cynthia Bohn
> Regional Coastal Program Coordinator
> Coastal Barrier Resources Act Regional Coordinator

From:	Niemi, Katie
To:	Bohn, Cynthia; Valenta, Aaron; Simon, Spencer; Willey, Seth
Cc:	Wright, Dana K; BalisLarsen, Martha; Phinney, Jonathan T; Shaughnessy, Michelle
Subject:	SOL responses to CBRA questions
Date:	Thursday, December 5, 2019 11:09:36 AM
Attachments:	Responses to CBRA program questions 112019 v2.docx 20191030 Memo from SOL to FWS.pdf

Hi Folks,
Attached are draft responses we received from SOL to questions we had regarding the new October 30, 2019 SOL memo on sand mining/beach nourishment. Also attached is the SOL memo for your reference. These are for internal use only; please do not share either of these documents outside of FWS/DOI. We look forward to coordinating with you on new policy issues related to CBRA consultations under the CBRA 6(a)(6)(G) exception (for nonstructural projects for shoreline stabilization). Thanks!

Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

DRAFT RESPONSES TO FWS' INITIAL QUESTIONS REGARDING 10/30/19 SOL MEMO

This memorandum responds to the document titled "Initial Questions from CBRA Program concerning 10/30/19 SOL Memo," provided to us at the November 12, 2019 meeting between FWS and the Solicitor's Office. We are responding only to those items flagged as questions for the Solicitor's Office, thus there are gaps in the numbering below.

(b) (5) [redacted]

[redacted]

[redacted]

3. Can the October 30, 2019 memo be shared publicly?

No, the memo is a legal opinion and it should not be released to the public.

(b) (5) [redacted]

[redacted]

[redacted]

b5-ACP

[redacted]

b5-ACP [redacted]

[redacted]

United States Department of the Interior

OFFICE OF THE SOLICITOR
Washington, D.C. 20240

IN REPLY REFER TO:

To: Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Peg Romanik, Associate Solicitor, Division of Parks and Wildlife

Re: Coastal Barrier Resources Act

Date: October 30, 2019

Introduction

You have requested our opinion as to whether Section 6(a)(6)(G) of the Coastal Barrier Resources Act ("CBRA" or "Act"), 16 U.S.C. § 3505(a)(6)(G), permits Federal funding for utilizing sand removed from a Coastal Barrier Resources System ("System") unit to renourish beaches located outside the System.

After considering the plain language of the Act, we conclude that the exemption in Section 6(a)(6)(G) is not limited to shoreline stabilization projects occurring within the System. Thus, sand from within a System unit may be used to renourish a beach that is located outside of the System. However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects.

Background

When it enacted the CBRA, Congress found that coastal barriers contain significant cultural and natural resources, including wildlife habitat and spawning areas, and function as natural storm protective buffers. *See* 16 U.S.C. § 3501(a). Congress further found that coastal barriers are generally unsuitable for development. *Id.* § 3501(a)(3). It enacted the CBRA to restrict Federal expenditures that encourage development of coastal barriers, thus minimizing the loss of human life and damage to natural resources within those areas. *Id.* § 3501(b). Section 5(a) of the Act prohibits most new Federal expenditures and financial assistance for activities occurring within the System. *Id.* § 3504(a). Section 6 of the Act sets forth exceptions to the prohibition, including "[n]onstructural projects for shoreline stabilization that are designed to

mimic, enhance, or restore natural stabilization systems," if such projects are consistent with the purposes of the Act. *Id.* § 3505(a)(6)(G).

A 1994 legal memorandum from then Assistant Solicitor - Branch of Fish and Wildlife interpreting Section 6(a)(6)(G) concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit, and not to projects to renourish beaches outside the System. The 1994 opinion "interpret[s] section 6(a)(6) to refer to projects designed to renourish solely a beach within the [System unit]." We understand that local communities and members of Congress have recently raised concerns about their inability to receive Federal funds for beach nourishment and have asked the Department to revisit this issue

Discussion

Section 6 of the Act sets forth certain exceptions to the limitations on Federal expenditures within the System. The introductory paragraph of the Section provides that a Federal agency, after consultation with the Secretary, "may make Federal expenditures or financial assistance available within the [System]" for certain enumerated activities. 16 U.S.C. § 3505(a). The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g., Hays v. Sebelius*, 589 F.3d. 1279, 1281 (D.C. Cir. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.") (citation omitted). Thus, the phrase applies solely to where the Federal expenditures or financial assistance may be applied. In this case, that means Federal funds associated with removing sand from a unit within the System.

By contrast, Section 3505(a)(6) does not contain language specifying that excepted actions must occur "within the [System]." That section permits certain "actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act." *Id.* § 3505(a)(6). Among those actions are "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G). The phrase "within the [System]" does not appear either in the introductory language to subsection 6 or in the subpart addressing shoreline stabilization projects. In sum, there is no express limitation on removing sediment from within the System and applying it to areas outside of the System for the purpose of shoreline stabilization.

The statutory language reflects that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Other provisions in Section 3505(a) indicate that Congress envisioned that the excepted activities might occur outside of the System. For example, Section 3505(a)(2) allows for the dredging of existing Federal navigation channels within the System, and the disposal of the dredge materials does not have to occur within the System. The House and Senate Reports specify that the "disposal site need not … be consistent with the purposes of the Act" as the dredge materials may contain contaminants, and

returning the contaminants to the system would not further the purposes of the CBRA.[1] Within Section 3505(a)(6), subparts (A) and (D) are similar in providing an exception for research for barrier resources, including fish and wildlife, which may require the study site to extend beyond the System to be most effective.

Alternatively, to the extent the statutory language could be viewed as ambiguous, our interpretation is reasonable and it furthers the purposes of the Act. There is no indication that Congress intended to conserve coastal barrier resources only within the System. Indeed, in calling for "coordinated action by Federal, State, and local governments," Congress appears to have envisioned the protection of broad swaths of coastal land. *Id.* § 3501(a)(1)(5). Our interpretation of Section 6(a)(6)(G) gives Federal agencies more flexibility to permit or undertake shoreline stabilization projects that will protect coastal resources, even if those resources are located outside of the System. These resources, identified in the CBRA's purpose, are "of significant value to society,"[2] providing over $1 billion in 1980 dollars for commercial fisheries, and high recreational value for people participating in sport fishing and waterfowl and duck hunting.[3]

Our interpretation also allows for projects that indirectly benefit coastal barrier resources within the System. For example, the U.S. Army Corps of Engineers ("Corps"), could use sand from a unit within the System to renourish a beach that is adjacent to that unit, but outside of the System. Stabilizing the adjacent beach could have positive effects on habitat located within the unit. The interpretation of Section 6(a)(6)(G) in the 1994 memorandum would preclude this project despite its beneficial effect on coastal barriers within the System.

Our interpretation does not alter the Service's (nor the action agency's) responsibility to consider on a case-by-case basis whether the proposed project is consistent with the purposes of the Act. *See id.* § 3505(a)(6). For example, the removal of the sand from within the System may not frustrate the "long-term conservation of these fish, wildlife, and other natural resources" associated with coastal barriers. *Id.* §3501(b). Thus, the Service should consider whether the sand could be removed without damage[4] to the natural resources within the System. Likewise, the project should not encourage development of coastal barriers in a manner that could result in "threats to human life, health, and property." *Id.* § 3501(a)(4). In addition, the Service should review whether the proposed project meets the limitations of the exception. That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to "mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G).

---

[1] CBRA Senate Report (May 26, 1982) at 7, and CBRA House Report (September 21, 1982) at 16.

[2] CBRA House Report (September 21, 1982) at 8.

[3] CBRA Senate Report (May 26, 1982) at 2, CBRA House Report (September 21, 1982) at 8.

[4] We note that "damage" here would have to cause more than insignificant impact to the natural resources. That is, it would have to be damage that would frustrate the purposes of the Act in some meaningful manner.

Conclusion

We recognize that our interpretation is a change from the conclusion presented in the 1994 legal memorandum. As noted above, however, that memorandum contained no analysis. After reviewing the legislative history and reading the plain language of the Act, we conclude a more reasoned interpretation is that the exception for shoreline stabilization projects is not expressly limited to projects occurring wholly within the System. And, to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act.

From:	Niemi, Katie
To:	BalisLarsen, Martha; Shaughnessy, Michelle
Cc:	Wright, Dana K; Bohn, Cynthia
Subject:	High Priority - Call with AD and ARD to discuss 2 new CBRA consultations
Date:	Monday, January 6, 2020 12:49:36 PM
Attachments:	Wrightsville Beach CBRA Inter-Agency Consultation Form - 19-Dec-2019.pdf Carolina Beach CBRA Inter-Agency Consultation Form - 19-Dec-2019.pdf

Martha & Michelle,
Please see below the CBRA consultations received from the Corps for two NC projects. These are the first two consultations we've received following the new SOL interpretation on sand mining and non-structural beach nourishment. Can we set up a call with either/both of you, Gary, Catherine, Cindy, Dana and me sometime in the next couple days? The Service's response to these two consultations will be precedent setting and we need to coordinate with the region to figure out the path forward. Cindy, Dana and I are happy to draft a response but we need input from Gary and Catherine on how to proceed with the draft response. Thanks.

Katie

---------- Forwarded message ---------
From: **Bohn, Cynthia** <cynthia_bohn@fws.gov>
Date: Mon, Jan 6, 2020 at 11:46 AM
Subject: Fwd: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports
To: Dana Wright <dana_wright@fws.gov>, Katie Niemi <katie_niemi@fws.gov>, Kathryn Matthews <kathryn_matthews@fws.gov>
Cc: Catherine Phillips <catherine_phillips@fws.gov>, Michelle Eversen <michelle_eversen@fws.gov>

Hi ladies, I wanted to be sure you all had a copy of the request. They sent a subsequent email with a requested 1/31/20 response date. I will need to get info from the Region on what they would like to do, as well as an update from HQ on how the guidance is going. In my briefing with RD Leo Miranda on 12/20 we had not received this request yet and he said it would be ARD Catherine Phillip's call on our regional response. I will try to get on her schedules to get the R4/2 input; and then try to set up a call with all of you. Please let me know if you have any additional information also. Thanks, Cindy

Cynthia Bohn
Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

TEMPLATE FOR INTERAGENCY CBRA CONSULTATIONS

The Coastal Barrier Resources Act (CBRA) (16 U.S.C. 3501 *et seq*.) encourages the conservation of hurricane prone and biologically rich coastal barriers. No new expenditures or financial assistance may be made available under authority of any Federal law for any purpose within the System Units of the John H. Chafee Coastal Barrier Resources System (CBRS) including: construction or purchase of roads, structures, facilities, or related infrastructure, and most projects to prevent the erosion of or otherwise stabilize any inlet, shoreline, or inshore area. However, the appropriate Federal officer, after consultation with the U.S. Fish and Wildlife Service (Service), may make Federal expenditures and financial assistance available within System Units for activities that meet one of the CBRA's exceptions (16 U.S.C. 3505). The CBRA imposes no restrictions on actions and projects within the CBRS that are carried out with State, local, or private funding. Any response from the Service to a CBRA consultation request is in the form of an opinion only. The Service has not been granted veto power. **The responsibility for complying with the CBRA and the final decision regarding the expenditure of funds for a particular action or project rests with the Federal funding agency.**

There are two types of units within the CBRS, System Units and Otherwise Protected Areas (OPAs). OPAs are denoted with a "P" at the end of the unit number (e.g., "FL-64P"). Most new Federal expenditures and financial assistance, including Federal flood insurance, are prohibited within System Units. The only Federal spending prohibition within OPAs is on Federal flood insurance; other Federal expenditures are permitted. **Consultation with the Service is not needed if the proposed action or project is located within an OPA.** However, agencies providing disaster assistance that is contingent upon a requirement to purchase flood insurance after the fact are advised to disclose the OPA designation and information on the restrictions on Federal flood insurance to the recipient prior to the commitments of funds.

The Service has developed the attached template to help facilitate the CBRA consultation process. This form, and any additional documentation, may be submitted to the appropriate Ecological Services Field Office to fulfill the CBRA's consultation requirement.

Additional Resources:

CBRS Mapper: *https://www.fws.gov/cbra/maps/mapper.html*

CBRS shapefile and Web Map Service: *https://www.fws.gov/cbra/maps/Boundaries.html*

CBRA consultations: *https://www.fws.gov/cbra* under "Project Consultations"

CBRS in/out property determinations: *https://www.fws.gov/cbra/Determinations.html*

Ecological Services Field Office contact information: *https://www.fws.gov/offices*

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

TEMPLATE FOR INTERAGENCY CBRA CONSULTATIONS

The Coastal Barrier Resources Act (CBRA) (16 U.S.C. 3501 *et seq*.) encourages the conservation of hurricane prone and biologically rich coastal barriers. No new expenditures or financial assistance may be made available under authority of any Federal law for any purpose within the System Units of the John H. Chafee Coastal Barrier Resources System (CBRS) including: construction or purchase of roads, structures, facilities, or related infrastructure, and most projects to prevent the erosion of or otherwise stabilize any inlet, shoreline, or inshore area. However, the appropriate Federal officer, after consultation with the U.S. Fish and Wildlife Service (Service), may make Federal expenditures and financial assistance available within System Units for activities that meet one of the CBRA's exceptions (16 U.S.C. 3505). The CBRA imposes no restrictions on actions and projects within the CBRS that are carried out with State, local, or private funding. Any response from the Service to a CBRA consultation request is in the form of an opinion only. The Service has not been granted veto power. **The responsibility for complying with the CBRA and the final decision regarding the expenditure of funds for a particular action or project rests with the Federal funding agency.**

There are two types of units within the CBRS, System Units and Otherwise Protected Areas (OPAs). OPAs are denoted with a "P" at the end of the unit number (e.g., "FL-64P"). Most new Federal expenditures and financial assistance, including Federal flood insurance, are prohibited within System Units. The only Federal spending prohibition within OPAs is on Federal flood insurance; other Federal expenditures are permitted. **Consultation with the Service is not needed if the proposed action or project is located within an OPA.** However, agencies providing disaster assistance that is contingent upon a requirement to purchase flood insurance after the fact are advised to disclose the OPA designation and information on the restrictions on Federal flood insurance to the recipient prior to the commitments of funds.

The Service has developed the attached template to help facilitate the CBRA consultation process. This form, and any additional documentation, may be submitted to the appropriate Ecological Services Field Office to fulfill the CBRA's consultation requirement.

Additional Resources:

CBRS Mapper: *https://www.fws.gov/cbra/maps/mapper.html*

CBRS shapefile and Web Map Service: *https://www.fws.gov/cbra/maps/Boundaries.html*

CBRA consultations: *https://www.fws.gov/cbra* under "Project Consultations"

CBRS in/out property determinations: *https://www.fws.gov/cbra/Determinations.html*

Ecological Services Field Office contact information: *https://www.fws.gov/offices*

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

From:	Bohn, Cynthia
To:	Wright, Dana K; Niemi, Katie
Cc:	Bohn, Cynthia
Subject:	Fwd: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports
Date:	Tuesday, January 7, 2020 1:43:37 PM
Attachments:	Wrightsville Beach CBRA Inter-Agency Consultation Form - 19-Dec-2019.pdf Carolina Beach CBRA Inter-Agency Consultation Form - 19-Dec-2019.pdf 20191030 Solicitor"s Memo on sand mining.pdf
Importance:	High

Sorry, I meant to include you on the cc list...

Cynthia Bohn
Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Bohn, Cynthia** <cynthia_bohn@fws.gov>
Date: Tue, Jan 7, 2020 at 1:16 PM
Subject: Fwd: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports
To: Catherine Phillips <catherine_phillips@fws.gov>, aaron valenta <Aaron_Valenta@fws.gov>, Matthew Dekar <matthew_dekar@fws.gov>
Cc: Michelle Eversen <michelle_eversen@fws.gov>, Pete Benjamin <pete_benjamin@fws.gov>, Robert Tawes <robert_tawes@fws.gov>

ACTION REQUESTED: I am requesting a meeting and a decision on how to proceed from Region2/4, and to make sure Catherine is briefed before a call from Michelle Shaughnessy later this week.

Catherine, Aaron, Matt, and all:

Please see below the formal request from the Wilmington Corps District for CBRA determinations for two Corps projects involving the removal of sand from within a CBRS unit for use outside a CBRS unit. The Corps has asked that we respond by Jan 31. We had requested that all projects involving sand mining be forwarded from the field to the RO due to the new Solicitor's memo overturning a 30 year old policy and pending guidance being developed at HQ. I worked on this as your Regional CBRA Coordinator with input from Kathyrn Matthews in the RANC FO. As my final duty, I provided Leo and Mike a briefing on 12/20; which I have sent you information on in a separate email. This email is to formally pass this request on to Aaron or whomever may be taking my old position, and to offer our assistance from HQ to you all if you would like. This will be a precedent setting CBRA response and is highly visible at the congressional, secretarial, and NGO level.

Issues:
The Corps has requested a 1/31/20 response but that is not mandatory. However, we have had Congressional inquiries as the RO and HQ to "request" that we give this immediate attention.

Leo has directed that the response be Catherine's decision and that his ARD policy of "check the "Due to many competing priorities..." box on the CBRA consultation template does not necessarily have to be used. HQ strongly suggests that we do provide some type of written response and not use that box as this may have precedent setting consequences and the issue will come up again after the projects are authorized. I recommend that HQ work with the FO and RO to develop a response.

HQ and USGS are working together to provide scientific underpinnings for the impacts of sand mining in inlets. The request and effort is currently ongoing in USGS. This was requested by Rep Raúl Grijalva, Arizona, Chair of the House Natural Resources Committee.

The new Solicitor's memo provides some uncertainty on how to apply CBRA for these projects. The standard is that the projects be non-structural, and consistent with the three purposes of CBRA. Although this is not new, the application of the standard may have changed and allows for some type of opportunity related to minimizing impacts to the barrier island and fish and wildlife resources that were not used in the past, if the FO agrees. Internal guidance is not yet developed, we have suggested working with the Corps to develop BMPs or monitoring of biological and geological resources. (I have attached the Solicitory's Memo which we have been asked not to share outside the agency.)

As I said before, this is highly visible by both the Administration, Congress, and NGO's that are watching to see how this plays out as there are numerous Corps beach nourishment and sand mining projects that will be coming in the future. There is also strong support for maintaining a restriction on sand mining in CBRS units, a letter was sent to the Secretary and signed by 30 NGOs including Audubon, R Street Institute, and
Southern Environmental Law Center. **letter** https://www.rstreet.org/2019/12/05/letter-to-secretary-bernhardt-on-coastal-barrier-resources-act/

There is a current GAO audit that was ordered last month to examine Federal Agency's compliance with CBRA.

Thanks so much, I will be looking forward to hearing from you.

Cynthia Bohn
National Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

TEMPLATE FOR INTERAGENCY CBRA CONSULTATIONS

The Coastal Barrier Resources Act (CBRA) (16 U.S.C. 3501 *et seq*.) encourages the conservation of hurricane prone and biologically rich coastal barriers. No new expenditures or financial assistance may be made available under authority of any Federal law for any purpose within the System Units of the John H. Chafee Coastal Barrier Resources System (CBRS) including: construction or purchase of roads, structures, facilities, or related infrastructure, and most projects to prevent the erosion of or otherwise stabilize any inlet, shoreline, or inshore area. However, the appropriate Federal officer, after consultation with the U.S. Fish and Wildlife Service (Service), may make Federal expenditures and financial assistance available within System Units for activities that meet one of the CBRA's exceptions (16 U.S.C. 3505). The CBRA imposes no restrictions on actions and projects within the CBRS that are carried out with State, local, or private funding. Any response from the Service to a CBRA consultation request is in the form of an opinion only. The Service has not been granted veto power. **The responsibility for complying with the CBRA and the final decision regarding the expenditure of funds for a particular action or project rests with the Federal funding agency.**

There are two types of units within the CBRS, System Units and Otherwise Protected Areas (OPAs). OPAs are denoted with a "P" at the end of the unit number (e.g., "FL-64P"). Most new Federal expenditures and financial assistance, including Federal flood insurance, are prohibited within System Units. The only Federal spending prohibition within OPAs is on Federal flood insurance; other Federal expenditures are permitted. **Consultation with the Service is not needed if the proposed action or project is located within an OPA.** However, agencies providing disaster assistance that is contingent upon a requirement to purchase flood insurance after the fact are advised to disclose the OPA designation and information on the restrictions on Federal flood insurance to the recipient prior to the commitments of funds.

The Service has developed the attached template to help facilitate the CBRA consultation process. This form, and any additional documentation, may be submitted to the appropriate Ecological Services Field Office to fulfill the CBRA's consultation requirement.

Additional Resources:

CBRS Mapper: *https://www.fws.gov/cbra/maps/mapper.html*

CBRS shapefile and Web Map Service: *https://www.fws.gov/cbra/maps/Boundaries.html*

CBRA consultations: *https://www.fws.gov/cbra* under "Project Consultations"

CBRS in/out property determinations: *https://www.fws.gov/cbra/Determinations.html*

Ecological Services Field Office contact information: *https://www.fws.gov/offices*

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

TEMPLATE FOR INTERAGENCY CBRA CONSULTATIONS

The Coastal Barrier Resources Act (CBRA) (16 U.S.C. 3501 *et seq*.) encourages the conservation of hurricane prone and biologically rich coastal barriers. No new expenditures or financial assistance may be made available under authority of any Federal law for any purpose within the System Units of the John H. Chafee Coastal Barrier Resources System (CBRS) including: construction or purchase of roads, structures, facilities, or related infrastructure, and most projects to prevent the erosion of or otherwise stabilize any inlet, shoreline, or inshore area. However, the appropriate Federal officer, after consultation with the U.S. Fish and Wildlife Service (Service), may make Federal expenditures and financial assistance available within System Units for activities that meet one of the CBRA's exceptions (16 U.S.C. 3505). The CBRA imposes no restrictions on actions and projects within the CBRS that are carried out with State, local, or private funding. Any response from the Service to a CBRA consultation request is in the form of an opinion only. The Service has not been granted veto power. **The responsibility for complying with the CBRA and the final decision regarding the expenditure of funds for a particular action or project rests with the Federal funding agency.**

There are two types of units within the CBRS, System Units and Otherwise Protected Areas (OPAs). OPAs are denoted with a "P" at the end of the unit number (e.g., "FL-64P"). Most new Federal expenditures and financial assistance, including Federal flood insurance, are prohibited within System Units. The only Federal spending prohibition within OPAs is on Federal flood insurance; other Federal expenditures are permitted. **Consultation with the Service is not needed if the proposed action or project is located within an OPA.** However, agencies providing disaster assistance that is contingent upon a requirement to purchase flood insurance after the fact are advised to disclose the OPA designation and information on the restrictions on Federal flood insurance to the recipient prior to the commitments of funds.

The Service has developed the attached template to help facilitate the CBRA consultation process. This form, and any additional documentation, may be submitted to the appropriate Ecological Services Field Office to fulfill the CBRA's consultation requirement.

Additional Resources:

CBRS Mapper: *https://www.fws.gov/cbra/maps/mapper.html*

CBRS shapefile and Web Map Service: *https://www.fws.gov/cbra/maps/Boundaries.html*

CBRA consultations: *https://www.fws.gov/cbra* under "Project Consultations"

CBRS in/out property determinations: *https://www.fws.gov/cbra/Determinations.html*

Ecological Services Field Office contact information: *https://www.fws.gov/offices*

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

United States Department of the Interior

OFFICE OF THE SOLICITOR
Washington, D.C. 20240

IN REPLY REFER TO:

To: Margaret Everson, Principal Deputy Director, U.S. Fish and Wildlife Service

From: Peg Romanik, Associate Solicitor, Division of Parks and Wildlife

Re: Coastal Barrier Resources Act

Date: October 30, 2019

Introduction

You have requested our opinion as to whether Section 6(a)(6)(G) of the Coastal Barrier Resources Act ("CBRA" or "Act"), 16 U.S.C. § 3505(a)(6)(G), permits Federal funding for utilizing sand removed from a Coastal Barrier Resources System ("System") unit to renourish beaches located outside the System.

After considering the plain language of the Act, we conclude that the exemption in Section 6(a)(6)(G) is not limited to shoreline stabilization projects occurring within the System. Thus, sand from within a System unit may be used to renourish a beach that is located outside of the System. However, any such project must further the purposes of the Act. That is, the shoreline stabilization project must be consistent with the Act's purposes of minimizing threats to human life and property and encouraging long-term conservation of natural resources associated with coastal barriers, and has to fit within the restrictions of the statutory exception for certain nonstructural projects.

Background

When it enacted the CBRA, Congress found that coastal barriers contain significant cultural and natural resources, including wildlife habitat and spawning areas, and function as natural storm protective buffers. *See* 16 U.S.C. § 3501(a). Congress further found that coastal barriers are generally unsuitable for development. *Id.* § 3501(a)(3). It enacted the CBRA to restrict Federal expenditures that encourage development of coastal barriers, thus minimizing the loss of human life and damage to natural resources within those areas. *Id.* § 3501(b). Section 5(a) of the Act prohibits most new Federal expenditures and financial assistance for activities occurring within the System. *Id.* § 3504(a). Section 6 of the Act sets forth exceptions to the prohibition, including "[n]onstructural projects for shoreline stabilization that are designed to

mimic, enhance, or restore natural stabilization systems," if such projects are consistent with the purposes of the Act. *Id.* § 3505(a)(6)(G).

A 1994 legal memorandum from then Assistant Solicitor - Branch of Fish and Wildlife interpreting Section 6(a)(6)(G) concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit, and not to projects to renourish beaches outside the System. The 1994 opinion "interpret[s] section 6(a)(6) to refer to projects designed to renourish solely a beach within the [System unit]." We understand that local communities and members of Congress have recently raised concerns about their inability to receive Federal funds for beach nourishment and have asked the Department to revisit this issue

<u>Discussion</u>

Section 6 of the Act sets forth certain exceptions to the limitations on Federal expenditures within the System. The introductory paragraph of the Section provides that a Federal agency, after consultation with the Secretary, "may make Federal expenditures or financial assistance available within the [System]" for certain enumerated activities. 16 U.S.C. § 3505(a). The phrase "within the [System]" must be read in conjunction with the immediately preceding phrase "Federal expenditures or financial assistance." *See, e.g., Hays v. Sebelius*, 589 F.3d. 1279, 1281 (D.C. Cir. 2009) (applying the "Rule of the Last Antecedent," which provides that "qualifying phrases are to be applied to the word or phrase immediately preceding and are not to be construed as extending to others more remote.") (citation omitted). Thus, the phrase applies solely to where the Federal expenditures or financial assistance may be applied. In this case, that means Federal funds associated with removing sand from a unit within the System.

By contrast, Section 3505(a)(6) does not contain language specifying that excepted actions must occur "within the [System]." That section permits certain "actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act." *Id.* § 3505(a)(6). Among those actions are "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G). The phrase "within the [System]" does not appear either in the introductory language to subsection 6 or in the subpart addressing shoreline stabilization projects. In sum, there is no express limitation on removing sediment from within the System and applying it to areas outside of the System for the purpose of shoreline stabilization.

The statutory language reflects that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Other provisions in Section 3505(a) indicate that Congress envisioned that the excepted activities might occur outside of the System. For example, Section 3505(a)(2) allows for the dredging of existing Federal navigation channels within the System, and the disposal of the dredge materials does not have to occur within the System. The House and Senate Reports specify that the "disposal site need not … be consistent with the purposes of the Act" as the dredge materials may contain contaminants, and

returning the contaminants to the system would not further the purposes of the CBRA.[1] Within Section 3505(a)(6), subparts (A) and (D) are similar in providing an exception for research for barrier resources, including fish and wildlife, which may require the study site to extend beyond the System to be most effective.

Alternatively, to the extent the statutory language could be viewed as ambiguous, our interpretation is reasonable and it furthers the purposes of the Act. There is no indication that Congress intended to conserve coastal barrier resources only within the System. Indeed, in calling for "coordinated action by Federal, State, and local governments," Congress appears to have envisioned the protection of broad swaths of coastal land. *Id.* § 3501(a)(1)(5). Our interpretation of Section 6(a)(6)(G) gives Federal agencies more flexibility to permit or undertake shoreline stabilization projects that will protect coastal resources, even if those resources are located outside of the System. These resources, identified in the CBRA's purpose, are "of significant value to society,"[2] providing over $1 billion in 1980 dollars for commercial fisheries, and high recreational value for people participating in sport fishing and waterfowl and duck hunting.[3]

Our interpretation also allows for projects that indirectly benefit coastal barrier resources within the System. For example, the U.S. Army Corps of Engineers ("Corps"), could use sand from a unit within the System to renourish a beach that is adjacent to that unit, but outside of the System. Stabilizing the adjacent beach could have positive effects on habitat located within the unit. The interpretation of Section 6(a)(6)(G) in the 1994 memorandum would preclude this project despite its beneficial effect on coastal barriers within the System.

Our interpretation does not alter the Service's (nor the action agency's) responsibility to consider on a case-by-case basis whether the proposed project is consistent with the purposes of the Act. *See id.* § 3505(a)(6). For example, the removal of the sand from within the System may not frustrate the "long-term conservation of these fish, wildlife, and other natural resources" associated with coastal barriers. *Id.* §3501(b). Thus, the Service should consider whether the sand could be removed without damage[4] to the natural resources within the System. Likewise, the project should not encourage development of coastal barriers in a manner that could result in "threats to human life, health, and property." *Id.* § 3501(a)(4). In addition, the Service should review whether the proposed project meets the limitations of the exception. That is, in order for the project to meet the standards of the exception, the Service should consider whether any beach renourishment outside the system is intended to "mimic, enhance, or restore natural stabilization systems." *Id.* § 3505(a)(6)(G).

---

[1] CBRA Senate Report (May 26, 1982) at 7, and CBRA House Report (September 21, 1982) at 16.

[2] CBRA House Report (September 21, 1982) at 8.

[3] CBRA Senate Report (May 26, 1982) at 2, CBRA House Report (September 21, 1982) at 8.

[4] We note that "damage" here would have to cause more than insignificant impact to the natural resources. That is, it would have to be damage that would frustrate the purposes of the Act in some meaningful manner.

Conclusion

We recognize that our interpretation is a change from the conclusion presented in the 1994 legal memorandum. As noted above, however, that memorandum contained no analysis. After reviewing the legislative history and reading the plain language of the Act, we conclude a more reasoned interpretation is that the exception for shoreline stabilization projects is not expressly limited to projects occurring wholly within the System. And, to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. Thus, we conclude that sand from units within the System may be used to renourish beaches located outside of the System assuming the project is in compliance with the Act. Specifically, the Service (and the action agency) must continue to review each proposed project to ensure that it meets the specific requirements of section 6(a)(6)(G) and is consistent with the purposes of the Act.

From: Bohn, Cynthia
To: Wright, Dana K; Niemi, Katie
Subject: Fwd: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports
Date: Wednesday, January 8, 2020 8:47:53 AM
Importance: High

---

do you all want to join us. this is last minute but looks like I have everyone together.

Cynthia Bohn
Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

---------- Forwarded message ---------
From: **Tawes, Robert** <robert_tawes@fws.gov>
Date: Tue, Jan 7, 2020 at 7:32 PM
Subject: Re: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports
To: Catherine Phillips <catherine_phillips@fws.gov>
Cc: Pete Benjamin <pete_benjamin@fws.gov>, Bohn, Cynthia <cynthia_bohn@fws.gov>, Aaron Valenta <aaron_valenta@fws.gov>, Matthew Dekar <matthew_dekar@fws.gov>, Michelle Eversen <michelle_eversen@fws.gov>, Kathryn Matthews <kathryn_Matthews@fws.gov>

I will be teleworking tomorrow morning but can call in at 9:00. Sounds like Kathryn will be calling in as well. We can use my conference line (b) (5) [redacted] .

On Tue, Jan 7, 2020 at 5:25 PM Catherine Phillips <catherine_phillips@fws.gov> wrote:

> 9am, all?
>
> Sent from my iPhone
>
> On Jan 7, 2020, at 5:04 PM, Pete Benjamin <pete_benjamin@fws.gov> wrote:
>
> > I'm going to be on the road and in a meeting most of tomorrow. If you want you can call me on my cell (below) between about 9 and noon, when I'll be driving. Also, I'm including Kathy of my staff here for here awareness. Please include her in the discussion (she's the one that actually knows things).

Pete Benjamin

Field Supervisor

U.S. Fish and Wildlife Service

Raleigh ES Field Office

O: 919-856-4520 x 11

M: 919-816-6408

From: Bohn, Cynthia <cynthia_bohn@fws.gov>
Sent: Tuesday, January 7, 2020 4:25 PM
To: Catherine Phillips <catherine_phillips@fws.gov>
Cc: aaron valenta <Aaron_Valenta@fws.gov>; Matthew Dekar <matthew_dekar@fws.gov>; Michelle Eversen <michelle_eversen@fws.gov>; Pete Benjamin <pete_benjamin@fws.gov>; Robert Tawes <robert_tawes@fws.gov>
Subject: Re: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports

Thanks Catherine, I am not sure how to do that. I'm in all day tomorrow. Is someone doing your scheduling or do you want to give me a time? I'll be available all day. cb

Cynthia Bohn

Coastal Barrier Resources Act Specialist

Phone: 404-679-7122

Fax: 404-679-7081

cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Tue, Jan 7, 2020 at 4:20 PM Catherine Phillips <catherine_phillips@fws.gov> wrote:

> Cindy,
>
> Let's set up a time to talk so I can make sure i fully understand.
>
> C
>
> Sent from my iPhone
>
> On Jan 7, 2020, at 1:16 PM, Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:
>
> > **ACTION REQUESTED: I am requesting a meeting and a decision on how to proceed from Region2/4, and to make sure Catherine is briefed before a call from Michelle Shaughnessy later this week.**
> >
> > Catherine, Aaron, Matt, and all:
> >
> > **Please see below the formal request from the Wilmington Corps District for CBRA determinations for two Corps projects involving the removal of sand from within a CBRS unit for use outside a CBRS unit.** The Corps has asked that we respond by Jan 31. We had requested that all projects involving sand mining be forwarded from the field to the RO due to the new Solicitor's memo overturning a 30 year old policy and pending guidance being developed at HQ. I worked on this as your Regional CBRA Coordinator with input from Kathyrn Matthews in the RANC FO. As my final duty, I provided Leo and Mike a briefing on 12/20; which I have sent you information on in a separate email. This email is to formally pass this request on to Aaron or whomever may be taking my old

position, and to offer our assistance from HQ to you all if you would like. This will be a precedent setting CBRA response and is highly visible at the congressional, secretarial, and NGO level.

Issues:

The Corps has requested a 1/31/20 response but that is not mandatory. However, we have had Congressional inquiries as the RO and HQ to "request" that we give this immediate attention.

Leo has directed that the response be Catherine's decision and that his ARD policy of "check the "Due to many competing priorities..." box on the CBRA consultation template does not necessarily have to be used. HQ strongly suggests that we do provide some type of written response and not use that box as this may have precedent setting consequences and the issue will come up again after the projects are authorized. I recommend that HQ work with the FO and RO to develop a response.

HQ and USGS are working together to provide scientific underpinnings for the impacts of sand mining in inlets. The request and effort is currently ongoing in USGS. This was requested by Rep Raúl Grijalva, Arizona, Chair of the House Natural Resources Committee.

The new Solicitor's memo provides some uncertainty on how to apply CBRA for these projects. The standard is that the projects be non-structural, and consistent with the three purposes of CBRA. Although this is not new, the application of the standard may have changed and allows for some type of opportunity related to minimizing impacts to the barrier island and fish and wildlife resources that were not used in the past, if the FO agrees. Internal guidance is not yet developed, b5-DPP [redacted] (I have attached the Solicitory's Memo which we have been asked not to share outside the agency.)

As I said before, this is highly visible by both the Administration, Congress, and NGO's that are watching to see how this plays out

Rob W. Tawes
Chief, Division of Environmental Review
U.S. Fish and Wildlife Service
South Atlantic, Gulf & Mississippi Basin Regions
1875 Century Boulevard
Atlanta, GA 30345
(w) 404/679-7142
(f) 404/679-7081
http://www.fws.gov/southeast/
www.fws.gov

NOTE: This email correspondence and any attachments to and from this sender is subject to the Freedom of Information Act (FOIA) and may be disclosed to third parties.

From:	Bohn, Cynthia
To:	Wr ght, Dana K; Phillips, Catherine; Valenta, Aaron; Benjam n, Pete; Dekar, Matthew P; Niemi, Katie; Tawes, Robert; Matthews, Kathryn H
Subject:	Invitation: Re: [EXTERNAL] Interagency CBRA Consultat ons for the Wri... @ Wed Jan 8, 2020 9am - 10am (EST) (kat e_niemi@fws.gov)
Start:	Wednesday, January 8, 2020 9:00:00 AM
End:	Wednesday, January 8, 2020 10:00:00 AM
Attachments:	invite.ics
Importance:	High

You have been invited to the following event.

Re: [EXTERNAL] Interagency CBRA Consultations for the Wrightsville Beach, NC, and the Carolina Beach, NC, Reports

When
Wed Jan 8, 2020 9am – 10am Eastern Time - New York
Video call
https://hangouts.google.com/hangouts/_/doi.gov/cynthia-bohn <https://hangouts.google.com/hangouts/_/doi.gov/cynthia-bohn?hceid Y3ludGhpYV9ib2huQGZ3cy5nb3Y.0gp04dug61rtioss0683ppcdv0>
Calendar
katie_niemi@fws.gov
Who
• cynthia_bohn@fws.gov
- organizer
• dana_wright@fws.gov
• catherine_phillips@fws.gov
• aaron_valenta@fws.gov
• pete_benjamin@fws.gov
• matthew_dekar@fws.gov
• katie_niemi@fws.gov
• robert_tawes@fws.gov
• kathryn_matthews@fws.gov
more details » <https://www.google.com/calendar/event?
action VIEW&eid MGdwMDRkdWc2MXJ0aW9zczA2ODNwcGNkdjAga2F0aWVfbmllbWlAZndzLmdvdg&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZmMTRkMDRjZGY2NGRjMzBhOTU3NTAxMTQ5ZjAwNzkwNTQ4M2NiODE2&ctz America%2FNew_York&hl en&es 1>

We can use my conference line (b) (6) [redacted] https://maps.google.com/maps?hl en&q Call-in%3A%20%20866%2F763-5944%2C%20pass%20code%204528045%23&source calendar> .

Going (katie_niemi@fws.gov)?
Yes <https://www.google.com/calendar/event?
action RESPOND&eid MGdwMDRkdWc2MXJ0aW9zczA2ODNwcGNkdjAga2F0aWVfbmllbWlAZndzLmdvdg&rst 1&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZmMTRkMDRjZGY2NGRjMzBhOTU3NTAxMTQ ZjAwNzkwNTQ4M2NiODE2&ctz America%2FNew_York&hl en&es 1>
-
Maybe <https://www.google.com/calendar/event?
action RESPOND&eid MGdwMDRkdWc2MXJ0aW9zczA2ODNwcGNkdjAga2F0aWVfbmllbWlAZndzLmdvdg&rst 3&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZmMTRkMDRjZGY2NGRjMzBhOTU3NTAxMTQ ZjAwNzkwNTQ4M2NiODE2&ctz America%2FNew_York&hl en&es 1>
-
No <https://www.google.com/calendar/event?
action RESPOND&eid MGdwMDRkdWc2MXJ0aW9zczA2ODNwcGNkdjAga2F0aWVfbmllbWlAZndzLmdvdg&rst 2&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZmMTRkMDRjZGY2NGRjMzBhOTU3NTAxMTQ ZjAwNzkwNTQ4M2NiODE2&ctz America%2FNew_York&hl en&es 1>
more options » <https://www.google.com/calendar/event?
action VIEW&eid MGdwMDRkdWc2MXJ0aW9zczA2ODNwcGNkdjAga2F0aWVfbmllbWlAZndzLmdvdg&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZmMTRkMDRjZGY2NGRjMzBhOTU3NTAxMTQ5ZjAwNzkwNTQ4M2NiODE2&ctz America%2FNew_York&hl en&es 1>

From: Hires, Brian K
To: Shire, Gavin G
Cc: Parramore, Laury; Niemi, Katie
Subject: Re: CBRA updates
Date: Wednesday, January 8, 2020 12:05:44 PM
Importance: High

It's not clear to CBRS whether this was approved or not and by whom, since all of this happened at DOI level. The "existing statement" item has factual inaccuracies that Katie would be happy to explain if helpful. Thanks,

Brian Hires
U.S. Fish and Wildlife Service | **Office of Public Affairs** | Falls Church, VA
(Office) 703.358.2191 | (Cell) 703.346.9941

On Wed, Jan 8, 2020 at 11:36 AM Shire, Gavin <gavin_shire@fws.gov> wrote:

> Was this ever approved?
>
> G
>
> Gavin Shire
> Chief of Public Affairs
> U.S. Fish and Wildlife Service
> MS: EA
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> 703-358-2649 (o)
> 703-346-9123 (c)
> gavin_shire@fws.gov
>
> On Wed, Jan 8, 2020 at 11:25 AM Hires, Brian <brian_hires@fws.gov> wrote:
>
>> Please see below as an FYI regarding the CBRS, Bernhardt memo and sand-mining issue in case it's helpful.
>>
>> Brian Hires
>> U.S. Fish and Wildlife Service | **Office of Public Affairs** | Falls Church, VA
>> (Office) 703.358.2191 | (Cell) 703.346.9941
>>
>> ---------- Forwarded message ---------
>> From: **Niemi, Katie** <katie_niemi@fws.gov>
>> Date: Wed, Jan 8, 2020 at 11:21 AM
>> Subject: Re: CBRA updates
>> To: Hires, Brian <brian_hires@fws.gov>
>> Cc: Michelle Shaughnessy <michelle_shaughnessy@fws.gov>, Wright, Dana <dana_wright@fws.gov>

Brian,
I believe the Secretary's statement below did appear in the media, as well as a different statement attributed to Margaret (see existing statement language below). I have concerns with both of the statements that were used in the past on this issue and recommend that we use the highlighted proposed new statement below. Please note this proposed new statement has not been vetted/approved internally.

Proposed new statement:
"The U.S. Fish and Wildlife Service is committed to protecting coastal environments. Our new interpretation allows for sand removal from within the Coastal Barrier Resources System to renourish beaches outside of the System, so long as the proposed project is consistent with the purposes and meets an exception of the Coastal Barrier Resources Act."

Existing statement:
"The U.S. Fish and Wildlife Service is committed to protecting coastal environments," U.S. Fish and Wildlife Service, Principal Deputy Acting as the Director Margaret Everson. "Our guidance to the Army Corps of Engineers is consistent with the purposes and intent of the Act in order to allow for local communities to conduct beach renourishment projects."

Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

On Wed, Jan 8, 2020 at 10:10 AM Hires, Brian <brian_hires@fws.gov> wrote:

> Good morning Katie,
>
> Apparently there is a need for any approved messaging developed and used for the Bernhardt memo a while back involving allowing sand-mining, for a media inquiry it sounds. Please see copied/pasted emails below for more details. I will call you to discuss shortly. Thanks,
>
> Brian Hires
> U.S. Fish and Wildlife Service | **Office of Public Affairs** | Falls Church, VA
> (Office) 703.358.2191 | (Cell) 703.346.9941
>
> Did a little poking around on Google and discovered this statement: https://vandrew.house.gov/media/press-releases/van-drew-overcomes-bureaucratic-objections-help-local-governments-cape-may

"The Trump Administration is committed to protecting our coastlines and utilizing our available resources to restore, enhance or stabilize our beaches consistent with the law Congress wrote," said U.S Secretary David Bernhardt. "Today's notification clarified our understanding of the crystal clear direction provided by Congress decades ago."

Do you know if there is anything else we should be using? Thanks.

Laury Marshall

Matt and Barbara are requesting. Sounds like it has something to do with an interview but I don't know the details. Do you, Gavin? I think OCO and OCL may have had a hand in developing the statement used in the Van Drew news release but I wasn't sure if there were more TPs or if we could see a copy of the congressional letter on this topic.

---------- Forwarded message ---------
From: **Parramore, Laury** <laury_parramore@fws.gov>
Date: Wed, Jan 8, 2020 at 9:44 AM
Subject: Fwd: CBRA updates
To: Hires, Brian <brian_hires@fws.gov>
Cc: Gavin Shire <gavin_shire@fws.gov>

Good morning! Did any messaging ever get developed on this? Thanks.

Laury Marshall

---------- Forwarded message ---------
From: **Parramore, Laury** <laury_parramore@fws.gov>
Date: Wed, Nov 6, 2019 at 1:12 PM
Subject: Re: CBRA updates
To: Hires, Brian <brian_hires@fws.gov>

Thanks.

Laury Marshall

On Wed, Nov 6, 2019 at 11:43 AM Hires, Brian <brian_hires@fws.gov> wrote:

> Gavin and Laury,
>
> Just a quick FYI that the CBRS sand-mining guidance change is public and we are

being told by the program to hang tight for a meeting between Gary and Margaret before developing any messaging. Not sure when meeting will happen and our messaging is contingent upon clarity about what the guidance actual entails and means for program.

You may want to talk to Barbara or Gary for additional details or suggestions/guidance.

Brian Hires
U.S. Fish and Wildlife Service | **Office of Public Affairs** | Falls Church, VA
(Office) 703.358.2191 | (Cell) 703.346.9941

---------- Forwarded message ---------
From: **Berg , Elizabeth** <elizabeth_berg@fws.gov>
Date: Wed, Nov 6, 2019 at 9:45 AM
Subject: CBRA updates
To: Brian Hires <brian_hires@fws.gov>

Hi Brian,

Here is the Van Drew PR: https://vandrew.house.gov/media/press-releases/van-drew-overcomes-bureaucratic-objections-help-local-governments-cape-may

Gary is planning to discuss the CBRA team's questions regarding the impacts and changes to existing guidance with Margaret. With the Directorate meeting next week, they are not expecting that discussion to occur for a couple of weeks. Following that discussion, they will make a plan for updating any publicly available documents.

See below for the SO and the Secretary's letter to members.

Thanks,
Liz
--

Elizabeth Berg
Congressional and Legislative Affairs Knauss Fellow
U.S. Fish and Wildlife Service
Office: 703-358-2225
elizabeth_berg@fws.gov

F om
To Balis a s n Ma tha
Cc S aug ne sy Mic elle h nney Jonathan T W ght Dana K
Subje t Re CBRA hot opi s fo me t ng with Di e to
Date W dnesday anua y 8 2020 12 23 53 M
At achments CBRA hot op cs fo Di ecto 1 8 0docx docx

Martha
Sorry I'm sti l rying to f gure out the Teams site. The hot top cs document is a tached.

Ka ie

On Wed Jan 8 2020 at 12 15 PM BalisLarsen Martha <martha balislarsen@fws go > w ote

> Kat e, I need access to the fi e.
>
> t s just a bu let so I was going to use your list o verbally expand on the bu let.
>
> Thanks!
>
> Martha
>
> Ma tha Ba -La sen
> Ch ef D v s on of Budget & Techn ca uppo t
> E o og ca Se v c s P og am
> U S ish and W ld i e Se v ce Head ua e s
> Eco og cal Se vic s MS ES
> 5 75 ees u g ke
> a s Chu ch VA 2204 3803
> 03-3 8-21 1 gene a)
> 03-3 8-23 4 d ec)
>
> On Wed Jan 8 2020 at 9 10 AM Niemi Kat e < @f g > wrote
>
>> Miche le and Martha
>> Here are the CBRA hot topics for your briefing wi h Aurel a. Is here a powerpoint we should add the key po n s to? Thanks.
>>
>> Kat e
>>
>> https / teams microsoft com/l file/518373ED-5D3A- 66A-B9DC-FC5C0AA 631? enan Id=0693b5ba- b18- d7b-93 1-f32f 00a5 9 &fileType=docx&objectUrl=h tps%3A%2F%2Fdoimspp sharepoint com%2Fsites%2FGeneralCBRA%2FShared%20Documen s%2FGeneral%2FCBRA%20hot%20top cs%20for%20D rector%201.7.20docx.docx&baseUrl=https%3A%2F%2Fdoimspp sharepo nt com%2Fsites%2FGeneralCBRA&ser ceName=teams&th eadId=19 560d5fd5 6fd a 88e81d675155695a1@thread.skype&groupId=12a39673-fcdc- fe0-8836-e6c770ed f8c
>>
>> Katie Niemi
>> Coastal Ba ie s Coo dinato
>> U S ish & W ld i e Se v ce
>> Eco og cal Se vices MS ES
>> 5275 eesbu g ke
>> al s Chu ch VA 2204 -3803
>> el (703) 358 207

Updated Interpretation of CBRA Exception for Beach Nourishment Projects
On November 4, 2019, Secretary Bernhardt issued letters to certain members of Congress to advise them that the Department had revisited its legal interpretation of a Coastal Barrier Resources Act (CBRA) exception related to beach nourishment. Since 1994, the Department and FWS have advised the Corps that the CBRA exception for "nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system" could not be applied to sand mining *within* the Coastal Barrier Resources System (CBRS) for beach nourishment projects that occur *outside* of the CBRS. The Department's Office of the Solicitor revisited this interpretation and issued a memo to FWS on October 30, 2019, which stated that sand from *within* the CBRS may be used to renourish beaches *outside* of the CBRS, provided that the federal funding agency consults with FWS and the project meets the requirements of the exception and is consistent with the purposes of CBRA.

FWS has received inquiries from Congress, NGOs, and other stakeholder groups seeking clarification on how the new interpretation will affect coastal storm damage reduction projects and the timeframe for FWS guidance on this matter. On December 20, 2019, FWS received consultation requests from the Corps Wilmington District for projects in Carolina Beach and Wrightsville Beach, NC; the Corps has requested a response to these two consultations requests by January 31, 2020. ES HQ is working with Region 2 on the responses to these two consultation requests.

ES HQ has also prepared a draft letter to the Corps Director of Civil Works to explain the Department's revised legal interpretation affecting coastal storm damage reduction projects.

USGS/FWS Study on Impacts of Sand Mining within and adjacent to the CBRS
The Chairman of the Committee on Natural Resources sent a June 24, 2019, letter to the Director of USGS and the Principal Deputy Director of FWS requesting that USGS, in conjunction with FWS, evaluate the short- and long-term impacts of sand/sediment removal on areas in and adjacent to the CBRS. FWS is working with USGS to define the scope of the study. A draft response letter to the Chairman is on hold in DTS.

Remapping of Certain CBRS Units in Florida and South Carolina
FWS plans to submit to the *Federal Register* an announcement of the availability of comprehensively revised boundaries for CBRS units in Okaloosa and Walton counties, Florida, and Beaufort and Charleston counties, South Carolina. The notice will announce a 60-day public comment period. Outreach will include a news bulletin; letters to Congress, federal, state, and local officials, and NGOs; and a stakeholder outreach toolkit available to local officials. The FR package is open with FWP and will be sent to the FR once cleared. ES staff had a conference call/webex with Katie Mills on December 10 to answer her questions related to this package. Senator Scott (SC) has inquired several times regarding the status of this remapping effort, and has been told that the public comment period was anticipated to begin in late 2019.

GAO Review of CBRA
81.5 (c) & 81.6(j)
[redacted]

[redacted]

[redacted]

81.5 (c) & 81.6(j)
[redacted]

Hurricane Sandy CBRS Remapping Project
In 2014, FWS initiated it's largest map modernization project to update the maps of approximately 370 CBRS units in the nine states along the North Atlantic coast most affected by Hurricane Sandy: Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Long Island), Rhode Island, and Virginia (comprising 16% of the total acreage within the CBRS). This project makes significant progress towards fulfilling the statutory requirement to modernize the entire set of CBRS maps. The modernization effort corrects mapping errors affecting property owners; adds new qualifying areas to the CBRS; and provides more accurate and accessible CBRS data for planning coastal infrastructure projects, habitat conservation efforts, and flood risk mitigation measures.

The public review for this project was conducted in two separate batches in 2018 and 2019. FWS is making appropriate adjustments to the boundaries based on public comments, CBRA criteria, and objective mapping protocols. FWS is also preparing summaries of and responses to the comments received along with final recommended maps that will be included in a report to Congress (anticipate report and related materials will go into surname in 2020). The revised CBRS maps (including proposed removals and proposed additions) will only become effective once the revised maps are adopted into law by Congress.

From:	Bohn, Cynthia
To:	Niemi, Katie; Wright, Dana K; Matthews, Kathryn H; Wells, Emily N
Subject:	Panama City white paper on CBRA conservation measures
Date:	Wednesday, January 8, 2020 2:05:41 PM
Attachments:	20170305 PCFOConservationMeasuresforCBRAException.pdf
Importance:	High

Hi ladies, I am attaching below the white paper that the Panama City FO put together to determine the standards for a CBRA restoration project. This is the document that Catherine referenced this morning on our call. I believe using this and then also looking at the draft guidance from HQ that was developed to address this change in the sand mining policy would be a good place to start. I would like to have a conference call on Monday around 10 am for us to map out our approach. I will send out a calendar invite.
Thanks everyone, Cindy

Cynthia Bohn
Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

b5-DPP [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

b5-DPP

[redacted]

From: Niemi, Katie
To: Shaughnessy, Michelle
Cc: Wright, Dana K
Subject: talking points for CBRA call with ARD
Date: Wednesday, January 8, 2020 2:29:00 PM
Attachments: 20200108 Talking Points on NC CBRA Consultations.docx

---

Michelle,
Attached are talking points on CBRA and the NC consultions for your discussion with Catherine. Thanks to Dana for drafting.

Katie

Talking Points on Coastal Barrier Resources Act Consultations

Background:

- Since 1994, DOI and FWS have advised the Corps that the CBRA exception for "nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system" could not be applied to sand mining within the CBRS for beach nourishment projects that occur outside of the CBRS.

- This interpretation affected several Corps shore-protection projects in areas along the Atlantic Coast (Stone Harbor, NJ; Topsail Beach, NC; Wrightsville Beach, NC; Carolina Beach, NC; and Folly Beach, SC), where communities and the Corps seek to use areas within the CBRS as borrow sites for beach-nourishment projects benefiting developed areas outside of the CBRS.

- SOL revisited this interpretation (upon request from the Secretary) and issued a memo to FWS on October 30, 2019, stating that sand from within the CBRS may be used to renourish beaches outside of the CBRS, provided that the federal funding agency consults with FWS and the project meets the requirements of the exception and is consistent with the purposes of CBRA.

- On November 4, 2019, the Secretary issued letters to certain members of Congress to advise that DOI revisited its legal interpretation of a CBRA exception related to beach nourishment. This issue has been publicized in local media, E & E, and the New York Times. FWS has received inquiries from Congress (including the HNR Committee), NGOs, and other stakeholder groups seeking clarification on how the new interpretation will affect projects and the timeframe for FWS guidance on this matter.

- There is strong support among NGOs for maintaining a restriction on sand mining in CBRS units (see letters as sent to the Secretary signed by 30 NGOs including Audubon, R Street, NRDC, NWF, and the Southern Environmental Law Center: first letter, second letter). Some of the concerns from these groups include: disruption of natural sand movement and sand supplies; impacts on benthic habitat, fisheries, and shorebird habitat; and adaptability of islands to sea-level rise. Conversely, there is strong support from communities, certain members of Congress, and the American Shore and Beach Preservation Association for mining sand from within the CBRS.

- Due to the high level of interest in this matter, Chairman Grijalva requested that USGS, in conjunction with the Service, evaluate the short- and long-term impacts of sand/sediment removal on areas in and adjacent to the CBRS. HQ ES is currently coordinating the scope of the study with USGS. However, the Service has not yet responded to the Chairman's incoming letter (DCN 070502).

- Chairman Grijalva also requested that GAO review CBRA. The entrance conference is anticipated to occur in late January. Among other things, GAO will examine the extent to which selected federal agencies have made expenditures in the CBRS and the extent to which those agencies have policies in place to ensure CBRA compliance.

Issue at hand:

- The new SOL memo creates uncertainty on how to apply CBRA to sand mining/beach nourishment projects and requires several policy decisions to be made. The standard is that the projects be "non-structural", that they "mimic, enhance, or restore natural stabilization systems", and that they also be consistent with the purposes of CBRA. B5-ACP-DPP [redacted]

- FWS has been advised that we cannot share the new SOL memo outside of the agency. No external or internal guidance has been developed on this issue. HQ ES has drafted a letter to the Corps (set up for Gary's signature) that would set the tone for future consultations. This letter is currently in surname (DCN 071591). The CBRA website has also been updated to indicate that "FWS will assist federal agencies in evaluating such projects through the interagency consultation process."

- On December 20, 2019, Region 2 received consultation requests from the Corps Wilmington District for projects in Carolina Beach and Wrightsville Beach, NC; the Corps requested a response by January 31, 2020 (though there is no statutory or regulatory time limit). North Carolina Congressional offices have requested that we give this issue immediate attention.

- b5-DPP [redacted]

Questions:

- What is the Region's plan for responding to these two consultation requests (and future consultation requests in general).
    - ES HQ CBRA team willing and able to help with response letters, but will require field support regarding the effects of the sand mining on fish and wildlife

- What is the timeframe for establishing the 1-2 CBRA regional coordinators?

- b5-DPP [redacted]

Prepared: January 8, 2020

From:	Bohn, Cynthia
To:	Wells, Emily N; Niemi, Kat e; Matthews, Kathryn H; Wright, Dana K
Subject:	Invitation: CBRA call w RANC @ Mon Jan 13, 2020 11am - 12pm (EST) (katie_niem @fws.gov)
Start:	Monday, January 13, 2020 11:00:00 AM
End:	Monday, January 13, 2020 12:00:00 PM
Attachments:	invite.ics
Importance:	High

You have been invited to the following event.

CBRA call w RANC

When
Mon Jan 13, 2020 11am – 12pm Eastern Time - New York
Video call
https://hangouts.google.com/hangouts/_/doi.gov/cynthia-bohn <https://hangouts.google.com/hangouts/_/doi.gov/cynthia-bohn?hceid Y3ludGhpYV9ib2huQGZ3cy5nb3Y.4gis0ernlcm4d0lrn3hjeq4kcb>
Calendar
katie_niemi@fws.gov
Who
• cynthia_bohn@fws.gov
- organizer
• emily_wells@fws.gov
• katie_niemi@fws.gov
• kathryn_matthews@fws.gov
• dana_wright@fws.gov
more details » <https://www.google.com/calendar/event?
action VIEW&eid NGdpczBlcm5sY200ZDBscm4zaGplcTRrY2Iga2F0aWVfbmllbWlAZndzLmdvdg&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZjMjUwODY5ZTIyMTU4Yzk2MzdkNTI3NGMxMTZkNGY5ZWNkZTU0ZjA4&ctz America%2FNew_York&hl en&es 1>

Discussion on the Wilmington Corps CBRA Consultation requests for Wrightsville Beach and Carolina Beach.

Call in information:
(b) [redacted]

Going (katie_niemi@fws.gov)?
Yes <https://www.google.com/calendar/event?
action RESPOND&eid NGdpczBlcm5sY200ZDBscm4zaGplcTRrY2Iga2F0aWVfbmllbWlAZndzLmdvdg&rst 1&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZjMjUwODY5ZTIyMTU4Yzk2MzdkNTI3NGMxMTZkNGY5ZWNkZTU0ZjA4&ctz America%2FNew_York&hl en&es 1>
-
Maybe <https://www.google.com/calendar/event?
action RESPOND&eid NGdpczBlcm5sY200ZDBscm4zaGplcTRrY2Iga2F0aWVfbmllbWlAZndzLmdvdg&rst 3&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZjMjUwODY5ZTIyMTU4Yzk2MzdkNTI3NGMxMTZkNGY5ZWNkZTU0ZjA4&ctz America%2FNew_York&hl en&es 1>
-
No <https://www.google.com/calendar/event?
action RESPOND&eid NGdpczBlcm5sY200ZDBscm4zaGplcTRrY2Iga2F0aWVfbmllbWlAZndzLmdvdg&rst 2&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZjMjUwODY5ZTIyMTU4Yzk2MzdkNTI3NGMxMTZkNGY5ZWNkZTU0ZjA4&ctz America%2FNew_York&hl en&es 1>
more options » <https://www.google.com/calendar/event?
action VIEW&eid NGdpczBlcm5sY200ZDBscm4zaGplcTRrY2Iga2F0aWVfbmllbWlAZndzLmdvdg&tok MjAjY3ludGhpYV9ib2huQGZ3cy5nb3ZjMjUwODY5ZTIyMTU4Yzk2MzdkNTI3NGMxMTZkNGY5ZWNkZTU0ZjA4&ctz America%2FNew_York&hl en&es 1>

From:	Bohn, Cynthia
To:	Niemi, Katie; Wright, Dana K; Matthews, Kathryn H; Wells, Emily N
Subject:	Re: Panama City white paper on CBRA conservation measures
Date:	Wednesday, January 8, 2020 2:52:57 PM
Importance:	High

I moved the call to 11 after seeing Dana had a conflict; Kathryn, I don't have access to your calendar to see if you have conflicts so please let me know. As a reminder, I don't work on Thursday and Friday this week but please feel free to contact each other or move forward without me if you like. Emily, sorry you were not on the call this morning, we can get you up to speed quickly.

thanks all, c

Cynthia Bohn
Coastal Barrier Resources Act Specialist
Phone: 404-679-7122
Fax: 404-679-7081
cynthia_bohn@fws.gov

Learn more about the Coastal Barrier Resources Act

On Wed, Jan 8, 2020 at 2:05 PM Bohn, Cynthia <cynthia_bohn@fws.gov> wrote:

> Hi ladies, I am attaching below the white paper that the Panama City FO put together to determine the standards for a CBRA restoration project. This is the document that Catherine referenced this morning on our call. I believe using this and then also looking at the draft guidance from HQ that was developed to address this change in the sand mining policy would be a good place to start. I would like to have a conference call on Monday around 10 am for us to map out our approach. I will send out a calendar invite.
> Thanks everyone, Cindy
>
> Cynthia Bohn
> Coastal Barrier Resources Act Specialist
> Phone: 404-679-7122
> Fax: 404-679-7081
> cynthia_bohn@fws.gov
>
> Learn more about the Coastal Barrier Resources Act
>
>

Information Act (FOIA) and may be disclosed to third parties.

From:	Frazer, Gary D
To:	Shaughnessy, Michelle; BalisLarsen, Martha; Phinney, Jonathan T; Niemi, Katie; Wright, Dana K
Subject:	Fwd: TPs for CBRS interview
Date:	Thursday, January 9, 2020 4:12:59 PM
Attachments:	ATT00001.htm CBRA Sand Mining Talking Points.docx
Importance:	High

Well done!

Sent from my iPhone

Begin forwarded message:

> **From:** "Shire, Gavin" <gavin_shire@fws.gov>
> **Date:** January 9, 2020 at 12:03:34 PM PST
> **To:** Barbara Wainman <barbara_wainman@fws.gov>, Gary Frazer <gary_frazer@fws.gov>
> **Cc:** Brian Hires <brian_hires@fws.gov>
> **Subject: TPs for CBRS interview**
>
> Attached.
>
> Gary, the background is entirely from your folks. The TPs on the interpretation are mostly theirs but broken out into separate bullets with some additional emphasis. Please let me know ASAP if these are OK to go to Aurelia.
>
> G
>
> Gavin Shire
> Chief of Public Affairs
> U.S. Fish and Wildlife Service
> MS: EA
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> 703-358-2649 (o)
> 703-346-9123 (c)
> gavin_shire@fws.gov

CBRA Sand Mining Talking Points

General CBRA Messages:

- The Fish and Wildlife Service is committed to implementing the Coastal Barrier Resources Act, according to its purposes of:
  - minimizing loss of human life
  - reducing wasteful expenditure of federal resources and
  - protecting the natural resources associated with coastal barriers
- We continue to update and modernize our implementation of the act through revised digital maps and where appropriate, revisions to our implementation of the statute.

Messages on the 2019 legal memo:

- Congress did not intend to constrain agencies in their ability to accomplish the act's overarching purpose of protecting coastal barrier resources. The act should be applied in a way that furthers this purpose.
- Our revised interpretation of gives federal agencies more flexibility to undertake projects that will protect coastal resources, even if those resources are located outside of the Coastal Barrier Resources System.
- This legal interpretation does not *guarantee* that sand within the Coastal Barrier Resources System may be used for beach replenishment outside the system, but it does make such projects eligible for consideration (including federal funding).
- Projects must further the purposes of the Act (see above three bullets).
- Project must be nonstructural, must be for the purposes of shoreline stabilization and must mimic, enhance or restore natural stabilization systems.
- Each project must be assessed on a case-by-case basis with the Service through the interagency consultation process.
- Factors that may restrict projects include (but are not limited to) the use of structural measures (e.g., seawalls, bulkheads, jetties, and geotextile dune cores) and damage to fish and wildlife resources from the dredging and/or nourishment activities.

Background:

- The Coastal Barrier Resources Act (CBRA) originally established the Coastal Barrier Resources System (CBRS) in 1982. The purpose of the law is to save taxpayer money and keep people out of harm's way by removing the federal incentive to develop ecologically sensitive and storm-prone coastal areas. CBRA prohibits most new federal expenditures and financial assistance within the CBRS, but does not restrict the use of private, state, or local funds or limit the issuance of federal permits within the CBRS.
- CBRA restricts most new federal expenditures within the CBRS including projects to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area (16 U.S.C. 3504(a)(3)).

- However, federal agencies, after consultation with FWS, may make expenditures within the CBRS for activities that meet one of CBRA's exceptions (16 U.S.C. 3505). The Service does not have enforcement authority over CBRA; each affected agency is independently responsible for complying with the law.
- Since 1994, DOI and FWS have advised the U.S. Army Corps of Engineers (Corps) that the CBRA exception for "nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system" (16 U.S.C. 3505(a)(6)(G)) could not be applied to sand mining within the CBRS beach nourishment projects that occur outside of the CBRS.
- This interpretation affected several Corps shore-protection projects in areas along the Atlantic Coast (Stone Harbor, NJ; Topsail Beach, NC; Wrightsville Beach, NC; Carolina Beach, NC; and Folly Beach, SC), where communities and the Corps seek to use areas within the CBRS as borrow sites for beach-nourishment projects benefiting developed areas outside of the CBRS.
- SOL revisited this interpretation and issued a memo to FWS on October 30, 2019, stating that sand from within the CBRS may be used to renourish beaches outside of the CBRS, provided that the federal funding agency consults with FWS and the project meets the requirements of the exception and is consistent with the purposes of CBRA.
- On November 4, 2019, the Secretary issued letters to certain members of Congress to advise that DOI revisited its legal interpretation of a CBRA exception related to beach nourishment. This issue has been publicized in local media, E & E, and the New York Times.
- Several of the local media articles convey a false impression that federally-funded sand mining activities are now automatically allowed within the CBRS as a result of the new interpretation. **However, the October 30, 2019 SOL memo is clear that such projects are still subject to the consultation process and must meet the standards of the exception**:
    - Must be "non-structural"
    - Must be designed to "mimic, enhance, or restore a natural stabilization system"
    - Must be consistent with the purposes of CBRA. The purposes of CBRA are: "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers…by restricting future Federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers…and by considering the means and measures by which the long-term conservation of these fish, wildlife, and other natural resources may be achieved" (16 U.S.C. 3501(b)).

- SOL has stated that these requirements apply to the entire project, both inside and outside of the CBRS (this is a significant change from how projects have been evaluated in the past, when consultations considered only activities within the CBRS).
- DOI and FWS have received inquiries from the House Natural Resources Committee and other stakeholder groups seeking clarification on how the new interpretation will affect projects and the timeframe for FWS guidance on this matter. Ecological Services (ES) is in the process of preparing a letter to the Corps' Director of Civil Works regarding CBRA consultations under the new interpretation.

- There is strong support among NGOs for maintaining a restriction on sand mining in CBRS units (see letters sent to the Secretary signed by 30 NGOs including Audubon, R Street, NRDC, NWF, and the Southern Environmental Law Center: first letter, second letter). Some of the concerns from these groups include: disruption of natural sand movement and sand supplies; impacts on benthic habitat, fisheries, and shorebird habitat; and adaptability of islands to sea-level rise. Conversely, there is strong support from communities, certain members of Congress, and the American Shore and Beach Preservation Association for mining sand from within the CBRS. Local communities seek federal funds for their storm damage reduction projects, and the Corps argues that it is preferable to mine sand from nearby inlets and channels within the CBRS (as opposed to offshore) due to sand quality and cost.

North Carolina Consultations and Examples of Issues to be Considered:

- On December 20, 2019, Region 2 (South Atlantic Gulf) received consultation requests from the Corps Wilmington District for projects in Carolina Beach and Wrightsville Beach, NC; the Corps requested a response by January 31, 2020 (though there is no statutory or regulatory time limit for CBRA consultations). North Carolina Congressional offices have requested that we give this issue immediate attention.
- HQ ES is working with Region 2 and the North Carolina ES Field Office on reviewing the two consultation requests. FWS will consider a number of factors, including:
    - Whether both the sand mining within the CBRS and beach nourishment outside of the CBRS constitute “non-structural” shoreline stabilization activities as required by the exception. An example of a disqualifying factor would be the use of structural elements in the project (e.g., jetties, groins, seawalls, geotubes, and bulkheads).
    - Whether both the sand mining within the CBRS and beach nourishment can be considered to “mimic, enhance, or restore a natural stabilization system.” For example, a project that includes the construction of artificially high, contiguous, densely vegetated dunes that is designed to prevent natural processes, such as overwash and erosion, may not mimic a natural stabilization system.
    - Whether the project minimizes damage to fish and wildlife resources. Non-structural forms of shoreline stabilization (e.g., nourishing beaches, altering natural dunes to be artificially high and/or contiguous, planting dune-stabilizing vegetation) can result in degradation and/or loss of habitat for coastal-dependent species. Dredging of inlets for sand can also be detrimental, causing changes in the benthic community and seafloor geomorphology.

From:	Google Calendar on behalf of Wright, Dana K
To:	Wells, Emily N; Bohn, Cynthia; Niemi, Katie; Wright, Dana K; Matthews, Kathryn H
Subject:	CBRA call w RANC
Date:	Monday, January 13, 2020 11:26:24 AM
Importance:	High

Can we try switching lines?

(b) (5) [redacted]

CBRA call w RANC

When Mon Jan 13, 2020 11am – 12pm Eastern Time - New York

Video call https://hangouts.google.com/hangouts/_/doi.gov/cynthia-bohn

Who
- cynthia_bohn@fws.gov - organizer
- emily_wells@fws.gov
- kathryn_matthews@fws.gov
- dana_wright@fws.gov
- katie_niemi@fws.gov

Discussion on the Wilmington Corps CBRA Consultation requests for Wrightsville Beach and Carolina Beach.

Call in information:
(b) (5) [redacted]

From: Wright, Dana K
To: kathyrn_matthews; Wells, Emily N
Cc: Bohn, Cynthia; Niemi, Katie
Subject: 2016 consultation background
Date: Monday, January 13, 2020 11:33:18 AM
Attachments: Talking Points on Hereford Inlet NJ-09 4.24.19.docx
Importance: High

Hi Kathy and Emily,

Attached is background on the Stone Harbor, NJ CBRA issue in the event that Trista Talton's questions about the 2016 consultation were referring to this (and not the 2016 ESA consultation in NC). There was the false perception among members of Congress and others that this 2016 NJ consultation was some sort of change or reversal in Service position (which it was not, as described by the talking points).

If she has questions on this, please refer her to Eric Schrading, the NJ field supervisor.

Thanks,

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

CBRS Stone Harbor Unit NJ-09 (Hereford Inlet) Talking Points

CBRA Basics:

- CBRA is a map based law comprising 870 units that make up the Coastal Barrier Resources System (CBRS), which contains 3.5 million acres of barriers and associated wetlands along the Atlantic, Gulf of Mexico, and Great Lakes coasts, as well as Puerto Rico and the U.S. Virgin Islands.

- The three purposes of CBRA are to minimize: wasteful federal expenditures, loss of human life, and damage to natural resources. CBRA achieves these goals by restricting federal funding and financial assistance that may encourage development, such as flood insurance, disaster assistance, beach nourishment, and new road construction. CBRA does not restrict the use of private, state, or local funds within the CBRS or limit the issuance of federal permits.

- A recent study in the Journal of Coastal Research estimated CBRA saved the taxpayers $9.5 billion from 1989-2013 (avoided coastal disaster expenditures by FEMA, DOT, EPA, and HUD).

- The Service is responsible for maintaining and updating the CBRS maps. With minor exceptions, only Congress can change the maps of the CBRS to add or remove lands.

- The Service receives numerous requests for changes to the maps from interested parties (generally property owners, local communities, and their members of Congress) that seek federal funding for specific areas. The Service conducts research, applies statutory criteria and objective mapping protocols, and prepares revised maps for Congressional consideration.

- CBRA has about a dozen exceptions, but consultation with the Service is required before a federal agency can obligate funding for an excepted activity. Any response provided by the Service is an opinion only. **The funding agency makes the final decision. The Service has no regulatory authority over CBRA.**

Hereford Inlet - Sand Mining Issues:

- **Hereford Inlet**, located along the Atlantic coast in Cape May County in southeastern New Jersey, **was first added to Unit NJ-09 of the CBRS in 1990**. The Service is currently remapping this area as part of a large project covering nine states in Region 5 using Hurricane Sandy supplemental funds.

- In 2016, the Corps requested a consultation from the Service's NJ Field Office for a project to dredge Hereford Inlet to obtain sand for use in nourishing beaches outside of the CBRS on Seven Mile Island to the northeast of the unit (Borough of Stone Harbor).

- In 2016, the Service found the project not allowable with federal funds under CBRA. Though CBRA contains an exception for shoreline stabilization to restore natural systems within the CBRS, **a 1994 DOI solicitor's opinion states that this exception does not allow for sand mining <u>within the CBRS</u> for the purposes of nourishing beaches <u>outside of the CBRS</u>.**

- The Corps previously assumed they could use the Hereford Inlet borrow site because they had received concurrence from the NJFO on a previous project within Unit NJ-09 in the late 1990's. The Corps proceeded to dredge Hereford Inlet (for nourishment projects outside of the CBRS) in 2011 and 2013 without consulting with the Service as required by law.

- The initial 1990's project was for environmental restoration within Unit NJ-09. It is our understanding that no sand was taken from Hereford Inlet to nourish beaches outside of the CBRS at that time. The project proposed in 2016 sought to borrow sand from the CBRS for use in nourishing a developed shoreline outside of the CBRS for storm protection. **These projects are different fact patterns and therefore there has been no "reversal" in Service policy (as has been reported in the media).**

- In light of the Service's 2016 non-binding opinion, the Corps decided not to fund the dredging of Hereford Inlet. **The Corps subsequently entered into an MOA with the State of NJ to use state funds for the dredging within the CBRS, and the project was completed. This approach to use non-federal funding for portions of projects within the CBRS has been applied elsewhere and is currently proposed for a large storm-damage-reduction project in Texas.**

- In 2016, the nearby Borough of Avalon filed suit against the Corps and the Service for violation of the Administrative Procedure Act, alleging an arbitrary and capricious interpretation of CBRA. The NJ District Court dismissed the suit in 2017 due to mootness and lack of standing.

- In 2019, the Corps pulled out of a planned renourishment project for the Borough of Stone Harbor due to CBRA. Recent news reports state that without federal funds, the project is too expensive.

- Interested parties now seek to downgrade the unit to an Otherwise Protected Area (OPA). System Units carry CBRA's full suite of restrictions on federal expenditures, while OPAs (generally comprised of park lands at the time of designation) restrict only federal flood insurance. Reclassifying the borrow site to an OPA would allow the use of federal funds for dredging. **The borrow site does not qualify for reclassification to OPA according to the Service's objective mapping protocols and CBRA's statutory definition of "otherwise protected."**

National Implications:

- The sand mining issue has come up in two other hot spots along the Atlantic Coast (southeastern NC and Folly Beach, SC), where local communities seek to use inlets within the CBRS as borrow sites for beach nourishment projects outside of the CBRS. The use of nearshore borrow sites is generally preferable to offshore borrow sites due to sand quality and cost.

- **Following recent Congressional inquiries, the Acting AS-FWP was briefed on this matter in November 2018 and declined to re-asses DOI's longstanding interpretation of CBRA**. A letter from the Service's Principal Deputy Director to seven members of Congress conveyed this position in December 2018.

- Numerous groups (e.g., Association of State Floodplain Managers, National Audubon Society, American Littoral Society) have submitted comments to the Service opposing the use of inlets within the CBRS as borrow sites due to impacts on these areas as natural storm buffers and habitat.

Prepared: April 24, 2019

From:	Wright, Dana K
To:	Owen, Gib A CIV USARMY HQDA ASA CW (USA)
Cc:	Niemi, Katie
Subject:	Re: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date:	Wednesday, January 22, 2020 3:11:40 PM
Importance:	High

Hello Gib,

Thank you for your message. We have received your request and will share it with our leadership and get back to you soon.

Thanks,

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Wed, Jan 22, 2020 at 2:31 PM Owen, Gib A CIV USARMY HQDA ASA CW (USA) <gib.a.owen.civ@mail.mil> wrote:

> Dana and Katie,
>
> 81.5 (c) & 81.6 (j) [redacted]
>
> Gib
>
> Gib Owen
> Water Resources Policy & Legislation
> Office of the Assistant Secretary of the Army for Civil Works
> Pentagon, Washington DC
> gib.a.owen.civ@mail.mil
> 703 695 4641 - Office
> 571 274 1929 - Cell
> ><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

From: Niemi, Katie
To: Chen, Linus Y
Cc: Shaughnessy, Michelle; Wright, Dana K
Subject: Fwd: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date: Wednesday, January 22, 2020 3:19:46 PM
Attachments: 11.04.19 Bernhardt CBRA Response.pdf
Importance: High

Linus,
Please see request below from the Office of the Assistant Secretary of the Army for Civil Works. Are we able to share the new CBRA SOL memo with the Corps and GAO? On a separate note, we had a call with the Corp South Atlantic Division and Wilmington District folks yesterday concerning two specific NC projects and they are also interested in a copy of the SOL memo as they are working on CBRA consultation requests related to sand mining/beach nourishment. Thanks.

Katie

---------- Forwarded message ---------
From: **Owen, Gib A CIV USARMY HQDA ASA CW (USA)** <gib.a.owen.civ@mail.mil>
Date: Wed, Jan 22, 2020 at 2:31 PM
Subject: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
To: dana_wright@fws.gov <dana_wright@fws.gov>, katie_niemi@fws.gov <katie_niemi@fws.gov>

Dana and Katie,
81.5 (c) & 81.6 (j)
[redacted]

Gib

Gib Owen
Water Resources Policy & Legislation
Office of the Assistant Secretary of the Army for Civil Works
Pentagon, Washington DC
gib.a.owen.civ@mail.mil
703 695 4641 - Office
571 274 1929 - Cell
><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Garret Graves
U.S. House of Representatives
Washington, DC 20515

Dear Representative Graves:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable David Rouzer
U.S. House of Representatives
Washington, DC 20515

Dear Representative Rouzer:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior

THE SECRETARY OF THE INTERIOR
WASHINGTON

NOV 04 2019

The Honorable Jeff Van Drew
U.S. House of Representatives
Washington, DC 20515

Dear Representative Van Drew:

Thank you for your letter dated October 25, 2019, regarding the Coastal Barrier Resources Act (CBRA). In your letter, you asked the following:

> Does the Department [of the Interior] take the view that, if otherwise consistent with the purposes of the Act, Sec. 6(G) of CBRA applies to any "non-structural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system," including those outside of a system unit?

The answer to your question is yes, application of the statutory exception is not limited to within a unit.

In particular, you raised concerns with a 1994 legal memorandum interpreting a section of the law that provides exceptions to limitations on Federal expenditures for shoreline stabilization projects. You note this flawed interpretation of the law has prevented a number of coastal storm damage reduction projects that would further the purposes of the statute as declared by Congress.

Based on the concerns raised in your letter and those of other members of Congress, I asked the Department of the Interior's (Department) Office of the Solicitor to review the 1994 opinion referenced to determine whether section 6 of CBRA permits Federal funding for utilizing sand removed from a unit of the Coastal Barrier Resources System (System) to renourish beaches located outside the System. After considering the plain language of the law and the legislative history, the Office of the Solicitor determined that the exemption in section 6 is not limited to shoreline stabilization projects occurring within the System. I personally reviewed the matter and agree.

In 1982, when Congress passed CBRA (which established the John H. Chafee Coastal Barrier Resources System), it found that coastal barriers contain significant cultural and natural resources—including wildlife habitat—and function as natural storm protective buffers. Congress found that coastal barriers are generally unsuitable for development. To achieve the purposes of the Act, "to minimize the loss of human life, wasteful expenditure of Federal revenues, and the damage to fish, wildlife, and other natural resources associated with coastal barriers," CBRA prohibits new Federal financial assistance incentives that encourage development of coastal barriers. Section 6 of the Act establishes exceptions to this restriction, including "[n]onstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system." Within the Department, the U.S. Fish and Wildlife Service is responsible for maintaining and updating the official maps of the System.

The 1994 legal memorandum interpreting section 6 that you referenced in your letter contained no analysis but summarily concluded that the exemption for shoreline stabilization projects applies only to projects designed to stabilize the shoreline of a System unit and not to projects to renourish beaches outside the System, even when those projects benefit coastal barriers within the System. Closely evaluating the text, I do not find this was a permissible reading of the statute. The language is not ambiguous.

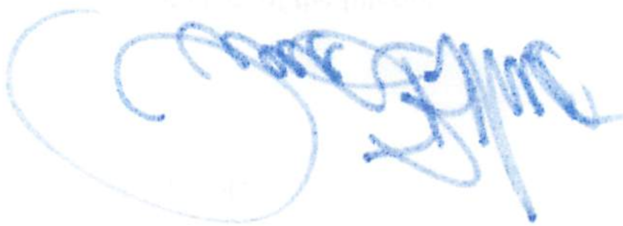
Even if some ambiguity could be identified in section 6, after reviewing the language of the Act and the legislative history, the more reasoned interpretation is that Congress did not intend to constrain the flexibility of agencies to accomplish the CBRA's broader purposes of protecting coastal barrier resources by requiring beach renourishment to occur "solely" within the System. Thus, even to the extent the statutory language could be considered ambiguous, it should be interpreted in a way that furthers Congress' stated purpose of protecting coastal barrier resources. As a consequence, sand from units within the System may be used to renourish beaches located outside of the System, provided the project is consistent with the purposes of the Act.

Thank you for highlighting the issues in your letter. The Department is committed to ensuring that we do not needlessly burden people or communities beyond the parameters Congress has determined to be appropriate. I welcome the opportunity to discuss these efforts with you going forward.

A similar letter has been sent to each of your cosigners, and I have directed the U.S. Fish and Wildlife Service to bring its communications into compliance with the statute.

Sincerely,

Secretary of the Interior



From: Wright, Dana K
To: Niemi, Katie
Subject: Re: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date: Thursday, January 23, 2020 8:38:15 AM
Attachments: 1994 SOL Opinion exception 6(a)(6)(G) and 1995 USACE letter.pdf
Importance: High

Attached is a PDF that you can share with the 94 opinion and 95 letter. It's saved here:

K:\CBRA\GAO\2020 CBRA GAO Audit\Materials to provide GAO

Dana Wright
Program Specialist
Ecological Services
U.S. Fish & Wildlife Service
5275 Leesburg Pike, MS: ES
Falls Church, VA 22041
703-358-2443 (office)
703-358-1800 (fax)

Learn more about the Coastal Barrier Resources Act

On Thu, Jan 23, 2020 at 8:12 AM Niemi, Katie <katie_niemi@fws.gov> wrote:

> Thanks Kristen and Linus for the confirmation. Can I give the Corps a contact in your office that they can share with GAO? Thanks!
>
> Katie
>
> Katie Niemi
> Coastal Barriers Coordinator
> U.S. Fish & Wildlife Service
> Ecological Services, MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> Tel (703) 358-2071
>
> On Wed, Jan 22, 2020 at 4:03 PM Floom, Kristen <kristen.floom@sol.doi.gov> wrote:
>
>> No, I have not heard that anything has changed -- as far as I know we still are not sharing the 2019 memo.
>>
>> On Wed, Jan 22, 2020 at 3:26 PM Chen, Linus <linus.chen@sol.doi.gov> wrote:
>>
>>> Hi Katie,
>>> (Adding Kristen Floom)
>>> I believe we were asked about sharing the new SOL memo a couple months ago, and at that time we said it could not be shared. I know nothing that has changed. I'm guessing Kristen hasn't heard anything to suggest that the new SOL memo can be shared either.
>>> Thanks,
>>> Linus

On Wed, Jan 22, 2020 at 3:19 PM Niemi, Katie <katie_niemi@fws.gov> wrote:

Linus,
Please see request below from the Office of the Assistant Secretary of the Army for Civil Works. Are we able to share the new CBRA SOL memo with the Corps and GAO? On a separate note, we had a call with the Corp South Atlantic Division and Wilmington District folks yesterday concerning two specific NC projects and they are also interested in a copy of the SOL memo as they are working on CBRA consultation requests related to sand mining/beach nourishment.
Thanks.

Katie

---------- Forwarded message ---------
From: **Owen, Gib A CIV USARMY HQDA ASA CW (USA)** <gib.a.owen.civ@mail.mil>
Date: Wed, Jan 22, 2020 at 2:31 PM
Subject: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
To: dana_wright@fws.gov <dana_wright@fws.gov>, katie_niemi@fws.gov <katie_niemi@fws.gov>

Dana and Katie,

81.5 (c) & 81.6 (j)

[redacted]

Gib

Gib Owen
Water Resources Policy & Legislation
Office of the Assistant Secretary of the Army for Civil Works
Pentagon, Washington DC
gib.a.owen.civ@mail.mil
703 695 4641 - Office
571 274 1929 - Cell
><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

--
Kristen Floom
U.S. Dept. of the Interior, Office of the Solicitor
Division of Parks & Wildlife
1849 C Street, N.W.
Washington, DC 20240
202-208-3795

From: Floom, Kristen B
To: Chen, Linus Y
Cc: Niemi, Katie; Wright, Dana K
Subject: Re: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date: Thursday, January 23, 2020 11:36:26 AM
Importance: High

I can be a contact as well. If you provide info for both of us we can coordinate with each other and our supervisors.

On Thu, Jan 23, 2020 at 10:17 AM Chen, Linus <linus.chen@sol.doi.gov> wrote:

> (Deleting Michelle)
> I can be a contact. (I'll let Kristen volunteer herself if she wants.)
>
> On Thu, Jan 23, 2020 at 8:12 AM Niemi, Katie <katie_niemi@fws.gov> wrote:
>
>> Thanks Kristen and Linus for the confirmation. Can I give the Corps a contact in your office that they can share with GAO? Thanks!
>>
>> Katie
>>
>> Katie Niemi
>> Coastal Barriers Coordinator
>> U.S. Fish & Wildlife Service
>> Ecological Services, MS: ES
>> 5275 Leesburg Pike
>> Falls Church, VA 22041-3803
>> Tel (703) 358-2071
>>
>> On Wed, Jan 22, 2020 at 4:03 PM Floom, Kristen <kristen.floom@sol.doi.gov> wrote:
>>
>>> No, I have not heard that anything has changed -- as far as I know we still are not sharing the 2019 memo.
>>>
>>> On Wed, Jan 22, 2020 at 3:26 PM Chen, Linus <linus.chen@sol.doi.gov> wrote:
>>>
>>>> Hi Katie,
>>>> (Adding Kristen Floom)
>>>> I believe we were asked about sharing the new SOL memo a couple months ago, and at that time we said it could not be shared. I know nothing that has changed. I'm guessing Kristen hasn't heard anything to suggest that the new SOL memo can be shared either.
>>>> Thanks,
>>>> Linus
>>>>
>>>> On Wed, Jan 22, 2020 at 3:19 PM Niemi, Katie <katie_niemi@fws.gov> wrote:
>>>>
>>>>> Linus,
>>>>> Please see request below from the Office of the Assistant Secretary of the Army for Civil Works. Are we able to share the new CBRA SOL memo with the Corps and GAO? On a separate note, we had a call with the Corp South Atlantic Division and Wilmington District folks yesterday concerning two specific NC projects and they are also interested in a copy of the SOL memo as they are working on CBRA consultation requests related to sand mining/beach nourishment. Thanks.

Katie

---------- Forwarded message ---------
From: **Owen, Gib A CIV USARMY HQDA ASA CW (USA)**
<gib.a.owen.civ@mail.mil>
Date: Wed, Jan 22, 2020 at 2:31 PM
Subject: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
To: dana_wright@fws.gov <dana_wright@fws.gov>, katie_niemi@fws.gov
<katie_niemi@fws.gov>

Dana and Katie,

81.5 (c) & 81.6 (j) [redacted]

Gib

Gib Owen
Water Resources Policy & Legislation
Office of the Assistant Secretary of the Army for Civil Works
Pentagon, Washington DC
gib.a.owen.civ@mail.mil
703 695 4641 - Office
571 274 1929 - Cell
><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

--

Linus Y. Chen, Attorney

Division Parks & Wildlife

(w) 202-208-5036

(f) 202-208-3877

--
Kristen Floom
U.S. Dept. of the Interior, Office of the Solicitor
Division of Parks & Wildlife
1849 C Street, N.W.
Washington, DC 20240

> > 202-208-3795

> --
>
> Linus Y. Chen, Attorney
>
> Division Parks & Wildlife
>
> (w) 202-208-5036
>
> (f) 202-208-3877

--
Kristen Floom
U.S. Dept. of the Interior, Office of the Solicitor
Division of Parks & Wildlife
1849 C Street, N.W.
Washington, DC 20240
202-208-3795

From:	Niemi, Katie
To:	Owen, Gib A CIV USARMY HQDA ASA CW (USA)
Cc:	Wright, Dana K; Chen, Linus Y; Floom, Kristen B; Shaughnessy, Michelle
Subject:	Re: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date:	Thursday, January 23, 2020 12:58:18 PM
Attachments:	1994 SOL Opinion exception 6(a)(6)(G) and 1995 USACE letter.pdf

---

Hello Gib,
Attached is the 1994 DOI Solicitor's Memo on the interpretation of CBRA Section 6(a)(6)(G). Also attached is a 1995 letter from the Assistant Secretary for Fish and Wildlife and Parks to the Acting Assistant Secretary for Civil Works regarding DOI's interpretation of Section 6(a)(6)(G). We have been advised by our Office of the Solicitor that we are unable to share the 2019 Solicitor's Memo related to the interpretation of CBRA Section 6(a)(6)(G) outside of DOI. Please contact Linus Chen (copied on this email and tel. 202-208-5036) or Kristen Floom (copied on this email and tel 202-208-3795) of our Solicitor's Office if you (or GAO) have further questions concerning the 2019 memo.
Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

On Wed, Jan 22, 2020 at 2:31 PM Owen, Gib A CIV USARMY HQDA ASA CW (USA) <gib.a.owen.civ@mail.mil> wrote:

> Dana and Katie,
> 81.5 (c) & 81.6 (j)
> [redacted]
>
> Gib
>
> Gib Owen
> Water Resources Policy & Legislation
> Office of the Assistant Secretary of the Army for Civil Works
> Pentagon, Washington DC
> gib.a.owen.civ@mail.mil
> 703 695 4641 - Office
> 571 274 1929 - Cell
> ><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

FWS.CW.0380

Memorandum

To: Ralph Morgenweck
Assistant Director, Fish and Wildlife Enhancement
Fish and Wildlife Service

From: Charles P. Raynor
Assistant Solicitor
Fish and Wildlife

Subject: Interpretation of Section 6(a)(6)(G) of the Coastal Barrier Resources Act

Introduction

You have requested our opinion as to whether a project to renourish a beach outside the Coastal Barrier Resources System (System) utilizing sand removed from within a unit of the System can qualify for the shoreline stabilization projects exemption in section 6(a)(6)(G) of the Coastal Barrier Resources Act (Act), 16 U.S.C. 3505(a)(6)(G). We conclude this exemption applies only to projects designed to stabilize the shoreline of a System unit and therefore does not apply to projects to renourish beaches outside the System even if the other requirements of section 6(a)(6)(G) are met.

Background

Section 5(a) of the CBRA, 16 U.S.C. 3504(a), prohibits new Federal expenditures or financial assistance for activities within the System, unless the activities are covered by one of the exceptions listed in section 6. The shoreline stabilization projects exception in section 6(a)(6)(G) covers:

> (6) Any of the following actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act:
>
> . . . .
>
> (G) Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems.

We understand Proposed beach renourishment projects within the CBRS that meet these standards and are consistent with the CBRA purposes may receive Federal funding.

Discussion

The Corps proposes to dredge approximately 975,000 cubic yards of sand from within the Midway Inlet Unit for use in renourishing the beach on Pawley's Island, which is not within the CBRS. We interpret the language of section 6(a)(6) of the CBRA, however, as referring to nonstructural projects devoted to stabilizing the shoreline of a Unit of the CBRS by mimicking, enhancing, or restoring the natural stabilization systems of the Unit. In other words, beach renourishment projects must be aimed at renourishing the beach of the CBRA Unit in order to qualify for Federal funding under section 6(a)(6). In contrast, the Corps' Pawley's Island project is intended solely to accomplish the renourishment of a beach outside of the CBRS. We therefore conclude that Federal funding or financial assistance for such a project would violate section 5 of the CBRA. Our opinion would not differ if the project were designed instead to renourish beaches both within and without the CBRS, because we interpret section 6(a)(6) to refer to projects designed to renourish solely a beach within the CBRS.

Even if this project were intended to renourish the beach of the Midway Inlet Unit, we believe it still would not qualify for a Federal funding exception because it would be inconsistent with the CBRA purposes. As noted above, the CBRA purposes include minimizing damage to fish, wildlife, and other natural resources of coastal barriers. In this case, the proposed dredging would damage the productive natural systems of Midway Inlet in several ways. The dredging would result in the outright destruction of all benthic organisms encountered by the dredging cutterhead that would be used. In addition, the borrow area, which currently is shallow, would be converted to deeper, less productive open water. The deepening of this area would also cause sloughing and/or erosion of adjacent shallow areas and thereby reduce their habitat values.

The existing shallow water of the borrow area provides, in conjunction with adjacent beaches, habitat for a number of species of birds and turtles. These include Wilsons plovers and Least terns (classified as threatened by the State of South Carolina) that nest and feed in the existing habitat. The loggerhead turtle (Federally listed as threatened under the Endangered Species Act) utilizes these beaches for nesting and the shallow ridged shoals for feeding and nesting during its "internesting period" (the time interval between nesting emergencies).

Finally, recent studies by the Corps of Engineers of the effects of other renourishent projects on North Carolina beaches suggest that they result in a reduction in nearshore and surf fisheries caused by disturbances to intertidal communities from renourishment activities.

Conclusion

The renourishment project proposed by the Army Corps of Engineers, dredging of sand from within the Midway Inlet Unit in order to renourish a beach outside the Coastal Barrier Resources System, does not fall within the CBRA section 6(a)(6) Federal funding exception, which applies only to projects for renourishment of beaches within the CBRS. In addition, the project would lead to significant adverse impacts on the natural resources of the Midway Inlet Unit, although section 6(a)(6) projects must be consistent with the CBRA purpose of minimizing damage to the natural resources of coastal barriers. For each of these reasons, we conclude that Federal funding or financial assistance for this beach renourishment project would violate section 5 of the Coastal Barrier Resources System.

Please refer any questions to David Gayer (343-2172).

cc: Coastal Barriers Coordinator
J. G. Harvey Geitner, Charleston, S.C. Field Office, FWS

United States Department of the Interior

OFFICE OF THE SECRETARY
1849 C Street, N.W.
Washington, D.C. 20240

JUN 12 1995

Dr. John H. Zirschky
Acting Assistant Secretary (Civil Works)
Department of the Army
108 Army Pentagon
Washington, D.C. 20310-0108

Dear Dr. Zirschky:

Thank you for your letter of February 16, 1995, requesting review of the U.S. Fish and Wildlife Service (Service) interpretation of the statutory requirements of the Coastal Barrier Resources Act (Act) in relation to the issue of federally funded beach nourishment activities. You specifically request that we reverse the Service's interpretation of section 6(a)(6)(G) of the Act as it relates to the U.S. Army Corps of Engineers (Corps) Folly Beach, South Carolina, beach renourishment project and other similar projects. You note that the Service's interpretation should be rescinded for the following reasons: 1) Corps studies indicate impacts to coastal barrier Unit M07, Bird Key Complex, from the Folly Beach project are not appreciable and may be beneficial, 2) the Energy and Water Development Appropriation Act for 1992 authorized the use of Unit M07 as a borrow area by the Corps, 3) the Service previously determined that the use of Unit M07 as a borrow area was an allowable activity under section 6(a)(6)(G) of the Act, and 4) the Service's current statutory interpretation places unexpected financial burdens on both the Federal Government and the non-Federal cost-sharing sponsors of the Folly Beach project and other similar Corps projects.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the Coastal Barrier Resources System (System). The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. We have conferred with the Department's Office of the Solicitor on this issue and, after careful consideration, determined that the current statutory interpretation is correct. Section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any Corps proposed action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception.

Relative to your point that the Folly Beach project would not be damaging to Unit M07 and may actually benefit the unit, the section 6 exception does not apply in this case regardless of whether the project may be non-detrimental or beneficial. The section 6 exception applies only to projects for stabilizing the shoreline of a unit of the System, not for projects outside the System. In fact, the Charleston Field Office recently reported that Bird Key, a highly important nesting site for colonial waterbirds, has actually undergone drastic erosion since the Folly Beach project began. Most, if not all of the nesting habitat, has been lost. Also, recent studies by the South Carolina Department of Natural Resources indicate that material accumulating in the project borrow area does not appear to be beach compatible material due to the high content of silt and clay material.

With regard to the 1992 Energy and Water Development Appropriations Act, Congress regularly enacts new legislation resulting in numerous federally funded activities. However, activities authorized by such newly enacted legislation must adhere to other statutory requirements unless the legislation specifically exempts the activities from existing statutory requirements.

You are correct in stating that the Corps previously received a Service determination that the Folly Beach project was an allowable activity under section 6(a)(6)(G). However, because of conflicting interpretations regarding section 6(a)(6)(G) in relation to beach renourishment activities within coastal barrier units, the Service requested an interpretation by the Department's Solicitor which resulted in the current statutory interpretation.

Finally, you note that the current statutory interpretation places unexpected financial burdens on both the Federal and non-Federal sponsors of the Folly Beach project. The purposes of the Act are to minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife, and other natural resources associated with units of the System. The Act does not restrict the use of private, State or local government funds for activities within the System. Therefore, implementation of the Act results in a savings of Federal dollars by placing the financial burden on those who chose to invest, live, or conduct development activities within the System, not the American taxpayer. The current statutory requirement only restricts the use of Federal funds for the purpose of removing sand from within the System. Furthermore, it is only the last 4,500 feet of the southwest portion of the total proposed borrow area for the Folly Beach project which is within Unit M07. The remaining unaffected borrow area is 7,170 feet long and 600 feet wide. Therefore, the project is not entirely prohibited and estimated future financial burdens may be inflated.

It is important to note that coastal barrier units include the fastland core of the coastal barrier itself, as well as associated aquatic habitat and the entire sand-sharing system, including the beach, shoreface, and offshore bars. The sand-sharing system of coastal barriers is defined by the 30-foot bathymetric contour. Congress approved this delineation criteria for units of the System in recognition of the important role the sand-sharing system plays in maintaining the dynamic, migratory nature of coastal barriers.

We hope this clarifies the Department's position on this issue. Thank you for your cooperation on this matter.

Sincerely,

/sgn/ George T. Frampton Jr.

George T. Frampton, Jr.
Assistant Secretary for Fish
and Wildlife and Parks

cc: 6229-MIB-ES(1)
6013-MIB-PMO-Secretary's Files
6013-MIB-PMOSecretary's Reading File (2)
6024-MIB-SOL
7456-MIB-PMB
3156-MIB-FW
6242-MIB-CL
6628-MIB-LM
3012-MIB-FWS-Directorate Reading File
3012-MIB-FWS-CCU
3024-MIB-FWS-AES
400-ARLSQ-FWS-DHC
400-ARLSQ-FWS-DHC-BHR

FWS/DHC/BHR:LKelsey:eob:358-2201:3/30/95 - Q:\DHC\kelseyl\Zirschky.ltr
REVISED:AES:MNash:4/3/95

From:	Niemi, Katie
To:	Garrity, Katherine
Cc:	Wright, Dana K; Tripp, Kimberly J
Subject:	Fw: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988
Date:	Thursday, January 30, 2020 12:45:56 PM
Attachments:	1994 SOL Opinion exception 6(a)(6)(G) and 1995 USACE letter.pdf

---

Hi Kathy,
Thanks for coordinating the GAO entrance conference yesterday. Below (and attached) is what we shared with the Corps last week (to pass along to GAO). Here is the contact information for the lawyers in our Solicitor's Office who can speak with GAO about the October 2019 SOL memo they requested.

Linus Chen tel. 202-208-5036; email Linus.Chen@sol.doi.gov
Kristen Floom tel 202-208-3795; email kristen.floom@sol.doi.gov

Thanks!
Katie

From: Niemi, Katie <katie_niemi@fws.gov>
Sent: Thursday, January 23, 2020 12:58 PM
To: Owen, Gib A CIV USARMY HQDA ASA CW (USA) <gib.a.owen.civ@mail.mil>
Cc: Wright, Dana K <dana_wright@fws.gov>; Chen, Linus Y <Linus.Chen@sol.doi.gov>; Floom, Kristen B <kristen.floom@sol.doi.gov>; Shaughnessy, Michelle <Michelle_Shaughnessy@fws.gov>
Subject: Re: [EXTERNAL] Coastal Barriers Resources Act - GAO audit 103988

Hello Gib,
Attached is the 1994 DOI Solicitor's Memo on the interpretation of CBRA Section 6(a)(6)(G). Also attached is a 1995 letter from the Assistant Secretary for Fish and Wildlife and Parks to the Acting Assistant Secretary for Civil Works regarding DOI's interpretation of Section 6(a)(6)(G). We have been advised by our Office of the Solicitor that we are unable to share the 2019 Solicitor's Memo related to the interpretation of CBRA Section 6(a)(6)(G) outside of DOI. Please contact Linus Chen (copied on this email and tel. 202-208-5036) or Kristen Floom (copied on this email and tel 202-208-3795) of our Solicitor's Office if you (or GAO) have further questions concerning the 2019 memo.
Thanks!
Katie

Katie Niemi
Coastal Barriers Coordinator
U.S. Fish & Wildlife Service
Ecological Services, MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
Tel (703) 358-2071

On Wed, Jan 22, 2020 at 2:31 PM Owen, Gib A CIV USARMY HQDA ASA CW (USA) <gib.a.owen.civ@mail.mil> wrote:

> Dana and Katie,
> 81.5 (c) & 81.6 (j) [redacted]

81.5 (c) & 81.6 (j) [redacted]

Gib

Gib Owen
Water Resources Policy & Legislation
Office of the Assistant Secretary of the Army for Civil Works
Pentagon, Washington DC
gib.a.owen.civ@mail.mil
703 695 4641 - Office
571 274 1929 - Cell
><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>`·.¸¸.·´¯`·.¸¸.><((((º>

FWS.CW.0380

Memorandum

To: Ralph Morgenweck
Assistant Director, Fish and Wildlife Enhancement
Fish and Wildlife Service

From: Charles P. Raynor
Assistant Solicitor
Fish and Wildlife

Subject: Interpretation of Section 6(a)(6)(G) of the Coastal Barrier Resources Act

Introduction

You have requested our opinion as to whether a project to renourish a beach outside the Coastal Barrier Resources System (System) utilizing sand removed from within a unit of the System can qualify for the shoreline stabilization projects exemption in section 6(a)(6)(G) of the Coastal Barrier Resources Act (Act), 16 U.S.C. 3505(a)(6)(G). We conclude this exemption applies only to projects designed to stabilize the shoreline of a System unit and therefore does not apply to projects to renourish beaches outside the System even if the other requirements of section 6(a)(6)(G) are met.

Background

Section 5(a) of the CBRA, 16 U.S.C. 3504(a), prohibits new Federal expenditures or financial assistance for activities within the System, unless the activities are covered by one of the exceptions listed in section 6. The shoreline stabilization projects exception in section 6(a)(6)(G) covers:

> (6) Any of the following actions or projects, but only if the making available of expenditures or assistance therefor is consistent with the purposes of this Act:
>
> . . . .
>
> (G) Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems.

We understand Proposed beach renourishment projects within the CBRS that meet these standards and are consistent with the CBRA purposes may receive Federal funding.

Discussion

The Corps proposes to dredge approximately 975,000 cubic yards of sand from within the Midway Inlet Unit for use in renourishing the beach on Pawley's Island, which is not within the CBRS. We interpret the language of section 6(a)(6) of the CBRA, however, as referring to nonstructural projects devoted to stabilizing the shoreline of a Unit of the CBRS by mimicking, enhancing, or restoring the natural stabilization systems of the Unit. In other words, beach renourishment projects must be aimed at renourishing the beach of the CBRA Unit in order to qualify for Federal funding under section 6(a)(6). In contrast, the Corps' Pawley's Island project is intended solely to accomplish the renourishment of a beach outside of the CBRS. We therefore conclude that Federal funding or financial assistance for such a project would violate section 5 of the CBRA. Our opinion would not differ if the project were designed instead to renourish beaches both within and without the CBRS, because we interpret section 6(a)(6) to refer to projects designed to renourish solely a beach within the CBRS.

Even if this project were intended to renourish the beach of the Midway Inlet Unit, we believe it still would not qualify for a Federal funding exception because it would be inconsistent with the CBRA purposes. As noted above, the CBRA purposes include minimizing damage to fish, wildlife, and other natural resources of coastal barriers. In this case, the proposed dredging would damage the productive natural systems of Midway Inlet in several ways. The dredging would result in the outright destruction of all benthic organisms encountered by the dredging cutterhead that would be used. In addition, the borrow area, which currently is shallow, would be converted to deeper, less productive open water. The deepening of this area would also cause sloughing and/or erosion of adjacent shallow areas and thereby reduce their habitat values.

The existing shallow water of the borrow area provides, in conjunction with adjacent beaches, habitat for a number of species of birds and turtles. These include Wilsons plovers and Least terns (classified as threatened by the State of South Carolina) that nest and feed in the existing habitat. The loggerhead turtle (Federally listed as threatened under the Endangered Species Act) utilizes these beaches for nesting and the shallow ridged shoals for feeding and nesting during its "internesting period" (the time interval between nesting emergencies).

Finally, recent studies by the Corps of Engineers of the effects of other renourishent projects on North Carolina beaches suggest that they result in a reduction in nearshore and surf fisheries caused by disturbances to intertidal communities from renourishment activities.

Conclusion

The renourishment project proposed by the Army Corps of Engineers, dredging of sand from within the Midway Inlet Unit in order to renourish a beach outside the Coastal Barrier Resources System, does not fall within the CBRA section 6(a)(6) Federal funding exception, which applies only to projects for renourishment of beaches within the CBRS. In addition, the project would lead to significant adverse impacts on the natural resources of the Midway Inlet Unit, although section 6(a)(6) projects must be consistent with the CBRA purpose of minimizing damage to the natural resources of coastal barriers. For each of these reasons, we conclude that Federal funding or financial assistance for this beach renourishment project would violate section 5 of the Coastal Barrier Resources System.

Please refer any questions to David Gayer (343-2172).

cc: Coastal Barriers Coordinator
J. G. Harvey Geitner, Charleston, S.C. Field Office, FWS

United States Department of the Interior

OFFICE OF THE SECRETARY
1849 C Street, N.W.
Washington, D.C. 20240

JUN 12 1995

Dr. John H. Zirschky
Acting Assistant Secretary (Civil Works)
Department of the Army
108 Army Pentagon
Washington, D.C. 20310-0108

Dear Dr. Zirschky:

Thank you for your letter of February 16, 1995, requesting review of the U.S. Fish and Wildlife Service (Service) interpretation of the statutory requirements of the Coastal Barrier Resources Act (Act) in relation to the issue of federally funded beach nourishment activities. You specifically request that we reverse the Service's interpretation of section 6(a)(6)(G) of the Act as it relates to the U.S. Army Corps of Engineers (Corps) Folly Beach, South Carolina, beach renourishment project and other similar projects. You note that the Service's interpretation should be rescinded for the following reasons: 1) Corps studies indicate impacts to coastal barrier Unit M07, Bird Key Complex, from the Folly Beach project are not appreciable and may be beneficial, 2) the Energy and Water Development Appropriation Act for 1992 authorized the use of Unit M07 as a borrow area by the Corps, 3) the Service previously determined that the use of Unit M07 as a borrow area was an allowable activity under section 6(a)(6)(G) of the Act, and 4) the Service's current statutory interpretation places unexpected financial burdens on both the Federal Government and the non-Federal cost-sharing sponsors of the Folly Beach project and other similar Corps projects.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the Coastal Barrier Resources System (System). The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. We have conferred with the Department's Office of the Solicitor on this issue and, after careful consideration, determined that the current statutory interpretation is correct. Section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any Corps proposed action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception.

Relative to your point that the Folly Beach project would not be damaging to Unit M07 and may actually benefit the unit, the section 6 exception does not apply in this case regardless of whether the project may be non-detrimental or beneficial. The section 6 exception applies only to projects for stabilizing the shoreline of a unit of the System, not for projects outside the System. In fact, the Charleston Field Office recently reported that Bird Key, a highly important nesting site for colonial waterbirds, has actually undergone drastic erosion since the Folly Beach project began. Most, if not all of the nesting habitat, has been lost. Also, recent studies by the South Carolina Department of Natural Resources indicate that material accumulating in the project borrow area does not appear to be beach compatible material due to the high content of silt and clay material.

With regard to the 1992 Energy and Water Development Appropriations Act, Congress regularly enacts new legislation resulting in numerous federally funded activities. However, activities authorized by such newly enacted legislation must adhere to other statutory requirements unless the legislation specifically exempts the activities from existing statutory requirements.

You are correct in stating that the Corps previously received a Service determination that the Folly Beach project was an allowable activity under section 6(a)(6)(G). However, because of conflicting interpretations regarding section 6(a)(6)(G) in relation to beach renourishment activities within coastal barrier units, the Service requested an interpretation by the Department's Solicitor which resulted in the current statutory interpretation.

Finally, you note that the current statutory interpretation places unexpected financial burdens on both the Federal and non-Federal sponsors of the Folly Beach project. The purposes of the Act are to minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife, and other natural resources associated with units of the System. The Act does not restrict the use of private, State or local government funds for activities within the System. Therefore, implementation of the Act results in a savings of Federal dollars by placing the financial burden on those who chose to invest, live, or conduct development activities within the System, not the American taxpayer. The current statutory requirement only restricts the use of Federal funds for the purpose of removing sand from within the System. Furthermore, it is only the last 4,500 feet of the southwest portion of the total proposed borrow area for the Folly Beach project which is within Unit M07. The remaining unaffected borrow area is 7,170 feet long and 600 feet wide. Therefore, the project is not entirely prohibited and estimated future financial burdens may be inflated.

It is important to note that coastal barrier units include the fastland core of the coastal barrier itself, as well as associated aquatic habitat and the entire sand-sharing system, including the beach, shoreface, and offshore bars. The sand-sharing system of coastal barriers is defined by the 30-foot bathymetric contour. Congress approved this delineation criteria for units of the System in recognition of the important role the sand-sharing system plays in maintaining the dynamic, migratory nature of coastal barriers.

We hope this clarifies the Department's position on this issue. Thank you for your cooperation on this matter.

Sincerely,

/sgn/ George T. Frampton Jr.

George T. Frampton, Jr.
Assistant Secretary for Fish
and Wildlife and Parks

cc: 6229-MIB-ES(1)
6013-MIB-PMO-Secretary's Files
6013-MIB-PMOSecretary's Reading File (2)
6024-MIB-SOL
7456-MIB-PMB
3156-MIB-FW
6242-MIB-CL
6628-MIB-LM
3012-MIB-FWS-Directorate Reading File
3012-MIB-FWS-CCU
3024-MIB-FWS-AES
400-ARLSQ-FWS-DHC
400-ARLSQ-FWS-DHC-BHR

FWS/DHC/BHR:LKelsey:eob:358-2201:3/30/95 - Q:\DHC\kelseyl\Zirschky.ltr
REVISED:AES:MNash:4/3/95

From:	Bohn, Cynthia
To:	Wright, Dana K; Niemi, Katie
Subject:	Fw: [EXTERNAL] RE: CBRA Consultation Teleconference Path Forward
Date:	Monday, February 3, 2020 3:38:32 PM
Attachments:	19980402_ltr_corps_fws_cbra.pdf 19980403_me_fws_cbra_elev.pdf 19990900_brf_corp_cbra position.pdf 20000121_me_rice_moody_cbra.pdf

The 20000121 paper from Tracy Rice is important to read if you have not. She has some discussion on the exemption. C

From: Matthews, Kathryn H <kathryn_matthews@fws.gov>
Sent: Monday, February 3, 2020 12:46 PM
To: Bohn, Cynthia <cynthia_bohn@fws.gov>
Subject: Fw: [EXTERNAL] RE: CBRA Consultation Teleconference Path Forward

---

From: Matthews, Kathryn H <kathryn_matthews@fws.gov>
Sent: Monday, February 3, 2020 11:46 AM
To: Bohn, Cynthia <cynthia_bohn@fws.gov>; Niemi, Katie <katie_niemi@fws.gov>; Wright, Dana K <dana_wright@fws.gov>
Cc: Benjamin, Pete <pete_benjamin@fws.gov>; Wells, Emily N <emily_wells@fws.gov>
Subject: Re: [EXTERNAL] RE: CBRA Consultation Teleconference Path Forward

I really do not think we were ok with it. Emily and I looked through 3 lateral file drawers of correspondence, and there is really no correspondence between our office on CBRA until 1998. You probably have all of these documents, but I am attaching them. Carolina Beach and Wrightsville Beach files have no mention of CBRA to speak of, anywhere. The file with discussion about it is the Masonboro Inlet file, which Emily and I are still working through. However, in the 1995 EA and 1997 FONSI, the Corps states that "Coordination of the EA will fulfill compliance requirements for exception 6(2)." I assume we disagreed, and then a flurry of documents (attached) commenced in 1998.

From: Bohn, Cynthia <cynthia_bohn@fws.gov>
Sent: Monday, January 27, 2020 11:22 AM
To: Niemi, Katie <katie_niemi@fws.gov>; Wright, Dana K <dana_wright@fws.gov>
Cc: Matthews, Kathryn H <kathryn_matthews@fws.gov>; Benjamin, Pete <pete_benjamin@fws.gov>
Subject: Fwd: [EXTERNAL] RE: CBRA Consultation Teleconference Path Forward

Cell: (910) 366-3822

PRIVILEGED COMMUNICATION

-----Original Message-----
From: Bohn, Cynthia [mailto:cynthia_bohn@fws.gov]
Sent: Monday, January 27, 2020 9:49 AM
To: Gasch, Eric K CIV USARMY CESAW (US) <Eric.K.Gasch@usace.army.mil>; Matthews, Kathryn H <kathryn_matthews@fws.gov>
Cc: Benjamin, Pete <pete_benjamin@fws.gov>; Wells, Emily N <emily_wells@fws.gov>; Niemi, Katie <katie_niemi@fws.gov>; Wright, Dana K <dana_wright@fws.gov>; Scerno, Deborah H CIV USARMY CESAD (US) <Deborah.H.Scerno@usace.army.mil>; Gatwood, Elden J CIV CESAW CESAD (US) <Elden.J.Gatwood@usace.army.mil>; Owens, Jennifer L CIV USARMY CESAW (USA) <Jennifer.L.Owens@usace.army.mil>; McCorcle, Justin P CIV USARMY CESAW (USA) <Justin.P.Mccorcle@usace.army.mil>; Pruitt, Carl E Jr CIV USARMY CESAW (USA) <Carl.E.Pruitt@usace.army.mil>; Conner, Kevin B CIV USARMY CESAW (USA) <Kevin.B.Conner@usace.army.mil>; Gager, Steven M CIV USARMY CESAW (USA) <Steven.M.Gager@usace.army.mil>; Medlock, James M (Jim) CIV USARMY CESAW (USA) <James.M.Medlock@usace.army.mil>
Subject: [Non-DoD Source] Re: CBRA Consultation Teleconference Path Forward

b5-DPP [redacted] e can discuss if you like. I think that I may need to seek some counsel on this with the rest of the HQ folks and our solicitor.

Thanks for all your efforts on this, Cindy ________________________________

From: Gasch, Eric K CIV USARMY CESAW (US) <Eric.K.Gasch@usace.army.mil>
Sent: Thursday, January 23, 2020 2:01 PM
To: Matthews, Kathryn H <kathryn_matthews@fws.gov>
Cc: Benjamin, Pete <pete_benjamin@fws.gov>; Wells, Emily N <emily_wells@fws.gov>; Bohn, Cynthia <cynthia_bohn@fws.gov>; Niemi, Katie <katie_niemi@fws.gov>; Wright, Dana K <dana_wright@fws.gov>; Scerno, Deborah H CIV USARMY CESAD (US) <Deborah.H.Scerno@usace.army.mil>; Gatwood, Elden J CIV CESAW CESAD (US) <Elden.J.Gatwood@usace.army.mil>; Owens, Jennifer L CIV USARMY CESAW (USA) <Jennifer.L.Owens@usace.army.mil>; McCorcle, Justin P CIV USARMY CESAW (US) <Justin.P.Mccorcle@usace.army.mil>; Pruitt, Carl E Jr CIV USARMY CESAW (USA) <Carl.E.Pruitt@usace.army.mil>; Conner, Kevin B CIV USARMY CESAW (USA) <Kevin.B.Conner@usace.army.mil>; Gager, Steven M CIV USARMY CESAW (USA) <Steven.M.Gager@usace.army.mil>; Medlock, James M (Jim) CIV USARMY CESAW

(USA) <James.M.Medlock@usace.army.mil>
Subject: [EXTERNAL] CBRA Consultation Teleconference Path Forward

Kathy,

Attached is a memo outlining what was discussed in the January 21, 2020 teleconference. Please review and let me know if I have made any mistakes or have misinterpreted your guidance on how to best complete the Carolina Beach and Wrightsville beach CBRA consultations.

Thank you,

Eric

FILE COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

April 2, 1998

Colonel Terry R. Youngbluth
District Engineer, Wilmington District
U.S. Army Corps of Engineers
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Attention: Brooke Lamson

Dear Colonel Youngbluth:

The U.S. Fish and Wildlife Service (Service) has received your January 26, 1998, letter regarding the proposed "Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina." The Service interprets the proposed activities to be inconsistent with the Coastal Barrier Resources Act (CBRA). Because the Wilmington District (District) has concluded that it does not concur with this position, and because of the significant implications of this dispute between our two agencies, we recommend that the disputed issues be elevated for consideration and resolution.

There appear to be two issues for consideration. First, the District has determined that the "navigation portions" of the project meet the exception at 16 U.S.C. § 3505(a)(2). Second, the District believes that the remainder of the proposed project, the "Shore and Hurricane Wave Protection project" is allowable under 16 U.S.C. § 3505(a)(6)(G). As we have indicated previously, the Service disagrees with both assumptions.

With regard to the first issue, the Service does not concur with the District's claim that the proposed project is associated with the "maintenance of existing channel improvements" such that it would be exempt under § 3505(a)(2) of CBRA. Indeed, this assertion belies the District's own language in the Environmental Assessment and Finding of No Significant Impact, Expansion of the Existing Borrow Area at Masonboro Inlet, Near Wrightsville Beach, New Hanover County, North Carolina (EA/FONSI), dated December 1997. The District states that the December 1997 EA/FONSI is intended to amend the "previously coordinated" EA/FONSI regarding channel realignment and maintenance dredging for Masonboro Inlet. Prior to the December 1997 amendment, the project was characterized as merely moving the channel's centerline northward to

ease the sharp turn that boaters were required to make, and to reduce the erosive currents that appear to be undermining the south jetty. However, the December 1997 EA/FONSI augmented that proposal to encompass expansion and deepening of "the existing borrow area in Masonboro Inlet" for the purpose of obtaining the additional 1,185,000 cubic yards of sand necessary to satisfy the current renourishment needs for Wrightsville Beach and sand bypassing to Masonboro Island. Of the estimated 1.41 million cubic yards of sand needed for the project, only 0.12 million cubic yards will be dredged during the channel realignment phase. The bulk of the material must be dredged from the expanded borrow site. Thus, clearly, the primary scope of the amended project is beach nourishment.

This is further emphasized by the alternatives section of the December 1997 EA/FONSI, which states that opting for the "no-action alternative" would "result in a shortfall of about 670,000 cubic yards of sand for the current renourishment needs of Wrightsville Beach and Masonboro Island." This statement does not reflect that there would be any consequence to the navigation channel or existing channel improvements should this alternative be pursued. Likewise, the second alternative, captioned "Alternative Borrow Areas," focuses on the lack of feasibility of using alternative sources of beach quality sand. Thus, by the District's own terms, the expansion and deepening of the inlet encompassed in the proposed project is not for the purposes of maintaining or improving the existing channel, but to expand the source of beach quality material needed for renourishment. For this reason, the "navigation exception"to CBRA at § 3505(a)(2) is inapplicable to this project.

Furthermore, because the U.S. Army Corps of Engineers (Corps) is undertaking this project to recover sand for beach renourishment, rather than to maintain or improve the existing navigation channel, the Corps may not rely on § 3505(a)(2) to authorize disposal of the dredged materials within the Coastal Barrier Resources System (System). Section 3505(a)(2) allows dredged materials "related to such maintenance or construction" to be disposed within the System. However, because the dredged materials are being mined for renourishment, rather than for channel maintenance, use of the "navigation exception" to authorize disposal of the dredged materials in the System is misplaced.

On the other hand, the Corps may rely upon the "shoreline stabilization" exception at § 3505(a)(6)(G) to justify placement of sand on beaches within the System under certain circumstances. However, the Service does not concur with the District's assertion that the exception also authorizes the proposed renourishment of Wrightsville Beach utilizing sand obtained from within the System. The boundary of System Unit L09 was modified in 1995 to reflect minor and technical changes in the unit's size and location; this office received the revised maps reflecting that change in late summer 1997. Based on those revised maps, it is apparent that almost the entire expanded borrow site is within the System. In correspondence dating back

several years, the Secretary of the Interior has consistently construed the § 3505(a)(6)(G) exception to apply only to projects to stabilize the shoreline of a unit of the System; it does not apply to projects to stabilize shorelines outside the system.

As a general matter, the exceptions to the funding limitations in CBRA apply to projects "within the Coastal Barrier Resources System," not to projects outside the System (16 U.S.C. § 3505(a)). Moreover, the "shoreline stabilization" exception must be considered within the context of the CBRA legislative history which demonstrates that Congress considered Federally-financed shoreline projects wasteful Federal expenditures which have had significant negative effects on fragile coastal barriers, while at the same time encouraging development of those areas. See, for example, *"Statements on Introduced Bills and Joint Resolutions: A Bill to Protect and Conserve Fish and Wildlife Resources, and for Other Purposes," S. 1018, Before Senate Committee on Environment and Public Works*, 97th Congress, 1st Session (1981; Statement of Senator Chafee); H.R. Rep. No. 841, Part 1, 97th congress, 2d Session 7-11 (1982). Because the entire impetus behind CBRA was to place limits on Federal subsidization of activities that negatively impact the natural resources of the designated coastal barrier units, the "shoreline stabilization" exception must be narrowly construed, applying only to projects to stabilize beaches within the System.

Furthermore, the types of projects described in the exceptions enumerated in § 3505(a)(6) are permissible only if the proposed project is "consistent with the purposes of this chapter," 16 U.S.C. § 3505(a)(6), which include minimizing wasteful Federal expenditures and damage to fish, wildlife, and other natural resources associated with coastal barriers by restricting Federal expenditures that have the effect of encouraging development of coastal barriers. Thus, even if the "shoreline stabilization" exception did apply to projects to renourish beaches outside the System, the project would have to be undertaken in furtherance of the purposes of CBRA. It is difficult to imagine how beach nourishment outside the System that does not benefit the beaches within the System could be consistent with these CBRA purposes.

The facts of this situation compel a conclusion that the proposed project is inconsistent with the purposes of CBRA. Here, the borrow area is located almost completely within the System, and the jetties constructed by the Corps inhibit longshore sediment transport across the inlet to Masonboro Island, which is also within the System. A significant sand deficit has severely restricted the plan and profile of the beach on Masonboro Island. The emphasis of the proposed project is being placed on renourishing Wrightsville Beach, while stabilization of "sand-starved" Masonboro Island is being neglected. Clearly, even if the Service construed the "shoreline stabilization" exception as applying to projects to renourish beaches outside the System, these aspects of the District's proposal demonstrate that the exception would be inapplicable because the project is inconsistent with the purposes of CBRA.

We appreciate your consideration of our request to elevate this matter beyond our offices to the next level within our respective organizations. The compelling nature of these issues and their potential impact on future consultations between our agencies merits this action. Please call Kevin Moody of my staff at (919) 856-4520 extension 19 if you have any questions or comments.

Sincerely,

John M. Hefner
Field Supervisor

cc:
DCM, Raleigh, NC (Steve Benton)

bc:
USDOI, SOL, Atlanta, GA (Margaret Fondry)
FWS, Charleston, SC (Ed EuDaly)
FWS, Washington, DC (Steve Glomb)
FWS, Alanta, GA (Ronnie Haynes)

FWS/R4:MFondry:KMoody:KM/04/01/98:919/856-4520 extension 19:\fondry.wpd

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

FILE COPY

In Reply Refer To:
FWS/R4/AES/RANC

April 3, 1998

Memorandum

To: Geographic Assistant Regional Director, Area II, Atlanta, GA

From: Field Supervisor, FWS, Raleigh, NC

Re: Elevating a CBRA Consistency Disagreement for Resolution

Attached for your review is my April 2, 1998 letter to Colonel Youngbluth regarding conflicting interpretations of the CBRA. The Wilmington District recently consulted with this office regarding the consistency of a proposed action with the Coastal Barrier Resources Act (CBRA). Based on a careful reading of the proposal, the law and legislative history, a verbal Solicitor's Opinion, previous consultations in this Region (dating back to 1983), and statements included in the Congressional Record during the introduction of this bill, we concluded that the proposed action was not consistent with the CBRA.

The Wilmington District disagreed with our interpretation, and has commenced work. We believe the issues are global in nature and should be elevated beyond the Field Office/District level. Two issues must be addressed: (1) the consistency of removing material from a System unit for use outside the unit, and (2) the source of terminology used during consistency determinations (i.e., the District relies on the "navigation" exception because the action is partially authorized and funded as a navigation project. However, mobilization, demobilization, the critical funding, and borrow area selection and scope are specifically linked to beach renourishment for a coastal city outside the System; further the authorized dimensions of the navigation channel are significantly less than the proposed borrow sites dimensions.

The first issue was, in our opinion, resolved at the Assistant Secretary level several years ago. However, the District now contends that because the Corps never responded affirmatively (or at all, for that matter), the issue was one of "agreeing to disagree." They do not believe the written determination from the Assistant Secretary has standing. Therefore, we recommend the Regional Director seek a third party to arbitrate this issue.

The CBRA provides the Office of Budget and Management (OMB) an oversight role for all Federal actions in System units. In our opinion, this agency would be the ideal arbitrator for this issue. The CBRA is intended to minimize the loss of human life, wasteful expenditures of Federal revenues, and damage to fish, wildlife, and other natural resources associated with coastal barriers. Section 7 of the CBRA provides that "The Director of the Office of Management and Budget shall... make written certification that each agency has complied with the provisions of this Act [CBRA]." Therefore, we believe that the OMB has a mandate to determine the consistency of Federal actions with the CBRA if there is a disagreement between the Service and any Federal action agency.

Thank you for the opportunity to bring this matter to your attention. We look forward to working with the Region as you pursue this issue with the South Atlantic Division.

FWS/R4:KMoody:KM:04/02/98:919/856-4520 ext. 19:\fondry2.wpd

cc:
FWS, Brian Cole

(b) (5)

[redacted]

[redacted]

(b) (5)

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]

(b) (5)

[redacted]