United States Department of the Interior

FISH AND WILDLIFE SERVICE
Anchorage Fish & Wildlife Field Office
605 West 4th Avenue, Room G-61
Anchorage, Alaska 99501-2249

In reply refer to: AFWFO

April 25, 2011

Mike Bussell, Director
US Environmental Protection Agency
Region 10 Office of Water and Watersheds
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

Re: Biological Opinion on Alaska's Revised Mixing Zone Policy within the Alaska Water Quality Standards (*consultation number 2008-0070*)

Dear Mr. Bussell:

The attached document transmits the U.S. Fish and Wildlife Service's (FWS) April 25, 2011, Final Biological Opinion of the proposed approval of revisions to Alaska's Mixing Zone Regulation section of the Alaska Water Quality Standards and its effects on species and habitats protected by the Endangered Species Act (16 U.S.C. 1531 et seq: 87 stat 884, as amended; ESA). This statewide consultation was initiated by the Environmental Protection Agency (EPA) because of the revisions to the regulation that were proposed by the State of Alaska's Department of Environmental Conservation (ADEC). However, because consultation, pursuant to section 7 of the ESA, had not previously been done on the Mixing Zone Regulation, both the EPA and the FWS agreed that the scope of the action should include the entire regulation, not only the incremental change due to the revisions.

The Biological Opinion, that is the product of this consultation, has earned the distinction of being one of the most complicated and lengthy that has ever been accomplished by the Anchorage Fish and Wildlife Field Office. We have appreciated your patience and cooperation throughout this extensive period, and believe that all of our efforts have resulted in greater assurances that listed species in Alaska will be protected. Other positive consequences of this consultation are the improved collaboration and mutual appreciation for the missions of the primary agencies (i.e., FWS, EPA, and ADEC). Herein, we provide a summary of: 1) the

consultation history for this action, and 2) the findings included in the Biological Opinion. A complete administrative record for this consultation is on file at the Anchorage Fish and Wildlife Field Office, and a full description of the effects analysis is provided in the Biological Opinion (enclosed).

Administrative Record

09/29/06	EPA determination and request for formal consultation;
12/21/06	FWS concurred with preliminary determinations made by EPA, but requested more information;
12/19/07	EPA requested initiation of formal consultation, but did not provide all the requested information;
01/17/08	FWS requested the remainder of the information needed for analysis;
02/05/08	FWS issued letter to EPA verifying that all necessary information had been received and that formal consultation had been initiated;
05/06/08	USFWS requested extension for the statutory 135 day time limit to issue the mixing zones Biological Opinion;
05/14/08	Joint FWS, EPA, ADEC, NMFS meeting at FWS Regional Office;
05/15/08	Polar bear was listed as threatened under the ESA;
06/19/08	FWS received clarification from EPA on the defined "life of project" necessary for analysis;
08/06/08	EPA sent FWS draft DEC mixing zone implementation guidance for review and comment;
08/07/08	FWS sent comments back to EPA;
11/17/08	EPA determined that mixing zones regulation is not likely to adversely affect polar bear;
12/09/08	FWS issued letter of non-concurrence with polar bear determination;
12/29/08	FWS entered into first round of internal review of the Draft Biological Opinion;
01/07/09	FWS entered into second round of internal review of the Draft Biological Opinion;
02/18/09	EPA emailed FWS the final, completed State of Alaska mixing zones implementation guidance dated 02/03/09;
02/23/09	FWS entered into third round of internal review of the Draft Biological Opinion;
03/25/09	Yellow-billed loon added to the ESA candidate list;
03/30/09	FWS entered into final internal review of the Draft Biological Opinion;
04/03/09	FWS issued EPA the Draft Biological Opinion on the mixing zones regulation – without conclusions, for review of the approach, technical information, and justification for conservation concerns regarding Steller's eiders;
10/08/09	Northern sea otter critical habitat designated;
11/05/09	Meeting among agency heads (G. Haskett, FWS; M. Pirzadeh, EPA; L. Hartig, ADEC) and staff to discuss the potential development of a Memorandum of Agreement among FWS, EPA, and ADEC to conserve Steller's eiders associated with mixing zones;
01/14/10	Meeting among agency heads (G. Haskett, FWS; M. Pirzadeh, EPA; L. Hartig, ADEC) to provide updates on status of the development of a Memorandum of Agreement and the Biological Opinion;

03/03/10	Meeting among agency heads (G. Haskett, FWS; M. Pirzadeh, EPA; L. Hartig, ADEC) and staff to discuss Steller's eiders, five harbors of special concern and future information needs;
03/08/10	FWS submitted draft Reasonable and Prudent Measures and Terms and Conditions to EPA for review and comment;
03/25/10	ADEC submitted 3-year permit issuance plan for APDES permits;
04/28/10	EPA recommended modifying Terms and Conditions by moving two items to the Memorandum of Agreement;
11/24/10	Polar bear critical habitat designated;
12/17/10	Memorandum of Agreement was finalized and circulated to agencies;
02/10/11	Pacific walrus added to the ESA candidate list;
04/13/11	FWS received verbal determination from EPA that approval of the mixing zones regulation is not likely to adversely affect yellow-billed loons and pacific walrus;
04/18/11	Memorandum of Agreement among FWS, EPA, and ADEC signed by all parties.

Based primarily on the distribution of their known concentration areas and the prediction of limited overlap with mixing zones, the FWS concurred with EPA's determinations that the State of Alaska's Mixing Zones Regulation and proposed modifications were not likely to adversely affect short-tailed albatross (endangered), yellow-billed loons (candidate) and pacific walrus (candidate). After reviewing all the available information on the Regulation and its proposed modifications (including the April 2011 Memorandum of Agreement among FWS, EPA and ADEC), and considering the best available information on the status, distribution, and life history of the listed species or their critical habitat that may be adversely affected or destroyed by the implementation of the Regulation, it is the Service's Biological Opinion that the action is:

1) not likely to result in measurable adverse affects to northern sea otters (threatened), spectacled eiders (threatened), polar bears (threatened), or Kittlitz's murrelets (candidate) or result in adverse modification of critical habitat designated for them; and
2) likely to adversely affect Steller's eiders (threatened), but is not likely to jeopardize their continued existence or result in adverse modification of critical habitat.

Currently Alaska-breeding Steller's eiders are estimated to number approximately 577 individuals, and we assume that listed population represents 0.8% of the Pacific winter population. Five fishing harbors in Alaska may be ecological traps for Steller's eiders. Ecological traps occur when an animal chooses a habitat that is poor for reproduction and survival (i.e., reduces fitness), but is preferred over other available, high quality habitats. Some mixing zones are attractive to wintering Steller's eiders; they feed within the mixing zone at a greater frequency than expected. Some of those mixing zones occur in waters that are polluted by petroleum hydrocarbons and other toxins such as fecal bacteria. The attraction to some mixing zones puts Steller's eiders at higher risk of exposure to harmful contaminants. The five harbors of concern are: 1) Akutan Harbor; 2) Kodiak-Chiniak Bay; 3) Sand Point Harbor; 4) Chignik Bay; and 5) Unalaska Bay, and they all share the following characteristics:

- winter concentration areas for Steller's eider;
- water bodies where mixing zones permit discharges of seafood processing and/or sewage wastes at levels that exceed Water Quality Standards;

- busy fishing harbors;
- water bodies where accidental petroleum hydrocarbon spills have occurred (Day and Pritchard 2000; ADEC 2008b; U.S. Coast Guard, National Response Center, http://www.nrc.uscg.mil, accessed 12/23/2008);

The FWS anticipates that 36 Steller's eider from the Alaska-breeding population will be taken incidentally, as a result of the Mixing Zone Regulation over the next 30 years. But while the Mixing Zone Regulation fails to protect Steller's eiders from the harmful and adverse effects that result from attraction and indirect exposure to contaminants, greater permitting oversight for mixing zones in the five harbors of concern is expected to improve the situation over time. The Memorandum of Agreement, that was signed by agency leaders from FWS, EPA and ADEC and becomes affective when the revised Mixing Zones Regulation is approved, provides a platform to identify timelines and procedures for agency review of those specific permits and associated data. The purpose of the Memorandum of Agreement is to reduce the risk of harm to Steller's eiders as a result of implementation of the Mixing Zones Regulation.

The enclosed Biological Opinion on the Approval of the State of Alaska's Mixing Zones Regulation Section of the Alaska Water Quality Standards includes Reasonable and Prudent Measures and Terms and Conditions that the FWS believes will minimize the impacts of incidental take to Steller's eiders.

Reasonable and Prudent Measures

The purpose of Reasonable and Prudent Measures is to reduce and minimize take.

- EPA shall use their discretionary authority to eliminate the attraction of Steller's eiders to mixing zones.
- EPA shall use their discretionary authority to minimize the risk of exposure of Steller's eiders to harmful contaminants while they occupy mixing zones.

Terms and Conditions

Terms and Conditions are non-discretionary and must be observed when implementing Reasonable and Prudent Measures.

1. The following terms and conditions shall implement Reasonable and Prudent Measure No.1. "EPA shall use their discretionary authority to eliminate the attraction of Steller's eiders to mixing zones."

1.1 EPA shall fund and/or otherwise engage in efforts to ensure completion of a study of Steller's eider attraction to seafood and municipal waste water treatment plant discharges with an objective to identify the precise pathway of the attraction. EPA shall coordinate with the FWS on study design and implement the study within six months of the issuance of this biological opinion or as soon as possible.

1.2 EPA shall use its discretionary authority, in overseeing the Alaska Department of Environmental Conservation's (ADEC) Alaska Pollutant Discharge Elimination System (APDES) program, to consider the impact of permitted discharges with mixing zones on listed

Steller's eiders in the five harbors of concern identified in the *December 17, 2010, Memorandum of Agreement (MOA) Among USFWS, EPA, and ADEC*. EPA's review shall include ADEC's APDES permitting efforts to reduce or eliminate the attraction of Steller's eiders to mixing zones, and to minimize the risk of exposure of Steller's eiders to harmful contaminants in mixing zones.

1.3 As part of EPA's oversight of ADEC's permit issuance program, EPA will meet with FWS on an annual basis to review upcoming ADEC permits with mixing zones as they pertain to attraction and adverse affects to Steller's eider, and to assess the progress made under the MOA regarding identifying and reducing or eliminating attraction of Steller's eiders to mixing zones. This annual FWS-EPA meeting will be scheduled after FWS has met with ADEC, on an annual basis, to discuss the upcoming ADEC permits with mixing zones and to assess progress under the MOA regarding identifying and reducing or eliminating attraction of Steller's eiders to mixing zones.

2. The following terms and conditions shall implement Reasonable and Prudent Measure No.2. "EPA shall use their discretionary authority to minimize the risk of exposure of Steller's eiders to harmful contaminants while they occupy mixing zones."

2.1 EPA shall use its discretionary authority, in overseeing the Alaska Department of Environmental Conservation's (ADEC) Alaska Pollutant Discharge Elimination System (APDES) program, to consider the impact of permitted discharges with mixing zones on listed Steller's eiders in the five harbors of concern identified in the MOA. EPA's review shall include reviewing ADEC's permits for consistency with 18 AAC 70.240(c)(4)(F) which provides that "...the mixing zone will not adversely affect threatened or endangered species except as authorized under 16 U.S.C. § 1531-§ 1544 (Endangered Species Act)."

2.2 As per the MOA, if EPA determines that a draft APDES permit is not in compliance with Alaska's mixing zone regulation at 18 AAC 70.240(c)(4)(F), EPA intends to use its discretion under the Clean Water Act to formally object to the proposed permit as per the procedures outlined in the NPDES Memorandum of Agreement (October 29, 2008) between the State of Alaska and EPA.

2.3 As part of EPA's oversight of ADEC's permit issuance program, EPA will work with ADEC to avoid adverse affects to Steller's eiders in the five harbors of concern. In accordance with the MOA Section V. F, EPA will consider FWS's written comments to ADEC, ADEC's written responses to comments, and the proposed permit conditions. As appropriate, and on a permit by permit basis, the EPA may recommend the following permit conditions to avoid adverse effects to Steller's eiders:

2.3.1. Permits shall not authorize mixing zones for fecal coliforms or other pathogenic bacteria when there is a potential for interaction or comingling with other discharges that cause Steller's eider attraction;

2.3.2. Permits with mixing zones that are suspected to cause attraction to Steller's eiders shall include regular monitoring for bioaccumulative pollutants, fecal coliform bacteria and petroleum hydrocarbon pollutants both inside and outside mixing zone;

2.3.3. Permits with mixing zones that are suspected to cause attraction to Steller's eiders shall include requirements to sample and analyze the invertebrate biota inhabiting mixing zones to assess potential biomagnification for pollutants of concern (bioaccumulative pollutants, bacteria, and petroleum hydrocarbons) in Steller's eider's prey.

Furthermore, to aid the EPA in their efforts to utilize their authorities to carry out programs for the conservation of threatened and endangered species, as directed in section 7(a)1 of the ESA, we offer the following, discretionary Conservation Recommendations :

1. EPA should play a strong role in recovery efforts for the Alaska breeding population of Steller's eider. EPA should provide funding to the FWS or the Alaska SeaLife Center (or other suitable entity) toward the Steller's eider reintroduction/augmentation program. Increased funding should compensate for lost breeding potential of individual Steller's eiders taken as a result of the mixing zones regulation.
2. Dischargers should not be authorized to exceed WQS for bioaccumulative pollutants (i.e., mercury, and 2,3,7,8-TCDD in a mixing zone where any listed species occur.
3. Dischargers should not be authorized to exceed WQS for petroleum hydrocarbons and cadmium in a mixing zone where any listed species occur.
4. Within the range of listed species, studies should validate the extent and performance of each mixing zone before a permit is reissued for that mixing zone.
5. EPA should ensure that permits and mixing zone regulations are properly enforced.

The enclosed document concludes formal consultation on Alaska's Revised Mixing Zone Policy within the Alaska Water Quality Standards. 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 retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the Biological Opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

In closing, we thank you for your cooperation in meeting our joint responsibilities under section 7 of the ESA. If you have any questions concerning this Biological Opinion, please contact me at (907) 271-2787, or Ellen Lance, AFWFO Endangered Species Branch Chief, at (907) 271-1467.

Sincerely,

Ann G. Rappoport
Field Supervisor

Enclosure
cc: William Beckwith, EPA
C:\Documents and Settings\ellenlance\Desktop\2008-0070_mixing zones cover letter.doc

BIOLOGICAL OPINION

For

Approval of the State of Alaska's Mixing Zones Regulation Section of the Alaska Water Quality Standards

Consultation with the
U.S. Environmental Protection Agency
Seattle, Washington

Prepared by:
Anchorage Fish and Wildlife Field Office
U. S. Fish and Wildlife Service
605 West 4th Ave., Rm G61
Anchorage, Alaska

April 25, 2011

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BIOLOGICAL OPINION
For
Approval of the State of Alaska's Mixing Zones Regulation Section of the Alaska Water Quality Standards

DESCRIPTION OF THE PROPOSED ACTION

The U.S. Environmental Protection Agency (EPA) is proposing to approve revisions to Alaska's Mixing Zone Regulation (MZR) section (18 AAC 70.240) of the Alaska Water Quality Standards (18 AAC 70; WQS). Alaska originally adopted, and EPA approved, the State's MZR in 1979. The MZR has been revised several times since 1979. The EPA has not previously consulted with the U.S. Fish and Wildlife Service (FWS) on the State's MZR under §7(a)(2) of the Endangered Species Act (16 U.S.C. 1531 et seq; ESA), and are vulnerable to violating §9 of the ESA if take of a listed species occurs as a result of permitted mixing zones. While the consultation was initiated because of the revisions to the regulation proposed by the State of Alaska, both the EPA and the FWS agree that, for this consultation, the scope of the action should include the entire MZR, not just the incremental change due to the revisions.

The State of Alaska's Department of Environmental Conservation (ADEC) revised the MZR and adopted it into State Law on March 23, 2006; the regulation was published in Register 177 (April 2006). By letter dated August 14, 2006, ADEC formally submitted the newly adopted MZR to EPA for approval.

The Clean Water Act (33 U.S.C. 1251 et seq; CWA) provides the statutory basis for the Water Quality Standards (WQS) program and defines broad water quality goals. Section 303(c) of the CWA requires that all states adopt WQS and that EPA review and approve these standards. EPA is to review and take action on the submitted standards within 60 days (approval) or 90 days (disapproval). The regulatory requirements governing WQS are established at 40 C.F.R. Part 131.

EPA's WQS regulation (CWA Section 301(b)(1)(C)) allows states to adopt provisions authorizing mixing zones (EPA 1996). Mixing zones are areas where an effluent discharge undergoes initial dilution and which is extended to cover the secondary mixing in the ambient water body (Figure 1). A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented (EPA 1991). Chronic standards for specific parameters designated by the State may be exceeded in the mixing zone, but acute criteria must generally be met within the mixing zone. A smaller area inside the mixing zone, identified as the zone of initial dilution (also called initial mixing or acute zone; ZID) in the State of Alaska's Draft Implementation Guidance for Mixing Zones (ADEC 2005), is an area in which acute WQS may be exceeded. In summary, chronic WQS must be met at the edge of the mixing zone, and acute WQS must be met at the edge of the ZID (within the mixing zone). If mixing zones were not allowed, discharges would be required to meet chronic WQS at the point of discharge.

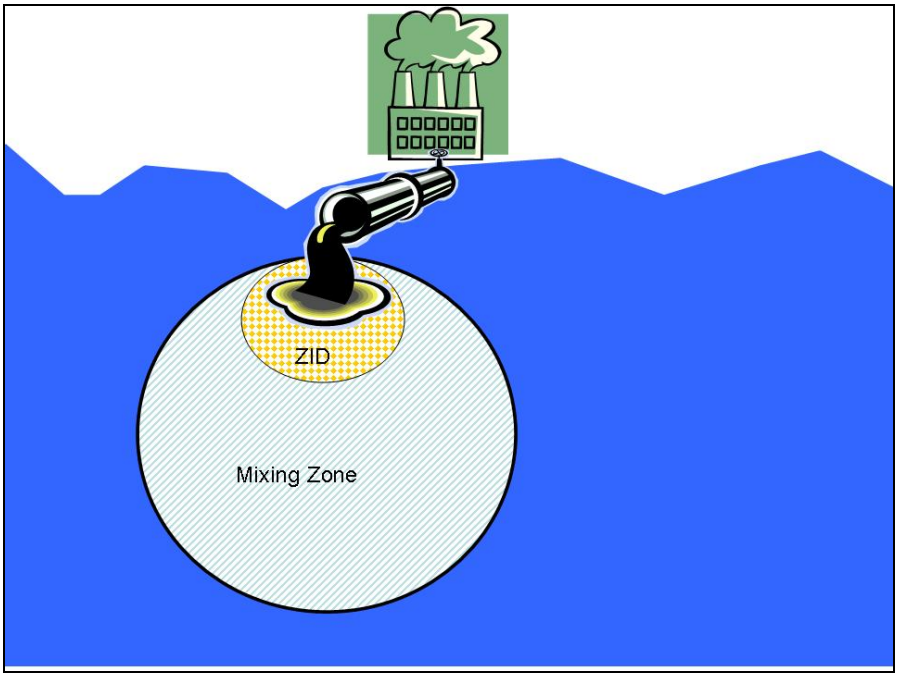

Figure 1. A characterization of a mixing zone that includes a zone of initial dilution (ZID). CWA chronic standards must be met outside the mixing zone.

EPA has promulgated regulations which provide that States may, at their discretion, include in their WQS "policies generally affecting their application and implementation, such as mixing zones, low flows, and variances" 40 C.F.R. §131.13. Policies such as mixing zone provisions that govern the implementation of WQS are inseparable from the standards themselves, except that policy changes do not require a public review as do regulations. When States do include such policies as part of their standards, then the policies are subject to EPA review and approval. EPA reviews such policies to determine if they are: 1) compatible with the State's WQS; 2) technically well founded; and 3) consistent with the CWA.

EPA provides guidance to the State for developing policy on mixing zones (EPA 1991, 1996). This guidance, which is non-regulatory, explains that it is not always necessary to follow the guidance to meet all water quality criteria intended to protect the integrity of the water body as a whole. EPA's guidance for the development of mixing zone policy points out several important elements that may be appropriate for States to include. Those elements that have potential relevance to threatened or endangered species and their critical habitat include: 1) mixing zone size limitations; 2) in-zone quality; 3) protection of sensitive areas; 4) prohibition of certain pollutants; and 5) protection of designated uses.

According to ADEC, the proposed revisions to the MZR provide for the consideration of measures that would mitigate the potential adverse effects of mixing zones on aquatic resources. Those considerations include:
1. expansion of the prohibition on mixing zones to include lakes;
2. exemptions to the prohibition on mixing zones in fish spawning habitat;
3. reorganization of the MZR to improve clarity and reduce redundancy;

4. simplification of some technical provisions including those dealing with risk assessment, flow calculations, and mixing zone models; and
5. update of a reference to federal technology based effluent limitations.

EPA's proposed approval of the State of Alaska's adopted MZR, and the determination that approval and implementation of this regulation may adversely affect listed species, provides the nexus for consultation under §7(a)(2) of the ESA. Because mixing zones may be permitted statewide, this consultation considers all ESA-protected species with the potential for exposure to mixing zones in Alaska. The EPA determined that this regulation is not likely to adversely affect the endangered short-tailed albatross (*Phoebastria albatrus*), or two candidate species, the yellow-billed loon (*Gavia adamsii*) and the Pacific walrus (*Odobenus rosmarus*). The FWS concurred with that determination due to the low probability that these species will be exposed to mixing zones based on their distributions.

EPA's determination that the MZR may affect and is likely to adversely affect: 1) the Alaska breeding population of Steller's eider (*Polysticta stelleri*); 2) spectacled eider (*Somateria fischeri*); 3) the southwest distinct population segment (DPS) of northern sea otter (*Enhydra lutra kenyoni*); 4) polar bear (*Ursus maritimus*); and 5) Kittlitz's murrelet (*Brachyramphus brevirostris*) has resulted in lengthy consultation since 2006 (see administrative record). Through the consultation process, a Memorandum of Agreement (MOA) was developed specifically to address avoidance of adverse effects to Steller's eiders in five specific marine waterbodies: 1) portions of Unalaska Bay, Amaknak and Unalaska islands (Dutch Harbor and the City of Unalaska); 2) Humbolt Harbor-Popof Strait, Popof (Sand Point); 3) St. Paul Harbor, Kodiak Island (Kodiak City); 4) Akutan Harbor, Akutan Island (Village of Akutan); and 5) Anchorage Bay, Chignik. The MOA, signed by FWS, EPA and ADEC, outlines the roles and responsibilities of each agency to assure that Steller's eiders are protected from harm, particularly where they concentrate during winter and industrial waste is discharged (Appendix I). This MOA has been incorporated into the action of EPA's approval of the MZR.

STATUS OF THE SPECIES

This section, which can be found in Appendices II-VI, includes detailed life history information on each of 5 species that are likely to be affected by the action: 1) Steller's eider (page 98); 2) spectacled eider (page 118); 3) southwest DPS of northern sea otter (page 132); 4) polar bear (page 144); and 5) Kittlitz's murrelet (page 154), a candidate species. It includes descriptions of the listed entity, as well as their demographics, distributions, population dynamics, status and threats. Much of the information provided in this section was used to establish the environmental baseline and to analyze effects of the action considered in this biological opinion. We suggest first reading Appendices II-VI before continuing on to the Environmental Baseline section below. But, in lieu of that, we recommend that the reader refer to the appropriate Status of the Species section when considering the baseline, the affects of the action, and cumulative effects for that species.

ASSUMPTIONS USED IN ANALYSES OF PAST, PRESENT AND FUTURE EFFECTS

Proportion of Wintering Steller's Eiders from Listed Population

Because not all Pacific wintering Steller's eiders are from the listed population, and because there is currently no way to validate which of the Pacific wintering Steller's eiders breed in

North America, we assume that 0.8% of all Steller's eiders occurring on the wintering grounds in Alaska is from the listed Alaska breeding population. This estimate is derived by taking the most recent North Slope breeding bird estimate (576; Stehn and Platte 2009), adding 1 for the Y-K Delta population (=577), and then dividing by the population estimate of Pacific-wintering Steller's eiders from 2010 (73,904; Larned and Bollinger 2011. Thus, 577 ÷ 73,904= (0.0078 * 100) = 0.8%.

Effects of Chronic Exposure to Petroleum Hydrocarbons

For Steller's eiders using marine waters in which there is a high probability of petroleum hydrocarbon contamination (Day and Pritchard 2000, ADEC 2007), we estimate that survivorship is reduced by 5.7% annually as a result of chronic exposure. This assumption is based on results from a comparative study of adult female harlequin ducks (*Histrionicus histrionicus*) inhabiting oiled verses unoiled bays, more than 6 years after the *Exxon Valdez* oil spill (Esler et al. 2000).

We use this reduction in survivorship estimate for harlequin ducks as a proxy because we lack the specific data to assess effects of chronic petroleum hydrocarbon exposure on Steller's eiders. Even with the recognition of the uncertainties and problems inherent with interspecific extrapolation of toxicological responses, the practice of using exposure assessment values from a tested species and extrapolating among other species is widely accepted for toxicological analyses (e.g., Sample and Arenal 1999; Fabricio et al. 2007; Hickie et al. 2007). In fact, this technique was applied by EPA in the Biological Evaluation for this Opinion. Extrapolation of adult female harlequin duck survivorship estimates for the purposes of estimating impacts of chronic exposure of petroleum hydrocarbons on Steller's eiders is built upon the following assumptions: 1) the level of exposure is the same; 2) the frequency of exposure is the same; 3) the toxicity of the petroleum hydrocarbons is the same; and 4) the response of Steller's eiders and harlequin ducks, if exposed similarly to petroleum hydrocarbons, is the same.

Because of their physiological and ecological similarities, we believe that harlequin ducks are an adequate proxy for Steller's eiders. Harelquin ducks are similar in size, have similar thermodynamic thresholds, and feed on similar prey (Goudie and Ankney 1986). Additionally, harlequin ducks and Steller's eiders may be derived from a shared ancestrial lineage (Livezey 1995). However, we acknowledge the following inconsistancies: 1) P450 induction rates are dissimilar between species (for further explanation see paragraph below); 2) when comparing exposure between the acute *Exxon-Valdez* oil spill and chronic fuel spills, biochemical composition of the spilled petroleum products and exposure rates of the birds to petroleum hydrocarbons are likely dissimilar.

Cytochrome P450s are enzymes produced in the liver that play important roles in the metabolism and excretion of environmental chemicals and other foreign substances (Tomkins and Wallace 2007). Research indicates that Steller's eiders and harlequin ducks inhabiting waters proximate to each other have differential biochemical responses when exposed to petroleum hydrocarbons (Miles et al. 2007). Although biochemical activity is increased in both species, the magnitude of the response is higher in harlequin ducks. This difference may be due to dissimilar foraging habits; harlequin ducks sometimes inhabit more nearshore waters than do Steller's eiders,

although the two species often overlap (Miles et al. 2007). Alternatively, differential P450 induction rates may be due to species-specific genetic differences (Tomkins and Wallace 2007).

In both Steller's eiders and harlequin ducks, population growth is most sensitive to adult, female survivorship (Runge 2004; Swem and Matz 2009; Esler et al. 2000). Hence, research efforts focused on estimating survivorship of adult female harlequin ducks that were chronically exposed to *Exxon-Valdez* oil in Prince William Sound. But, because we lack the data to quantify the proportion of male, female, adult, and juvenile Steller's eiders on their wintering grounds, we assume that both sexes and all age classes of Steller's eiders are affected similarly by exposure to petroleum hydrocarbons. Both male and female harlequin ducks are highly philopatric to their wintering grounds (Robertson 1997). Flint et al. (2000) documented that both sexes of Steller's eider are highly philopatric to their molting areas, but we lack specific information to conclude that they are also philopatric to their wintering grounds. Thus, we assume that, like harlequin ducks, Steller's eiders return to the same wintering areas year after year, and those that winter in contaminated areas are chronically exposed to contaminants.

Research following the *Exxon-Valdez* oil spill (Short et al. 2006) indicates that much of the oil remaining from the 1989 oil spill is trapped in the intertidal areas likely to be inhabited by harlequin ducks. While we acknowledge that the periodic releases of hydrocarbons from oiled beaches in Prince William Sound (PWS) may differ biochemically from the periodic releases of hydrocarbons from fishing vessels and refueling spills, we assume that the exposure rate and net effect is the same. Factually however, weathered, *Exxon-Valdez* crude oil degrading in the environment for several years post-spill differs from petroleum products in the majority of spills in and around boat harbors. Weathered crude oil is more persistent but less toxic than recently spilled gasoline and diesel fuels, which contain high proportions of toxic aromatic compounds (Stout 1998). Gasoline and diesel fuels dissipate more quickly than crude oil, so it is less likely that Steller's eiders would be chronically exposed to these compounds from a single event. However, as we explain below, smaller spills occur with regularity in some Steller's eider wintering areas so it is plausible that Steller's eiders are frequently exposed to these less weathered, more toxic constituents.

Patterns of Petroleum Hydrocarbon Releases

Day and Pritchard (2000) compiled existing information on fuel spills within the range of Pacific wintering Steller's eiders in Alaska. Their summary primarily focused on fuel spills at 10 harbors in the northern Gulf of Alaska and the Bering Sea, between January 1990 and November 1999. Their conclusions provide the basis for the following assumptions regarding future patterns of petroleum releases within harbors (expanded to include the entire action area, as defined below):

- Spills are reasonably certain to occur at harbors and boat moorages;
- Spills occur at both large and small harbors;
- Chronic discharges occur in greater frequency than acute releases;
- Underreporting of chronic discharges occurs at all locations; and
- Marine waters are most affected when spills occur.

ENVIRONMENTAL BASELINE

The environmental baseline, as described in section 7 regulations (50 CFR §402.02) includes the past and present impacts of all Federal, State, or private actions and other human activities in the

action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process.

Determination of Action Area

The proposed federal action that is the subject of this biological opinion is EPA's approval of revisions to the section of State of Alaska's WQS addressing mixing zones. Under the CWA, State WQS apply to surface waters within State boundaries. State boundaries correspond with the territorial seas of the United States as that term is defined under the statute. Territorial sea is defined as "the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three miles," CWA section 502(8). The line of ordinary low water and the line marking the seaward limit of inland waters are also known as "baseline." Thus, because mixing zones could potentially be authorized in a wide variety of fresh and marine waters, the scope of the regulation potentially includes all surface waters of the State and marine waters within State boundaries up to 3 nautical miles (nm) from baseline. EPA's proposed approval action does not apply to, and thus the action area of this consultation does not include, any waters within Indian Country (as defined in 18 USC 1151).

Factors Affecting Species' Environment in the Action Area

This analysis describes factors affecting the environment of the species or critical habitat in the action area.

Incidental Take - Research

The FWS has issued permits under Section 10 of the ESA to authorize take of endangered or threatened species for purposes of enhancement of propagation or survival. Annual reporting requirements associated with §10 permits for both spectacled (Table 1a) and Steller's eiders (Table 1b) reveal that 11 spectacled eider adults and 5 eggs have reportedly died as an indirect result of research activities since 1993[1]. Since listing, 130 direct and <u>intentional</u> takings of spectacled eider adults have been permitted, but only 40 have actually occurred (not accounted for in Table 1a).

It was sometimes unclear if the 0.8% correction factor for listed Steller's eiders was used when permits were issued for the incidental take of individuals from the Pacific wintering population. As noted in the description of assumptions (see page 6), we assume that 0.8% of Pacific wintering Steller's eiders are also from the listed North American breeding population. When it was suspected that a correction factor was not used for incidental take within the marine, non-breeding distribution of Steller's eiders, we applied a 0.8% correction factor to the numbers of individuals, and reported those results. A total of 37 Steller's eiders were reported as actually taken, incidental to research activities, from 1997 to present. Because those birds were all from the wintering population, we applied the correction factor and determined that approximately 1 bird from the Alaska breeding population has died incidental to research activities. Since listing,

[1] Due to the numerous amended actions and permits, and because of the variation and inconsistencies in reporting, accomplishing a precise tally of incidental take proved difficult.

there have been 16 permitted and 16 actual, direct and intentional takings of Steller's eider adults on the wintering grounds. Thus, it is unlikely that any of those individuals were from the North American breeding population (i.e., 16 * 0.008 = 0.128). Additionally, permits have been issued to salvage and opportunistically collect up to 68 Steller's eider eggs from the North American breeding population for a captive breeding program at the Alaska SeaLife Center (ASLC). To date 31 eggs have been taken.

Since their listing, the lethal, incidental take of 1 sea otter has been permitted. There has been no lethal, incidental take authorized for polar bears.

Incidental Take - Other Federal Actions (other than §10 research permits)
Since listing, permits have been issued for the incidental, lethal take of 1251 spectacled eiders (Table 2a) and less than 78 Alaska breeding Steller's eiders (Table 2b). Although reporting is required upon issuance of an incidental take permit, it is not consistently provided by permittees so we do not know how many eiders have actually died as a result of these actions. We consider lethal take more severe than take from disturbance or habitat loss.

To date, there has been no lethal incidental take permitted for the southwest DPS of northern sea otter (beyond one individual under §10 for research) or the polar bear.

Hunting
In 2003, the FWS proposed to open a spring/summer harvest of migratory birds, allowed under the amended treaty protocols with Canada and the United Mexican States. The harvest has occurred within the constraints imposed by the treaties and to the extent possible, legalizes the customary and traditional subsistence harvest practices of Alaskan indigenous inhabitants. The term "indigenous" has been interpreted to mean all permanent rural inhabitants. Subsistence harvest areas have been defined to include most village areas within the Alaska Peninsula, Kodiak Archipelago, the Aleutian Islands, and areas north and west of the Alaska Range. Hunting for spectacled and Steller's eiders was closed in 1991 by Alaska State regulations and FWS policy. There is no subsistence harvest permitted for the listed eiders in Alaska, but accidental and/or intentional shooting of adult breeding and non-breeding Steller's eiders and spectacled eiders has been estimated using surveys (ADF&G 2008; FWS 2008a), and has been documented in the field (FWS, Fairbanks Fish and Wildlife Field Office, Unpublished Data).

The number of harvested, listed-eiders reportedly taken on the North Slope in 2005 was nine Steller's eiders and 33 spectacled eiders. But, based on extrapolated survey data, the estimates of subsistence harvest for that year on the North Slope were 18.72 (9-37 95% CI) Steller's eiders and 34.5 (33-39.5 95% CI) spectacled eiders (FWS 2008a). Crippling loss may have also occurred that year, but it was not estimated (USFWS 2008a). Thus, we suspect that field observations of hunter-killed Steller's and spectacled eiders may be an underestimate of the actual amount of harvest that is occurring. Another extrapolated survey for the spring, summer and fall substance harvest in various subregions in Alaska during 2007 estimates that 165 Steller's eiders (36 from the North Slope during spring and summer) and 1069 spectacled eiders were killed (ADF&G 2008). Illegal harvest of Steller's eiders was confirmed in 2008, when law enforcement officers documented 20 Steller's eiders that had been shot near Barrow on the North Slope (FWS, Fairbanks Fish and Wildlife Field Office, Unpublished Data).

Table 1a. Incidental (i.e., unintentional), lethal take permitted by the FWS for spectacled eiders under §10 of the ESA.

	1993	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Adult	11	3	0	0	80	11	87	3	4	3	3	44	4	84	4	8
Chick	10	6	0	0	0	9	5	9	14	9	9	10	10	10	0	7
Egg	73	15	0	0	0	0	80	15	35	20	20	23	23	150	130	268
Nest	0	0	0	0	0	0	12	8	20	10	12	19	13	0	0	16

Table 1b. Incidental (i.e., unintentional), lethal take permitted by the FWS for Steller's eiders under §10 of the ESA.

	1997	1998	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Adult	965	12	18	26	29	16	14	24	28	18	25	0	3
Chick	5	4	5	19	7	7	7	7	7	7	0	0	7
Egg	0	0	108	114	0	24	24	24	44	20	0	0	0
Nest	0	0	0	20	3	3	3	5	5	5	2	0	<1

Table 2a. Incidental take permitted as per section 7 consultation for spectacled eiders from 1993 to present.

Action	Incidental Take Type	Estimated Take	Life Stage	Lethal Y/N
Alpine Development Project - 2004	Habitat Loss	4	Eggs/Chicks	N
Alpine Development Project - 2004	Collisions	3	Adults	Y
Barrow Airport Expansion - 2006	Habitat Loss	14	Eggs/Chicks	N
Barrow Hospital – 2004 & 2007	Habitat Loss	2	Eggs/Chicks	N
Barrow Landfill - 2003	Habitat Loss	1	Nest/y for 45 y	N
Barrow Tundra Manipulation Exp.- 2005	Habitat Loss	2	Eggs/Chicks	N
Barrow Tundra Manipulation Exp. -2005	Collisions	2	Adults	Y
Barrow Global Climate Change Research Facility Phase 1 & 2 – 2005 & 2007	Habitat Loss	6	Eggs/Chicks	N
Barrow Global Climate Change Research Facility Phase 1 & 2 – 2005 & 2007	Collisions	1	Adults	Y
Barrow Wastewater Treatment - 2005	Habitat Loss	3	Eggs/Chicks	N
Beaufort Sea Planning Area Lease Sale 186, 195, & 202 - 2002	Collisions	5	Adults	Y
Chukchi Sea LS 193 - 2007	Collisions	3	Adults	Y
Pioneer's Oooguruk Project - 2006	Habitat Loss	3	Eggs/Chicks	N
Pioneer's Oooguruk Project - 2006	Collisions	3	Adults	Y
BP's 69Kv Powerline - 2006	Collisions	10	Adults	Y
BP's Liberty Project - 2007	Habitat Loss	2	Eggs/Chicks	N
BP's Liberty Project - 2007	Collisions	1	Adult	Y
KMG Nikaitchuq Project - 2006	Habitat Loss	2	Eggs/Chicks	N
BLM Summer Activities, NPR-A – 2007	Disturbance	21	Eggs/Chicks	N
BLM Summer Activities, NPR-A – 2008	Disturbance	56	Eggs/Chicks	N
BLM Summer Activities, NPR-A – 2009	Disturbance	49	Eggs/Chicks	N
BLM Northern NPR-A - 2008	Disturbance	87	Eggs/Chicks/y for 100 y	N
BLM 2008 Northern (NE and NW) NPR-A – 2008	Collisions	6	Adult/y for 100 y	Y
Savoonga wind turbine - 2005	Collisions	1	Adults	Y
FWS Subsistence Harvest Regs-2005	Harvest	31	Adults	Y
FWS Subsistence Harvest Regs -2006	Harvest	179	Adults	Y
NOAA National Weather Service Office in Barrow	Habitat Loss	< 4	Eggs/Chicks	N
MMS Beaufort and Chukchi Sea Program Area Lease Sales-2009	Collision	12	Adults	Y
BLM North Slope Activities -2010	Disturbance	32	Eggs	N
FWS Goose Banding -2010	Disturbance	4	Eggs/Chicks	N
FWS Subsistence Harvest Regs -2011	Harvest	400	Adult	Y

Table 2b. Incidental take permitted as per section 7 consultation for Steller's eiders from 1997 to present.

Action	Incidental Take Type	Estimated Take	Life Stage	Lethal Y/N
Barrow Airport Expansion - 2006	Habitat Loss	29	Eggs/Chicks	N
Barrow Hospital – 2004 & 2007	Habitat Loss	17	Eggs/Chicks	N
Barrow Landfill - 2003	Habitat Loss	1	Nest/y for 45 y	N
Barrow Tundra Manipulation Exp. - 2005	Habitat Loss	1	Eggs/Chicks	N
Barrow Tundra Manipulation Exp. - 2005	Collisions	2	Adults	Y
Barrow Global Climate Change Research Facility Phase 1 & 2 – 2005 & 2007	Habitat Loss	25	Eggs/Chicks	N
Barrow Global Climate Change Research Facility Phase 1 & 2 – 2005 & 2007	Collisions	1	Adults	Y
Barrow Wastewater Treatment - 2005	Habitat Loss	3	Eggs/Chicks	N
Beaufort Sea Planning Area Lease Sale 186, 195, & 202 - 2002	Collisions	1	Adults	Y
Chukchi Sea Lease Sale 193 - 2007	Collisions	1	Adults	Y
BLM Northern NPR-A - 2008	Disturbance	8	Eggs/Chicks/y for 100 y	N
BLM Northern NPR-A - 2008	Collisions	0.2	Adult/y for 100 y	Y
False Pass Harbor - 2001	Contaminants	4	Adults	N
Chignik Lagoon Tank Farm - 2001	Contaminants	14	Adults	N
Chignik Dock - 2002	Contaminants	4	Adults	N
Chignik Bay Tank Farm -2002	Contaminants	5	Adults	N
Fairweather Seismic - 2003	Disturbance	66	Adults	N
Nelson Lagoon Tank Farm - 2003	Contaminants	20	Adults	N
Nelson Lagoon Tank Farm - 2003	Collisions	1	Adults	Y
Akutan Transportation - 2007	Disturbance	20	Adults	N
Akutan Mooring Basin - 2003	Contaminants	9	Adults	N
Akutan Mooring Basin - 2003	Collisions	1	Adults	Y
Unalaska harbor - 2007	Habitat Loss	1	Adults	N
Unalaska harbor - 2007	Contaminants	1	Adults	N
Unalaska harbor - 2007	Collisions	1	Adults	Y
Goodnews Bay Processor - 2008	Disturbance	28	Adults	N
NPDES-GP - 2001	Collisions	1	Adults	Y
Sandpoint Harbor - 2002	Contaminants	11	Adults	Y
Sandpoint Harbor - 2002	Collisions	1	Adults	Y
Sandpoint Harbor -2002	Habitat Loss	1	Adults	N
FWS Sport-harvest Regs - 2006	Harvest	1	Adults	Y
FWS Subsistence Harvest Regs-2005	Harvest	17	Adults	Y
FWS Subsistence Harvest Regs-2006	Harvest	14	Adults	Y
NOAA National Weather Service Office in Barrow	Collisions	1	Adults	Y
MMS Beaufort and Chukchi Sea Program Area Lease Sales-2009	Collision	<1	Adults	Y
FWS Subsistence Harvest Regs -2011	Harvest	4	Adult	Y

The estimated harvest of adult Steller's eiders on the North Slope is of particular concern due to the current status of the Alaska-breeding Steller's eiders (only several hundred Steller's eiders are thought to attempt to breed on the North Slope). Any Steller's eiders killed on the North Slope during the spring/summer harvest represent potential breeding adults of the listed Alaska-breeding population. Due to increased concern about the shooting of Steller's eiders on their breeding grounds, the FWS along with local governments have recently established new measures to protect these birds during the hunting seasons (FWS 2009). The FWS continues to use adaptive management strategies with local governments and hunters to reduce harvest of listed eiders. Education, communication, and outreach efforts are ongoing, and routine monitoring should verify that listed eiders are not being shot.

To our knowledge, Kittlitz's murrelets are not hunted. Sea otters can be hunted for subsistence purposes under strict harvest regulations (see page 140), which are governed by a co-management council.

For most populations, particularly those in North America, harvesting polar bears is a regulated activity. In most jurisdictions, the total numbers of bears killed by humans in pursuit of sport and subsistence hunting, accident, and in defense-of-life-or-property are documented. Sport hunting of polar bears is illegal in Alaska. Legal harvesting activities within the Chukchi population are currently restricted to Inuit in western Alaska. In Alaska, average annual polar bear harvest declined by approximately 50% between the 1980s and the 1990s (Schliebe et al. 1998) and has remained low in recent years. The southern Beaufort Sea population is managed under a 1988 agreement between the Inuvialuit Game Council of Canada, and the North Slope Borough of Alaska. This agreement has been successful in ensuring that the total harvest and the proportion of the harvest comprised of adult females, remains within sustainable limits (Schliebe et al. 2006b)

Petroleum Hydrocarbons

Vessel Discharges -- Species addressed in this consultation are considered at risk for acute and chronic exposure to spilled petroleum compounds. Steller's eiders, sea otters, and Kittlitz's murrelets are of greatest concern due to their association with the near-shore habitats of the Aleutians and Alaska Peninsula. Accidental petroleum releases can adversely affect Steller's eiders and otters through contamination of feathers and fur, direct consumption of petroleum (e.g., during preening and grooming), contamination of food resources, or reduction in prey availability, and can result in reduced survivorship and subsequent population declines (NOAA 1996; Ballachey et al. 2000b; Esler et al. 2000). Degradation of habitat due to chronic exposure to petroleum compounds is difficult to quantify.

An estimated 65% of petroleum released into marine waters is due to chronic discharges, and the remaining 35% from massive spills (Maccarone and Brzorad 1994). Contaminated bilge water discharged from vessels represents a source of chronic exposure to petroleum compounds, and accounted for 2% of all measured material spilled in Alaskan waters (Day and Prichard 2000). Diesel fuel accounted for 89% of all measured material spilled and 68% of all spills of known type; thus, we conclude that diesel fuel constitutes the majority of material likely to be spilled at harbors and associated facilities.

Both the number of spills and the amount of material spilled were found to be greatest at Alaska's three busiest fishing harbors (Akutan Harbor, Dutch Harbor/Unalaska, and St. Paul Island). Between 1990 and 1999, a total of 11,444.5 gallons were reported spilled at Akutan Harbor in 35 separate spills (Day and Pritchard 2000). The greatest number of spills and amount of material spilled across 10 potentially expanding harbors resulted primarily from operator error (49% of all spills with known cause) and, secondarily from equipment failure (34%; Day and Pritchard 2000). Most releases appeared to occur during refueling operations. Fueling stations represented a significant source of chronic petroleum contamination.

Small oil spills frequently occur in marine habitat within the range of Kittlitz's murrelets. From 1995 through August 2005, at least 1,923 small fuel spills from vessels resulted in the release of more than 271,700 gallons of petroleum hydrocarbons in Alaska waters (ADEC, Anchorage, Alaska, Unpublished Data, 2005). Ninety percent of those spills occurred within the range of Kittlitz's murrelets. Additionally, cruise ships and recreational boating activity is increasing in glaciated fjords within Glacier Bay and Prince William Sound (PWS), in the habitats that are most important to Kittlitz's murrelets (Day et al. 1999; Murphy et al. 2004). Recreational boating in northern PWS is expected to increase 45-fold over 15 years as a result of better access to harbors (Murphy et al. 2004). As vessel traffic increases, so does the threat of petroleum contamination from both accidental spills and routine vessel operation.

Bulk Fuel Facilities -- While upgrades to bulk fuel facilities greatly decrease the likelihood of catastrophic spills and reduce chronic contamination originating at bulk fuel storage facilities, listed species occupying habitat in the vicinity of these facilities are at continued risk of acute and chronic exposure to spilled, petroleum hydrocarbons. Facilities with associated marine fueling stations pose a greater risk of discharging oil into marine waters.

Oil and Gas Production -- Potential exposure of listed species to petroleum hydrocarbons comes from direct contact and ingestion of crude oil and refined products from acute and chronic oil spills. Range overlaps of listed species with active and planned oil and gas operations will determine risk of exposure. Polar bear range overlaps with many active and planned oil and gas operations within 40 km (25 mi) of the coast or offshore (Schliebe et al. 2006a).

Collisions

See "Life History – New Threats" for a discussion of the potential for Steller's (page 112) and spectacled eiders (page 126) to collide with lighted vessels and shore-side infrastructure.

Climate Change

Habitat alteration -- There is widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades (IPCC 2001a). It is expected that this warming trend will alter weather patterns. It is anticipated that warming will be greatest over land and at high northern latitudes (IPCC 2007). In the north, an ice-albedo feedback mechanism occurs, where the reflective areas of Arctic ice and snow retreat and the earth absorbs more heat, accelerating the warming (NRC 2001). The proximate effects of climate change in the Arctic are expressed as increased average winter and spring temperatures and changes in precipitation amount, timing,

and type (Serreze et al. 2000). These changes, in turn, result in physical changes such as reduced sea-ice, increased coastal erosion, changes in hydrology, and increased depth to permafrost (ACIA 2005).

It is highly likely that the increase in average yearly temperatures over the past 50 years is primarily due to the global rise in anthropogenic greenhouse gases (Crowley 2000, IPCC 2001a, Karl and Trenberth 2003, Stott 2003, IPCC 2007. Global average surface temperatures are projected to increase 1.4-5.8 ºC from 1990-2100 (IPCC 2001b). Projected surface temperature changes along the North Slope of Alaska may increase by 6.0-6.5 °C in the late 21st century (2090-2099), relative to the period 1980-1999 (IPCC 2007).

Data indicate that sea-ice in the Arctic is undergoing rapid changes. There are reported changes in sea-ice extent, thickness, age, and melt duration; the age of Arctic ice is younger, the thickness is decreasing, and the melt duration is increasing. Furthermore, the sea-ice extent is generally becoming much less in the Arctic summer and slightly less in winter. These factors lead to a decreasing perennial Arctic ice pack. It is thought that the Arctic will be regularly ice-free in summer, as was witnessed during summer of 2008 (Figure 2).

While changes in the reduction of summer sea-ice extent are apparent, the cause(s) of the change are not fully established. The evidence suggests that a combination of oceanic and atmospheric conditions may be causing the change. Incremental solar heating and ocean heat flux, long-wave radiation fluxes, changes in surface circulation, and reductions in multiyear sea-ice all may play a role.

There is high agreement among sea ice projections that by the end of this century, the Chukchi Sea will be completely ice covered only during February, March, and April; the timing and amount of partial ice cover during other months is uncertain (Douglas 2010). For the Bering Sea, median March ice extent is projected to be about 25 percent less than the 1979–1988 average by 2050, and 60% less by the end of the century. The ice-free season in the Bering Sea is expected to increase from an average of 5.5 months to about 8.5 months by the end of the century. The ice edge typically will pass through the Bering Strait in May and January at the end of the century rather than June and November as presently observed (Douglas 2010).

These physical changes are resulting in, or are expected to result in, changes to the biological environment, causing shifts, expansion or retraction of home range, changes in behavior, and changes in population parameters of plant and animal species. Research in recent years has focused on the potential for global climate regime shifts to cause changes in habitat structure over large areas. Threats posed by the direct and indirect effects of global climatic change will be most pronounced for ice-obligate species such as the polar bear, Pacific walrus, and Kittlitz's murrelets.

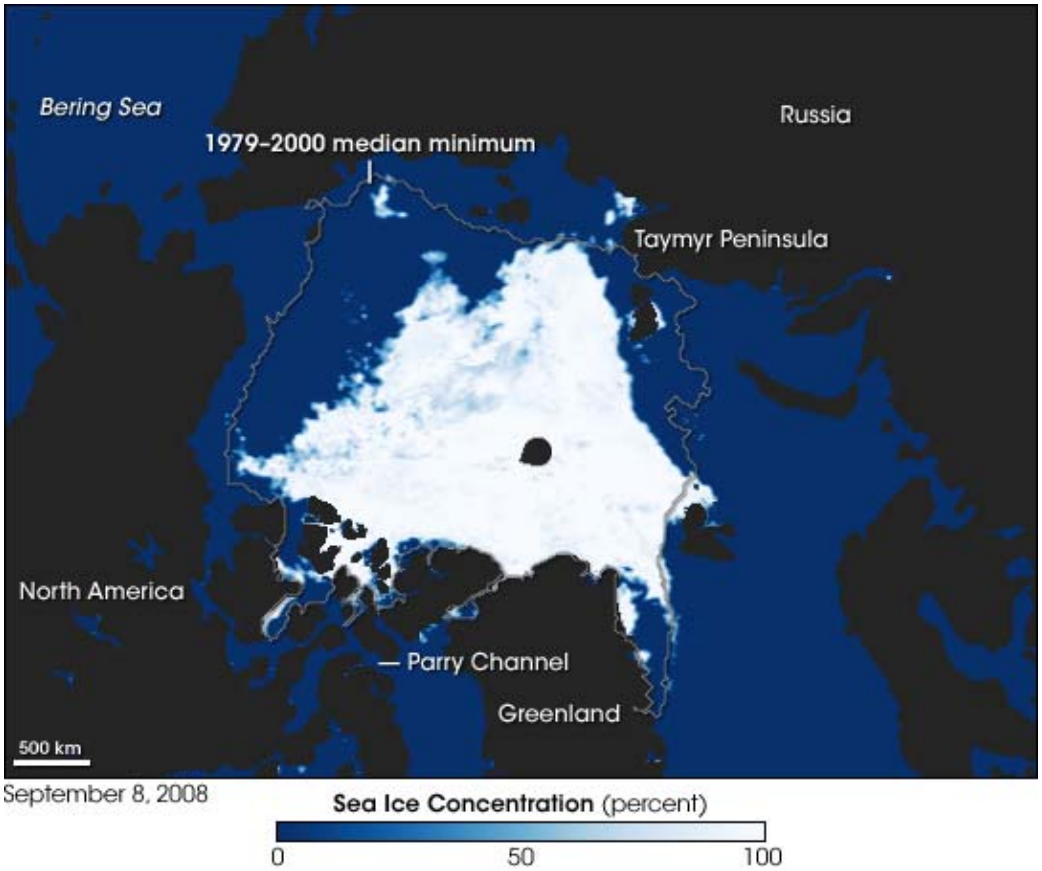

Figure 2. Arctic sea-ice extent on September 8, 2008, as observed by the Advanced Microwave Scanning Radiometer–Earth Observing System sensor on NASA's Aqua satellite (NASA 2008).

Related Contaminant Effects --Projected increases in temperature will enhance contaminant influxes to aquatic systems, and increase the susceptibility of aquatic organisms to contaminant exposure, resulting in higher contaminant loads and biomagnification in ecosystems (ACIA 2005). Temperature changes fundamentally influence contaminant fate and transport, since water solubility and propensity for atmospheric transport of contaminants are mediated by temperature. In general, under warmer climactic conditions, chemicals will more readily move from soil to air, increasing the amount of atmospheric transport and net transport to the Arctic (AMAP 2003). Permafrost loss can also affect pollutant transport, resulting in a shift toward dendritic drainage patterns that allow more efficient transport of contaminants into ponds and lakes and possibly re-mobilize contaminants entrained in tundra soils (MacDonald et al. 2005).

Mercury is of particular concern for Alaska and other areas within the Arctic. Jörnhagena et al. (2007) evaluated mercury deposition and loss dynamics in a Swedish palsa mire (an organically rich, permafrost-dominated peat bog), estimating that erosive loss of mercury to a nearby lake was 10-60 times greater than observed atmospheric deposition rates. They concluded that erosion of these organically rich mires could greatly influence mercury levels in freshwater ecosystems within the Arctic.

Mercury transport by the Mackenzie River to the Beaufort Sea was recently studied, in order to understand very high concentrations of mercury in marine mammals and other higher trophic-level biota in the Mackenzie River Delta and Beaufort Sea (Leitch et al. 2007). Mercury concentrations were positively correlated with river flow, and increased mercury concentrations may in part reflect increased surface inundation and bank erosion. Mercury concentrations were greatest during spring freshets (rapid rise in stream flow due to runoff from rain or snowmelt) and high flow events. The mercury fluxes from the Mackenzie River are expected to increase further with the projected climate warming in the Mackenzie Basin (Leitch et al. 2007).

Various modeling studies, reviewed in the ACIA (2005) report, suggest that a warming climate will lead to more and larger fires. Turetsky et al. (2006) evaluated climate-related changes in fire incidence and associated mercury emissions. They found that mercury formerly sequestered in cold, wet peat soils is released to the environment during fires in Canadian boreal forests and will present a growing threat to sensitive aquatic habitats and northern food chains as the climate warms. Estimates of circumboreal mercury emissions presented in this study are 15-fold greater than estimates that did not account for mercury stored in peat soils.

In addition to the factors discussed above (e.g., fire-related emissions, increased river discharge, and increased erosion rates) other climate-related factors that are predicted to increase mercury concentrations in aquatic top predators include: flooding of sediments which increases methylation; an increase in the number of trophic levels increasing biomagnification; and a shift toward larger fish size (ACIA 2005).

Collectively, this information suggests that a changing climate may alter contaminant transport pathways, release contaminants currently sequestered in permafrost and vegetation, and alter foodweb relationships that in turn affect bioaccumulation of contaminants.

Effects to Eiders –High latitude regions, such as Alaska's North Slope, are thought to be especially sensitive to the effects of climate change (Quinlan et al. 2005, Smol et al. 2005). While climate change will likely affect individual organisms and communities, it is difficult to predict with any specificity or reliability how these effects will manifest. Biological, climatological, and hydrologic components of the ecosystem are interlinked and operate on multiple spatial, temporal, and organizational scales with feedback among components (Hinzman et al. 2005).

There are a wide variety of changes occurring throughout the circumpolar region, including Alaska's North Slope. Arctic landscapes are dominated by lakes and ponds (Quinlan et al. 2005), which are used by listed eiders for feeding and brood rearing. In many areas these water bodies are drying out or draining during summer as a result of thawing permafrost (Smith et al. 2005, Oechel et al. 1995), and increased evaporation and evapotranspiration as they are ice-free for longer periods (Schindler and Smol 2006, Smol and Douglas 2007). Productivity of lakes and ponds appears to be increasing as a result of nutrient inputs from thawing soil and an increase in degree days (Chapin et al. 1995, Hinzman et al. 2005, Quinlan et al. 2005, Smol et al. 2005). Changes in water chemistry and temperature are resulting in changes in the algal and invertebrate communities, which form the basis of the food web in these areas (Quinlan et al. 2005, Smol et al. 2005).

With the reduction in summer sea-ice, the frequency and magnitude of coastal storm surges has increased. These often result in breaching of lakes and low lying coastal wetland areas, killing salt intolerant plants and altering soil and water chemistry, and hence, the fauna and flora of the area (USGS 2006). Historically sea-ice has served to protect shorelines from erosion; however, this protection has decreased as sea-ice has declined. Coupled with softer, partially thawed permafrost, the lack of sea-ice has significantly increased coastal erosion rates (USGS 2006), reducing available coastal tundra habitat.

Changes in precipitation patterns, air and soil temperature, and water chemistry are also affecting tundra vegetation communities (Chapin et al. 1995, Hinzman et al. 2005, Prowse et al. 2006), and boreal species are expanding their range into tundra areas (Callaghan et al. 2004). Changes in the distribution of predators, parasites, and disease-causing agents associated with climate change may have significant effects on listed species and other Arctic fauna and flora. Climate change may also result in asynchronous timing of migration and the availability of suitable prey in Arctic ponds (Callaghan et al. 2004). Further, these climate changes may result in disruption of the population cycles of small mammals such as lemmings to which productivity of many other species, including nesting Steller's eiders (Quankenbush and Suydam 1999), is linked (Callaghan et al. 2004).

While the impacts of climate change on some listed species in the marine environment are unclear, species with small populations are vulnerable to environmental change (Crick 2004). Climate change will likely result in multiple system effects, some may be beneficial to listed eiders while others may have negative effects. The mechanisms through which climate change may operate and the interactions of changes in multiple systems and levels of the ecosystem are not understood. Until we can observe and understand the mechanisms through which climate change will affect the ecosystems in which these species occur, we can not reliably predict how climate change may affect listed eiders.

Effects to Sea Otters --The projected adverse effects of climate change on sea otters may include reduced prey availability and/or altered prey composition, but may relate more immediately to increased disease prevalence. Warming ocean temperatures are expected to cause nutritional stress and result in higher probabilities of exposure to anthropogenic contaminants and pathogens (Burek et al. 2008). For example, *Vibrio* spp. is associated with warmer waters (Vasconcelos et al. 1974; Kaysner 1981) and therefore may be more prevalent as the ocean temperatures climb due to a rapidly warming climate (see detailed discussion of *Vibrio* spp under *Disease* below, page 23). Phocine distemper virus (PDV), a deadly virus associated with massive die-offs of harbor seals (*Phoca vitulina*) in the Atlantic Ocean, was recently discovered in northern sea otters in the Pacific Ocean (Goldstein et al. 2009; see detailed discussion of PDV under *Disease* below, page 23). This infectious disease is new to the Pacific Ocean; transmission may have occurred when marine mammals migrated from the Atlantic via new ice-free waters in the Arctic (Goldstein et al. 2009).

Effects to Polar Bears -- Climate change will significantly impact polar bears in the marine environment. It may also lead to changes in habitat use and vulnerability of polar bears in the action area. An estimated 50% of females from the Beaufort Sea stock den on land, while the

remaining 50% den on drifting pack ice. Durner et al. (2006) noted in order for reproduction by ice-denning females to be successful, ice must be relatively stable. As climate change continues, the quality of sea-ice may decrease, forcing more females to den on land (Durner et al. 2006). However, if large areas of open water persist until late winter due to a decrease in the extent of pack ice, females may be unable to access land to den (Stirling and Andriashek 1992). Climate change may also affect the availability and quality of denning habitat on land. A large proportion of terrestrial dens on Alaska's North Slope confirmed between 1981 and 2005 were on coastal bluffs (Durner et al. 2006). These areas are suffering rapid erosion and slope failure as permafrost melts and wave action increases in both duration and magnitude. In all areas, dens are constructed in autumn snowdrifts (Durner et al. 2003). Changes in autumn and winter precipitation or wind patterns predicted by climate change models (Hinzman et al. 2005) could significantly alter the quality and availability of denning habitat.

Polar bears' use of coastal habitats in fall, during open-water and freeze-up conditions, has increased since 1992 (FWS 2006a). This may increase the number of human–polar bear interactions as bears occur close to human settlements or developments. Amstrup (2000) observed that direct interactions between people and polar bears in Alaska have increased markedly in recent years. The number of bears taken for safety reasons, based on three-year running averages, increased steadily from about 3 per year in 1993, to about 12 in 1998, and has averaged about 10 in recent years. The apparent rise in interactions could be an artifact of increased reporting by hunters, but may also be the consequence of bears spending a greater amount of time on land and less time feeding. Since the late 1990s, the timing of ice formation in the fall has occurred later in November or early December. Later formation of near-shore ice increases the probability of bear-human interactions occurring in coastal villages (Schliebe et al. 2006a). Derocher et al. (2004) noted that some experts predict the number of polar bear–human interactions will increase as climate change continues.

Climate change is having profound effects on polar bears in their principal marine habitat. Use of the action area by polar bears is likely to alter as climate change continues. Polar bears are ice obligate species, but some use terrestrial habitats seasonally (FWS 2008e). Open water is an important interface for polar bears, and it supports their main prey: fur seals (*Callorhinus ursinus*). With the loss of sea-ice, and the resultant increase in open water, polar bears will be forced into more frequent and extensive open water swimming forays. Loss of sea-ice is expected to reduce prey availability and alter the bears' movement patterns and seasonal distribution (FWS 2008e). In summary, climate change is expected to negatively impact polar bear nutrition, body condition, reproductive output and survivorship (FWS 2008e).

<u>Effects to Kittlitz's murrelets</u> -- Loss of glacial volume is occurring on a global scale (Dyurgerov and Meier 2000, IPCC 2007). Glacial retreat has been occurring since the end of the Little Ice Age (around 1850), but during recent decades, glaciers are melting at rates that cannot be explained by historical trends (Brown et al. 1982, Dyurgerov and Meier 2000).

Glaciers respond to change in climate almost immediately (Dyurgerov and Meier 2000). Correlations between warm mean surface temperatures and concomitant glacial melting events (Dickey et al. 2002) suggest that glaciers, particularly the maritime glaciers of Alaska, are sensitive to warming trends (Wiles and Calkin 1994). Glacial retreat is accelerated when ice

thickness decreases (van der Veen 1996). The retreat rate of tidewater glaciers is related to water depth, such that the deeper the water, the more rapidly the glaciers retreat (Adalgeirsdottir et al. 1998). The widespread decrease in glaciers and ice caps has contributed to sea level rise, creating a feedback mechanism, which increases the rate of retreat for tidewater glaciers in particular (IPCC 2007). There is high confidence that the rate of observed sea level rise increased from the 19th to the 20th century, and the rate of global average sea level rise has increased over the past decade (IPCC 2007). Projected climate change over the next century will further affect the rates at which glaciers melt. Best estimates for average surface air warming ranges from 1.1°C (the lowest estimate under the B1 or low emission scenario) to 6.4°C (the highest estimate under the A1F1 or highest emission scenario). Even with an average temperature rise of 1°C, glaciers will continue to retreat in the next century (Oerlemans et al. 1998).

The especially rapid retreat of Alaska's glaciers represents about half the loss in mass of glacial ice worldwide (Hassol 2004). Most glaciers in Alaska have been receding since the turn of the 20th century (Lethcoe 1987, Molnia 2001). The Harding Icefield on the Kenai Peninsula is the largest ice field in North America. Seven of its 38 glaciers are currently tidewater, and on average the icefield has undergone a total volume reduction of 34 km^3 over the past 43 years (Adalgeirsdottir et al. 1998). This volume change corresponds to an average elevation change of -21 m (±5 m). From 1961 to 2003, the thickness of "small" glaciers reportedly decreased approximately 8 m (NSIDC 2006); however Adalgeirsdottir et al. (1998) found no significant correlation between volume loss and type or characteristics of glaciers. Bering Glacier, located south of Wrangell-St. Elias National Park and the largest glacier in North America, has shrunk up to 7.4 miles in length during the past century (Barretta 1997, Wiles et al. 1999). Muir Glacier in Glacier Bay has been retreating since the turn of the 20th century (Powell 1991), and is presently retreating at a rate of 3m per year (Hunter 1994). In PWS, there has been a near-continuous ice retreat with minor advances since the Little Ice Age; one glacier reportedly has retreated 62 m per year for the past 75 years (Wiles et al. 1999).

Kittlitz's murrelets exhibit a strong association to glacially-influenced marine habitat in PWS, Kenai Fjords, Glacier Bay, Icy Bay, and the south side of the Alaska Peninsula (Kendall and Agler 1998, Kuletz et al. 2003, Robards et al. 2003, van Pelt and Piatt 2003, van Pelt and Piatt 2005, Agness 2006). The preference of these small seabirds for areas near stable or advancing tidewater glaciers may be related to the diversity and abundance of high energy forage fishes such as Pacific capelin (*Mallotus villosus*) and Pacific sand lance (*Ammodytes hexapterus*; Piatt et al. 1994; Day and Nigro 2000; Agness 2006; Kissling et al. 2007). The distribution and availability of these high-energy forage fishes may change as glaciers recede and the physical parameters of marine habitats are modified. Reduced diversity and abundance of these fishes may reduce the Kittlitz's murrelet's ability to feed young during nesting season.

The accelerated melting and calving of tidewater glaciers is conducive to high rates of sedimentation (Koppes and Hallet 2002). Fjords are efficient traps for sediment produced by tidewater glaciers, leaving little opportunity for removal by tidal or current action. Sedimentation can change the suitability of marine habitats for fish upon which Kittlitz's murrelets feed. In extreme cases, sedimentation, glacial retreat and glacial rebound may combine to transform marine habitat into glacial rivers draining onshore cirque and valley glaciers (Plassen and Vorren 2003), which may no longer support the forage fish that sustain Kittlitz's murrelets.

Climate warming may be causing glaciers to release increasingly contaminated melt water to receiving water bodies. A substantial percentage of current glacial melt originated from ice that was deposited in 1950 through 1970 when organochlorines were more concentrated in the atmosphere than they were before or after this time period (Blais et al. 2001). In addition, organochlorines that were deposited during that 20-year time period were deposited more heavily in colder locations, such as ice fields. Glacial streams, which are characterized by low organic matter content, contain unusually high proportions of persistent organic pollutants in solution due to the low potential for these compounds to adsorb to suspended sediments in the glacial stream. The prevalence of organochlorine compounds (OC) in the dissolved phase (rather than being tightly bound to suspended sediments), coupled with the low dissolved organic carbon concentrations in the lake water indicates a high bioavailability of these compounds to aquatic biota (Blais et al. 2001). Contaminants in the melt-water from glaciers may contribute high concentrations of pesticides for decades or centuries (Donald et al. 1999).

In 2005, Italian researchers observed a sharp increase in pp´-DDT and its metabolites in mussels and fish from Lakes Como and Iseo, the main glacier-fed lakes of the southern Alpine region. DDT levels in zebra mussels *(Dreissena polymorpha*) were more than 150 times higher than levels in 2003, and concentrations in pelagic fish exceeded the Italian safety threshold for human consumption. The authors concluded that glacial meltwater was the main cause of the pollution peak observed in biota of these glacial-fed lakes (Bettinetti et al. 2008).This then leads to the hypothesis that increased contaminants in receiving waters of melting glaciers bioaccumulate in fish associated with those waters and subsequently are consumed by the Kittlitz's murrelets that prey on those fish.

The interrelated effects of a rapidly warming climate on the glacially-influenced marine environment may result in reduced availability of high quality food for Kittlitz's murrelet adults and young. If forage quality and quantity are reduced, the birds' productivity will be negatively affected and mortality will increase. Increased mortality of breeding adults generally has greater population level effects in long-lived species with delayed maturity and low rates of reproduction (k-selected species such as seabirds), than it does for more r-selected species (e.g., geese and ducks; MacArthur and Wilson 1967; Beissinger 1995).

Parasites and Diseases

Eiders –Hollmen et al. (2008) found that wintering Steller's eiders generally carry intestinal parasites, but prevalence was geographically variable; 56% of fecal samples were positive for Helminth parasite eggs at Unalaska and 33% at Izembek Lagoon. Further, they found evidence of adenovirus, reovirus, influenza virus, aspergillus, and Newcastle disease virus exposure in Steller's eiders captured at Unalaska, but did not conduct a comparative analysis at other locations. *Staphylococcus* spp. was found in Steller's eider fecal material during all 3 years of continuous screening at Unalaska. *Escherichia coli (E. coli*), a fecal coliform bacterium, was detected in seaducks screened at Unalaska; 16% (n=120) in Steller's eiders and 67% (n=21) in harlequin ducks (Hollmen et al. 2008). Comparatively, only 2% (n=48) of the Steller's eiders screened at Izembek Lagoon were positive for *E. coli* (see *A Case Study: Steller's Eiders Wintering Around Unalaska Island in the Aleutians*, page 25).

Sea Otters -- Infection from the *Vibrio* spp. bacteria (the genus of bacteria that causes cholera in humans) has been documented in a recent screening of sea otters in Alaska (V. Gill, FWS, Marine Mammals Management, Anchorage, Unpublished Data). *Vibrio alginolyticus* was isolated from two sea otters located in Kachemak Bay, *Vibrio fluvalis* was isolated from one sea otter located in Resurrection Bay, and *Vibrio parahemolyticus* was isolated from four sea otters in south-central Alaska (i.e., Prince William Sound, Resurrection Bay, and Kachemak Bay).

The known distribution of *Vibrio* spp. is coastal and estuarine waters along the Atlantic, Pacific, and Gulf coasts of the United States; the reported densities, however, vary widely (Watkins and Cabelli 1985). Filter feeders, such as mussels and oysters, concentrate microbes, such as *Vibrio* spp., from surrounding waters. Other invertebrates such as worms and crabs bioaccumulate bacterial pathogens as well (Miller et al. 2006). *Vibrio* spp. may be more prevalent in waters rich in organic nutrients, such as might be expected in areas heavily impacted by land runoff and wastewater discharges (Watkins and Cabelli 2005). Indeed, risk of exposure to pathogenic bacteria such as *Vibrio* spp. was highest in association with sewage and fecal pollution (Watkins and Cabelli 2005, Miller et al. 2006).

Little is known about *Vibrio* spp. in Alaska, but it has been documented in southeast Alaska, where the bacteria occurred in low density, but was strongly associated with the presence of fish waste (Vasconcelos et al 1974). It was surmised that the low year-round temperatures of the marine waters were instrumental in keeping the *Vibrio* spp. bacteria counts so low.

The fecal protozoan parasite *Toxoplasma gondii* has been identified in 33 species of marine mammal from seven families (Borel 2008), including the California sea otter (*E. lutris nereis*), and is suspected as a contributing factor to some sea otter deaths (Miller et al. 2004). It has been estimated that 17% of California sea otter deaths are caused by toxoplasmosis (Borel 2008). *T. gondii* infection with associated meningoencephalitis was found to be a major cause of death in subadult and prime-aged sea otters along the California coast. Sea otters and other marine mammals can be exposed to *T. gondii* when the oocytes or cyst stages of these parasites are shed in the feces of wild and domesticated terrestrial animals (Conrad et al. 2005). It is believed that the oocytes are transported into fresh and marine waters via wastewater sewage systems or storm water drainage and freshwater runoff. After reaching the sea, oocytes can be concentrated by filter-feeding marine invertebrates (Conrad et al. 2005) or possibly in fish such as anchovies (Borel 2008).

Phocine distemper virus (PDV), which has caused massive die-offs of harbor seals in the Atlantic Ocean, has been recently found in northern sea otters from both the listed DPS (southwestern Alaska) and from the southcentral stock (Goldstein et al. 2009). This disease was not present in the Pacific Ocean before 2000. Both harbors seals and sea otters infected by PVD die of secondary bacterial infections. This highly infectious disease is cause for great concern (Goldstein et al. 2009).

Polar Bears -- Except for the presence of *Trichinella* larvae, the occurrence of diseases and parasites in polar bears is relatively rare compared to other bears. Polar bears feed primarily on fat, which is relatively free of parasites, except for *Trichinella* (Rogers and Rogers 1976, Forbes 2000). It is unknown whether polar bears are more susceptible to new pathogens due to their lack

of previous exposure to diseases and parasites. Many different pathogens and viruses have been found in seal species that are polar bear prey (Duignan et al. 1997, Measures and Olson 1999, Dubey et al. 2003, Hughes-Hanks et al. 2005), so the potential exists for transmission of these diseases to polar bears. As polar bears become more stressed they may eat more of the intestines and internal organs than they do presently, thus increasing their potential exposure to parasites and viruses (Derocher et al. 2004, Amstrup et al. 2006b).

Kittlitz's murrelet -- Except for one record of a tapeworm (*Alcataenia*) in a Kittlitz's murrelet from Kodiak Island (Hoberg 1984), there is no information available on disease or parasites in this species (Day et al. 1999).

Seafood Processing Industry

Past and present impacts to listed species, in particular Steller's eiders and sea otters, resulting from direct and indirect effects of the seafood industry are associated with: 1) the degradation of habitat due to the release of organic waste into near-shore marine waters; 2) the accidental release of fuels into the marine environment during refueling operations; 3) the accidental release of petroleum through the release of contaminated bilge water or from grounded/sunk vessels; 4) collisions with fishing vessels; 5) consumption of contaminated or otherwise harmful offal (waste parts after butchering); 6) nuisance attraction to seafood waste; and 7) increased exposure to predators.

Fish waste generally causes the degradation of habitat due to the release of organic waste into the near-shore marine environment (Christie and Moldan 1977, Schroeder 2001). Seafood processing waste primarily consists of unused portions of fish and shellfish that have been processed. Dissolved wastes can include soluble organic matter and nutrients leached from blood, fish, and shellfish tissues during processing (EPA 2008a). Organic matter and suspended solids settle out at various distances from the outfall, depending on tides and circulation. Once settled, the fish waste decomposes and exerts an oxygen demand, which could limit the distribution of some organisms (Christie and Moldan 1977, Himelbloom and Stevens 1994, Schroeder 2001). An anaerobic sludge may occur where particles settle out on the seafloor, and hydrogen sulphide and methane gasses, which are highly toxic to marine organisms, are released (Christie and Moldan 1977).This waste may create visible surface slicks and turbidity plumes that attract predators (Himelbloom and Stevens 1994). Further, microbial counts are significantly higher at fish waste dump sites as compared to control sites (Himelbloom and Stevens 1994). Fish waste contains *E. coli* (Himelbloom and Stevens 1994), which may result from the sewage discharged from fishing boats (Kaysner 1981). Under some discharge permits sewage is allowed to comingle with seafood discharges but in other instances, adjacent facilities operating under independent permits discharge both municipal and seafood effluents into the same receiving waters.

Discharges can attract listed species directly, or indirectly, through eutrophication of the benthic environment s (Reed and Flint 2007). Eutrophication refers to an increased input of inorganic nutrients such as nitrogen, which results in increased primary production (Gunnarsson et al. 2000). The eutrophication process may also enhance bioaccumulation of hydrophobic contaminants such as petroleum hydrocarbons in benthic environments (Gunnarsson et al. 2000).

A Case Study: Steller's Eiders Wintering Around Unalaska Island in the Aleutians
Some Steller's eiders winter in the marine waters that surround Unalaska Island in the Aleutian Island chain, which is the home to the most productive (by volume) fisheries port in the United States (http://www.alaskacoast.state.ak.us/Explore/AWCRSA_04_07/unalaska.html, accessed 1/28/2009). Anecdotally (Chris Hoffman, US Army Corps of Engineers, Anchorage, Unpublished Data) the simple numeric abundance of Steller's eiders wintering around Unalaska Island appears to be declining at a higher rate than the overall annual rate of decline for the Pacific wintering population (9.4% per year, Paul Flint, US Geological Survey, pers. comm.; versus 2.7% per year, Larned and Bollinger 2011, respectively). This higher rate of decline at Unalaska suggests that Steller's eiders are being removed from the local population either through mortality, habitat abandonment, or emigration.

The FWS, US Geological Survey (USGS), and the ASLC studied Steller's eiders around Unalaska for nearly a decade. During a study in late January and early February of 2004, 28 Steller's eiders and 32 harlequin ducks were captured and fitted with radio transmitters to investigate home range size and habitat use in the vicinity of Unalaska (Reed and Flint 2007). That same February, 10 radio transmitters indicated mortality; four from Steller's eiders and six from harlequin ducks (Reed and Flint, Unpublished Data). With the aid of the radio transmitter signals, the researchers were able to retrieve four bird carcasses (three Steller's eiders and one harlequin duck).

Necropsy of the recovered ducks revealed that two of the three Steller's eiders were emaciated, in poor body condition, and had intestinal parasites. There was physical evidence of predation by eagles, or alternatively, that post-mortem scavenging of the carcass had occurred (Reed and Flint 2004). Two Steller's eiders had lesions in the oral cavity. The cause of the lesions remains unknown, but *Staphylococcus* spp. was isolated from similar lesions found in Steller's eiders in a previous year (Tuula Hollmen, ASLC, Unpublished Data). Enteric bacteria were growing subcutaneously where the transmitters were attached to the birds (T. Hollmen, ASLC, Pers. comm.). Transmitters were attached using the prong and suture method (Peitz et al. 1995). These bacterial growths led to concerns regarding water quality within the bird's habitat, (specific habitat use by the individual birds was identified using the radio tracking data).

Seaducks, including Steller's eiders at Unalaska, have been observed roosting or feeding near discharge plumes from fish processing plants and wastewater treatment facilities at South Unalaska Bay (Miles et al. 2007; Reed and Flint 2007; Figure 3). Radio-tracking data suggest that most (86%) Steller's eiders wintering in the vicinity of Unalaska use South Unalaska Bay on a regular basis (Reed and Flint 2007). South Unalaska Bay is the receiving water body for discharges from two seafood processing plants and the City of Unalaska's wastewater treatment facility. All three facilities are permitted for mixing zones within the Bay. In 1994, South Unalaska Bay was placed on the §303(d) list for water quality degradation (residues and BOD_5) due to waste products from seafood processors and the sewage treatment plant (ADEC 2008a).

Food availability for seaducks is high in South Unalaska Bay, likely due to the effects of human-caused eutrophication (Reed and Flint 2007). Mobile invertebrate scavengers such as amphipods are attracted to fish processing discard (Blum and Bechtel 2003). Amphipods are among the high energy prey that Steller's eiders and harlequin ducks select (Goudie and Ankney 1986; Bustnes

et al. 2000; Fischer and Griffin 2000; Bustnes and Systad 2001). It is reasonable to assume that Steller's eiders are attracted to areas with enhanced availability of high energy prey, especially during winter. This assumption is supported by results indicating low foraging effort by Steller's eiders at Unalaska during a period of high energetic demand (e.g., winter), suggesting that food availability during that time was high (Reed and Flint 2007).

The fish offal discharged into South Unalaska Bay may have directly or indirectly caused the attraction of Steller's eiders to the area, and may have attracted other bird species as well. Scavenging seabirds are attracted to fish offal (Furness et al. 1992), and eagles tend to congregate in the vicinity of processing facilities and outfalls. Predation by eagles may be an important mortality factor for Steller's eiders that winter in the vicinity of South Unalaska Bay (Reed and Flint 2007), particularly if the seaducks are weakened by disease, parasites, or other factors.

Due to increasing concern regarding overall health, and the mortality factors affecting Steller's eiders wintering in the vicinity of Unalaska Island, Steller's eiders were screened for disease over a 3-year period. During one year, disease prevalence was compared with Steller's eiders wintering at Izembek Lagoon, which is designated as critical habitat under the ESA, and is considered relatively pristine due to the absence of point-source discharges. In addition to Steller's eiders, harlequin ducks were also screened since they are more common and occupy many of the same habitats as Steller's eiders.

As mentioned above, *E. coli* was detected in seaducks screened at Unalaska; 16% (n=120) in Steller's eiders and 67% (n=21) in harlequin ducks (Hollmen et al. 2008, 2010). Comparatively, only 2% (n=48) of the Steller's eiders screened at Izembek Lagoon were positive for *E. coli*. Fecal coliforms are a family of bacteria that originate in the gut of warm-blooded animals. *E. coli* is a type of fecal coliform inhabiting the colon of many vertebrate species, including humans. There are many genetically distinct forms of *E. coli*. Some are known to occur in birds and some in mammals. Some are pathogenic to some taxa and some are not. Many have not been genetically characterized and thus are very difficult to identify. Because of technique limitations, *E. coli* from Steller's eiders and harlequin ducks sampled at Unalaska were generally categorized as either avian or mammalian, and either pathogenic or non-pathogenic.

Serum biochemistry and DNA subtyping methods revealed that avian pathogenic *E. coli* was present in Steller's eiders and harlequin ducks during all 3 years of sampling at Unalaska (Hollmen et al. 2008). In 2005, 2 of 23 (9%) Steller's eiders were positive for avian pathogenic *E. coli;* in 2006, 3 of 13 (23%) were positive; and in 2007, 1 out of 12 (8%) Steller's eiders were positive for avian pathogenic *E. coli*. Steller's eiders that carried avian pathogenic *E. coli* had lower serum total protein and albumen concentrations, providing further evidence of pathogenicity (Hollmen et al. 2010). Low serum protein and albumin levels are used as tools for some avian bacterial infections (Reidaron and McBain 1995) and indicators of poor health and increased mortality risk in humans (Peralta and Rubery 2008). Interestingly, virulence attributes associated with mammalian pathogenic *E. coli* were identified in two harlequin ducks from Unalaska, but the health effects of mammalian pathogenic *E. coli* on seaducks is unknown.

Figure 3. Visual extent of residues from seafood processing discharges mixed with discharges from the City of Unalaska's wastewater treatment facility. The scale of this photo is approximately 1cm=341 meters.

To assess potential links between *E. coli* prevalence in ducks and the sources of *E. coli* in the environment, water samples were collected at five sites around Unalaska over a 3-year period (Hollmen et al. 2008). Presumptive *E. coli* was found in water samples from four out of five bays around Unalaska, with the highest fecal coliform (including *E. coli*) concentrations from the vicinity of the sewage treatment discharge outfall. None of the *E. coli* in the water samples was a pathogenic form (T. Hollmen, ASLC, Unpublished Data). But, in February of 2006, a genetic match was made between *E. coli* found in a water sample collected at South Unalaska Bay and a harlequin duck sampled from that bay (Hollmen et al. 2010). This genetic match provides evidence of *E. coli* transmission between the nearshore marine waters and birds (Hollmen et al. 2010).

Transmission of *E. coli* to the harlequin duck may have occurred through swimming and resting or though ingestion. Mussels, another preferred food of harlequin ducks and Steller's eiders (Peterson 1981), bioaccumulate fecal bacteria such as *E. coli*, *Vibrio* sp. and *Enerococcus durans* (Moles and Hale 2003; Marino et al. 2004). Although we can not conclusively make the connection among: 1) the City of Unalaska's sewage treatment facility's discharges; 2) the *E. coli* in the water; and 3) the *E. coli* in the seaducks, this pathway appears highly probable.

Mammalian pathogenic *E. coli* transmission to Antarctic fur seals (*Arctocephalus gazelle*) has been linked to human wastes discharged into Antarctic waters (Hernandez et al. 2007).

During February 2004, when the 4-radiomarked seaduck carcasses were salvaged from Unalaska (Reed and Flint 2007), the City of Unalaska's sewage treatment plant was violating the conditions of their National Pollutant Discharge Elimination System (NPDES) permit; fecal coliforms in the effluent of the sewage treatment facility were more than 20 times the allowed concentration in their permit (EPA 2008b). This incident was not unique. Effluent monitoring data indicate that fecal coliform concentrations exceeded the permitted average monthly limit of 10,000 colonies per 100 ml on average 7 months per year over 5 years. Furthermore, 60% of those exceedances occurred from November through March, when Steller's eiders occupy the waters of South Unalaska Bay.

Sewage effluent from the City of Unalaska, a town of more than 4,000 permanent residents plus seasonal employees working in the fishing industry, is discharged to South Unalaska Bay. The sewage currently and historically has only received primary treatment, and as a consequence may contain biological and chemical agents harmful to Steller's eiders. The primary sewage treatment has been insufficient to meet current permit requirements for fecal coliform and 5-day biochemical oxygen demand (BOD_5), as evidenced by the numerous violations of the numeric standards for these parameters (http://oaspub.epa.gov/enviro/pcs_det_reports.pcs_tst?npdesid=AK0043451&npvalue=1&npvalue=2&npvalue=3&npvalue=4&npvalue=5&npvalue=6&rvalue=13&npvalue=7&npvalue=8&npvalue=10&npvalue=11&npvalue=12, accessed 2/14/2009). Eutrophication from sewage and nearby seafood waste may enhance bacterial growth in South Unalaska Bay (Watkins and Cabelli 1985, Gunnarsson et al. 2000). Additionally, leachate from the municipal landfill flows into the wastewater treatment facility without pre-treatment and is discharged with the sewage.

The primary treatment offered by the City of Unalaska's wastewater treatment facility has proved insufficient at removing potential contaminants such as bacteria. Discharged wastes may also include parasites, pathogens and various regulated and unregulated contaminants such as endocrine disrupting chemicals, personal care products, household cleaning products, industrial wastes, and metals. As a result, a mixture of contaminants is likely entering Steller's eiders' habitat, potentially harming Steller's eiders. Indeed, South Unalaska Bay may be setting an ecological trap (Dwernychuk and Boag 1972, Battin 2004) for Steller's eiders.

An ecological trap occurs when animals choose a habitat that is poor for reproduction and survival (i.e., reduces fitness), but is preferred over other available, high quality habitats (Donovan and Thompson 2001, Batten 2004, Robertson and Hutto 2006). Reed and Flint (2007) have shown that Steller's eider's are attracted to the eutrophied benthic environment of South Unalaska Bay, in the same water body where harmful or potentially harmful contaminants such as petroleum hydrocarbons and bacteria are discharged or spilled. We hypothesize that attraction to seafood processing discharges in some water bodies may set an ecological trap for Steller's eiders.

The NPDES permit for the City of Unalaska's sewage treatment facility allows the discharge of aromatic hydrocarbons (EPA 2004). Steller's eiders are sensitive to polycyclic aromatic

hydrocarbons (PAHs) at low doses, and exposure to PAHs was documented in Steller's eiders captured around Unalaska (Miles et al. 2007). Furthermore, an analysis of PAHs available in Steller's eider prey in the Aleutians indicated that concentration of total PAHs in blue mussels (*Mytilus edulis*) were highest at Unalaska Island, compared to other locations (Miles et al. 2007). High concentrations of PAHs in blue mussels suggest exposure to Steller's eiders that feed on blue mussels during winter (Miles et al. 2007). In the last months of 2007 and the early months of 2008, permit limitations for aromatic hydrocarbons discharged from the City of Unalaska's sewage treatment facility were exceeded, and significant non-compliance and effluent violations were reported (EPA 2008b).

PAHs are known to sorb to materials high in organic carbon such as seafood and human waste (Persson et al 2000, Gunnarsson et al. 2000, Skei et al. 2000 as cited in Miles et al. 2007). Analysis of floating solids that were available near outfalls at two locations in the Aleutians (Sand point and Dutch Harbor) revealed that the concentrations of total PAHs in flocculi were 92.8 ng/g and 48.3 ng/g respectively (Miles et al. 2007). These PAHs may bioaccumulate in filter feeders, and be ingested by Steller's eiders.

Exposure to PAHs has affected or killed Steller's eiders (Fox et al. 1997). Petroleum hydrocarbons may adversely affect Steller's eiders through: 1) fouling feathers, thus compromising thermoregulation; 2) causing direct toxicity through consumption of petroleum (e.g., during preening); or 3) contaminating food resources. Chronic exposure to PAHs through contaminated food sources may have sub-lethal effects on reproductive success, immune system function, and overall body condition (Springman et al. 2005).

We believe that Steller's eiders are attracted to South Unalaska Bay due to the high energy, enhanced quantity of food resources there. This food source is associated with the eutrophied habitat resulting from seafood/sewage waste that is discharged to South Unalaska Bay, although we have not precisely identified the attractant (e.g., macroinvertebrates feeding on seafood residues or the residues themselves). Several lines of evidence suggest that attraction to South Unalaska Bay is causing Steller's eiders to be 1) at high risk of predation by eagles; and 2) at high risk of exposure to harmful agents such as petroleum hydrocarbons and bacteria. The mixing zones that allow the discharge of various effluents into the Bay are permitted under several NPDES permits. The harm is a result of exposure to contaminants such as bacteria and PAHs that may be a result of permitted discharges. This scenario provides just one example of attraction to mixing zones and the resultant adverse effects to Steller's eiders. There are several other busy harbors in Alaska that we believe are similar ecological traps for Steller's eiders.

EFFECTS OF THE ACTION

"Effects of the action" refers to the direct and indirect effects of the action on the species or its critical habitat. The effects of the action were evaluated together with the effects of other activities interrelated or interdependent with the action. These effects were then added to the environmental baseline and considered with cumulative effects when determining the proposed action's effects upon the species or its critical habitat (50 CFR Part 402.02).

In this analysis we have attempted to consider all potential effects to listed and candidate species. The effects may be considered a direct result of the action of promulgating regulations to permit

mixing zones, or an indirect effect of the regulation that is later in time, but is reasonably certain to occur. Only lawful actions may be considered an effect of the action, but illegal activities that are known to occur must be considered within the constructs of the environmental baseline or cumulative effects, and in the jeopardy analysis. Examples of illegal actions associated with the consultation on mixing zones include illegal oil spills, and violations of permitted exeedance of WQS. At times it was difficult to assess the proportion of harm attributable to the legal activity of permitting mixing zones versus illegal activities. We used the best information available when analyzing potential effects of exposure of specific pollutants to specific species. In the absence of data specific to the listed species, we use research conducted on other closely related taxa as a proxy.

General Description

As stated above (page 4), the proposed action is EPA's approval of the State of Alaska's revised water quality standards concerning mixing zones (18 AAC 70.240-270). Mixing zones are areas around discharges that allow for effluent dilution by the receiving water body. State WQS are exceeded in this designated area to allow this dilution to occur. Chronic water quality standards must be met at the edge of the mixing zone. Surface water within the mixing zone should not exceed acute toxicity levels, but may exceed chronic toxicity levels. In some instances a ZID is defined where the wastewater first enters the surface water. Surface water in this zone adjacent to the wastewater discharge is not required to meet acute, numeric WQS, but acute water quality criteria should be met at the edge of this initial zone. Surface water discharges within a ZID should not result in aquatic mortality (a narrative water quality standard). Chronic criteria should be met at the edge of the mixing zone (EPA 1991). The CWA allows mixing zones at the state's discretion. The State of Alaska's proposed mixing zones standards address mixing zones, but do not define the ZID where acute standards may be exceeded**.** However, the mixing zones implementation guidance document (ADEC 2009) describes compliance with the regulation for the initial mixing or acute zone to protect aquatic life.

Permit limitations on wastewater discharges are either technology-based or water quality-based. Technology-based limits are based upon: 1) the facility type (e.g., standard industrial code (SIC), 2) the appropriate effluent guidelines, 3) results of any required priority pollutant scans, 4) characteristics of the receiving water body (such as water quality impaired segments), and 5) the level of treatment that is achievable using available technology for the facility type being permitted. Water quality-based limits are designed to prevent exceedance of the WQS in the receiving water and are used for water quality-limited stream segments and water bodies. Some facilities are required to conduct priority pollutant scans to determine if any additional contaminants have a reasonable potential to violate WQS, and if so, should be assigned effluent limitations in the permit. Validation by regulators of the functionality of mixing zones, which are designed by modeling, appears to be extremely rare in Alaskan marine waters.

There are numerous confounding factors involved when considering potential effects of permitted mixing zones on listed species and their marine environment. Discharges from sewage treatment facilities may vary due to fluctuating inputs into the system. Seafood facilities discharging offal and domestic waste may discharge bioaccumulated contaminants contained within the seafood tissues, with the specific types and concentrations dependent on type of seafood processed and the location from where it was obtained. Based on permit and compliance

reviews conducted by the FWS, regulator-required monitoring for WQS compliance at the edge of and outside of mixing zones appears to be rare in Alaska marine waters. Finally, some water bodies in which mixing zones are permitted are contaminated by non-point source pollutants.

Ten major industrial categories are permitted mixing zones for their discharges: 1) seafood and aquaculture; 2) forest products; 3) air/sea transport; 4) mining (non-placer); 5) placer mining; 6) oil and gas; 7) water supply; 8) wastewater; 9) construction and development; and 10) miscellaneous. Based on previous mixing zones permits, and the potential overlap with the ranges of our listed species, we focused our analyses of effects on discharges from half of the industries: 1) seafood and aquaculture; 2) mining (non-placer); 3) placer mining; 4) oil and gas; and 5) wastewater.

Factors to be Considered

Proximity of the Action

Mixing zones can be permitted anywhere within the state of Alaska including US waters out to 3-nm, and they have been permitted within the breeding, molting, wintering, and foraging habitat of listed Steller's and spectacled eiders (Figure 4a), the southwest DPS of sea otter (Figure 4b), polar bears (Figure 4c), and Kittlitz's murrelets (Figure 4d), a candidate species. Because projections cannot be made regarding the spatial distribution of future facilities that may be permitted for a mixing zone, these analyses consider the existing spatial distribution of existing mixing zones permits, and assume that mixing zones may be permitted anywhere within the ranges of listed species.

Nature of the Effects

Factors which have the potential to harm species protected under the ESA include: 1) habitat degradation; 2) exposure to harmful agents including bioaccumulative contaminants; and 3) nuisance attraction. These factors have the potential to affect listed species where the mixing zone or constituents thereof overlap with species ranges.

In several locations, multiple mixing zones either overlap or are adjacent (Figure 5), or the potential for overlap exists (where exact coordinates of the discharge pipe are not available). At times the overlapping mixing zones involve discharges with common pollutants. There is potential for WQS to be exceeded outside the mixing zone due to the combined impact of multiple discharges.

As stated above and in previous consultations with the EPA (e.g., FWS 2001), there is potential for some discharges to attract wildlife, including certain listed species (e.g., Steller's eiders), thereby exposing them to harm via contaminants exposure, disease, and predation. Seafood processing plants may discharge liquid and solid wastes including fish remains, and crustacean waste products; discharges that may serve as an attractant to listed species by providing additional food sources, or increasing localized production of prey items through nutrient enrichment. The amounts of potentially bioaccumulative contaminants contained in the discharged material will vary with the type and source of origin of the processed fish species (Ben-David et al. 2001, Jewett and Duffy 2007). Fish waste may attract predators at various trophic levels (e.g., benthic scavengers and gulls; Furness and Ainley 1984, Blum and Bechtel 2003).

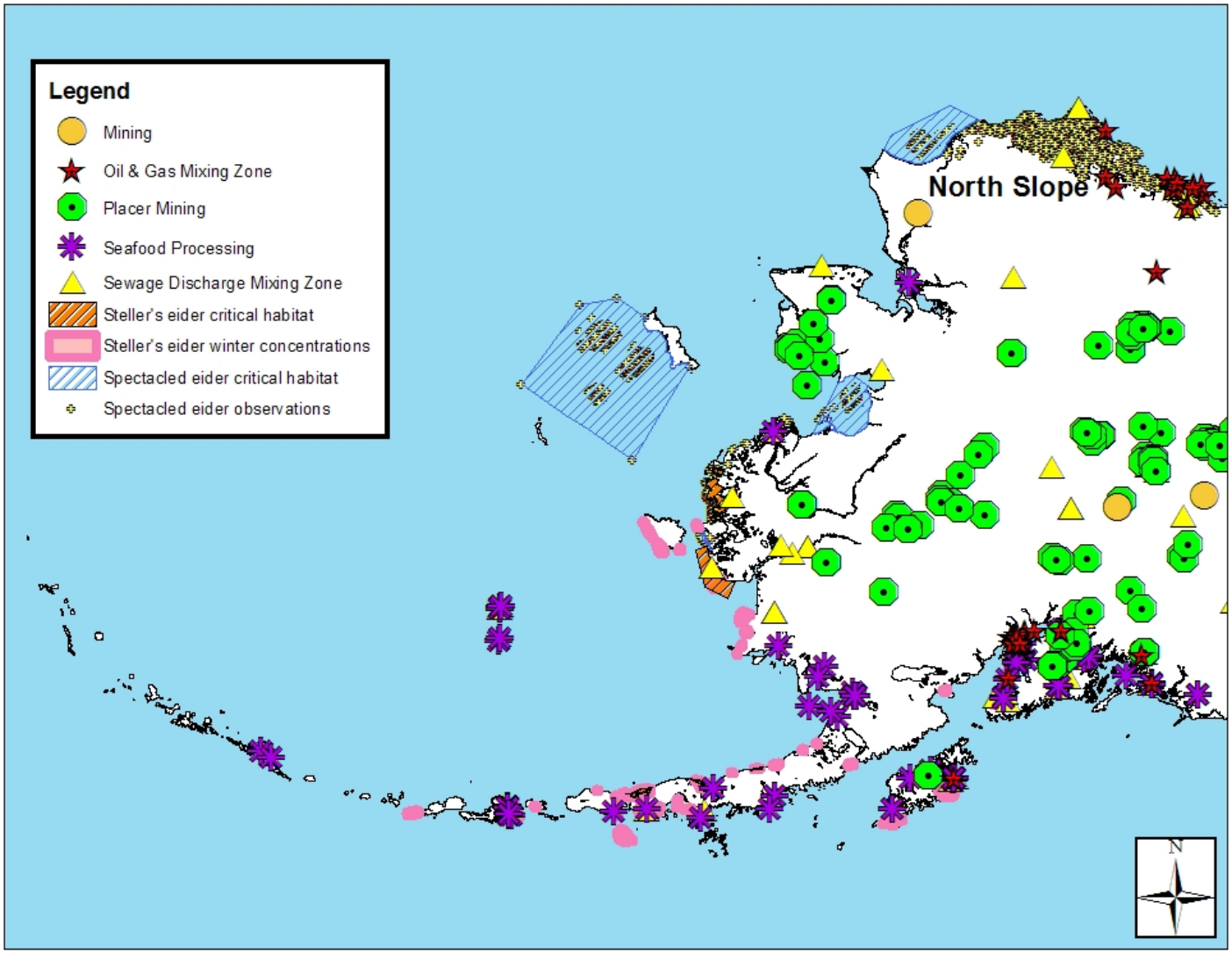

Figure 4a. Distribution of mixing zones in relation to Steller's and spectacled eiders and their habitat (data sources: FWS, EPA, ADEC).

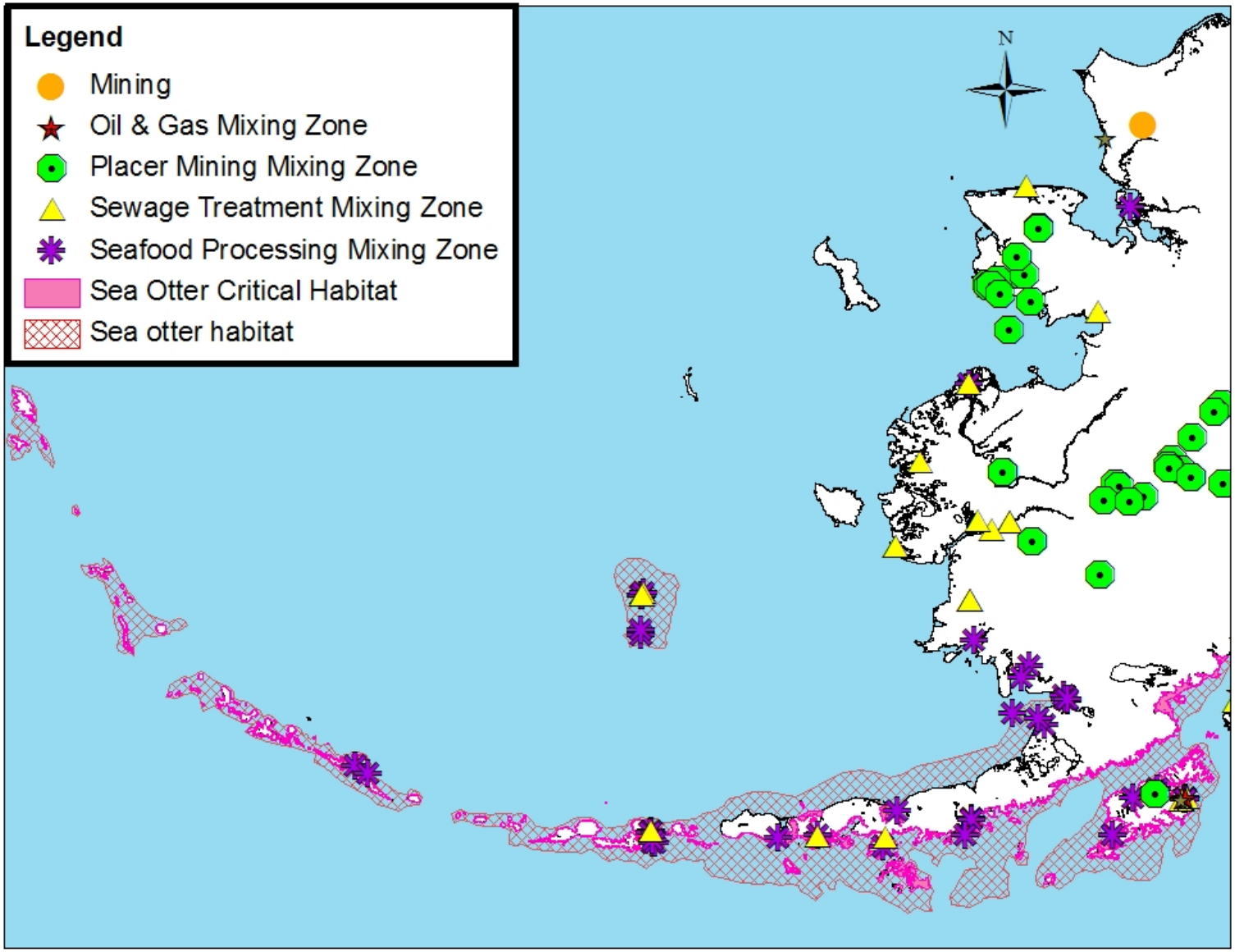

Figure 4b. Distribution of mixing zones in relation to habitat used by the southwest DPS of northern sea otter.

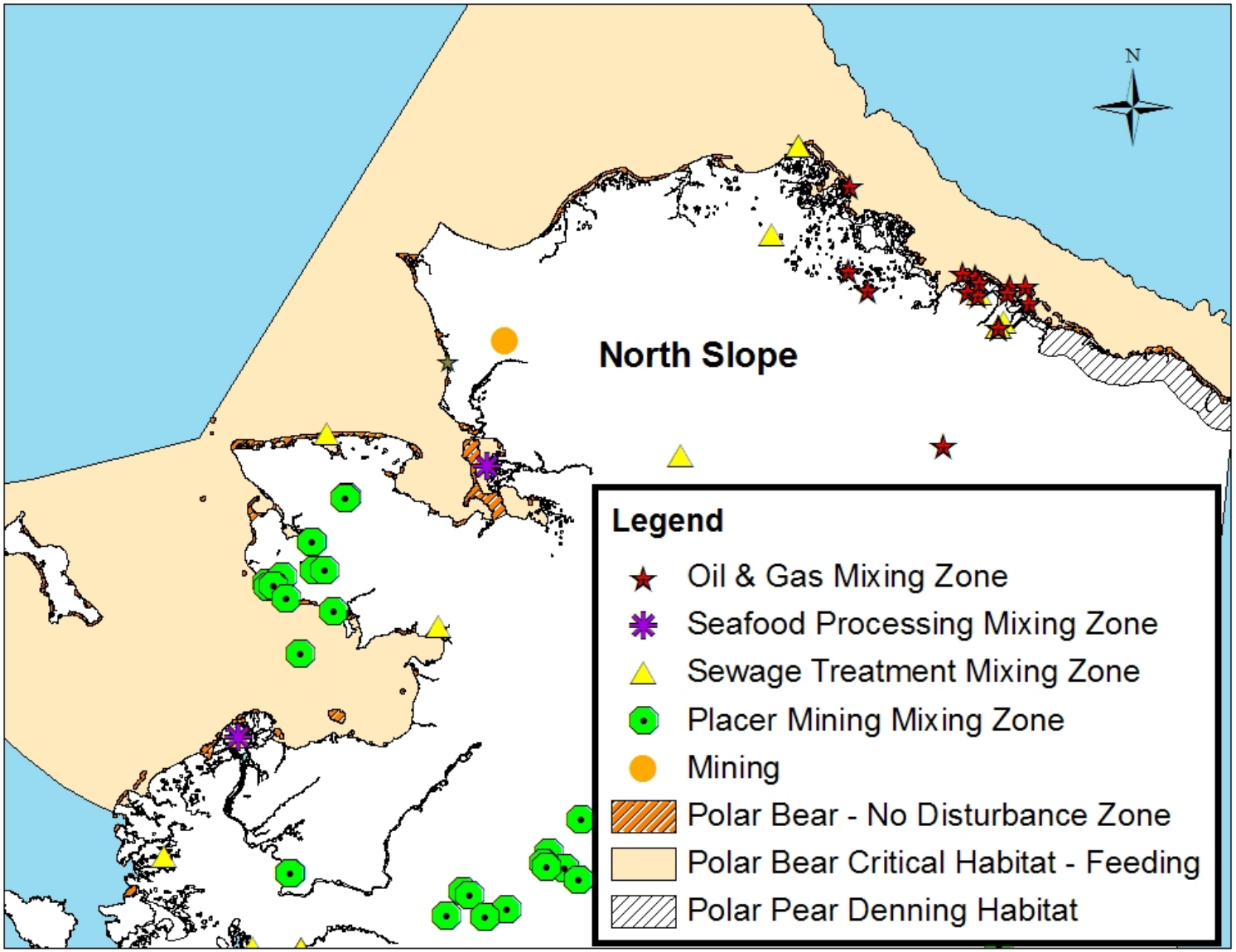

Figure 4c. Distribution of mixing zones in relation to habitat used by polar bears in Alaska.

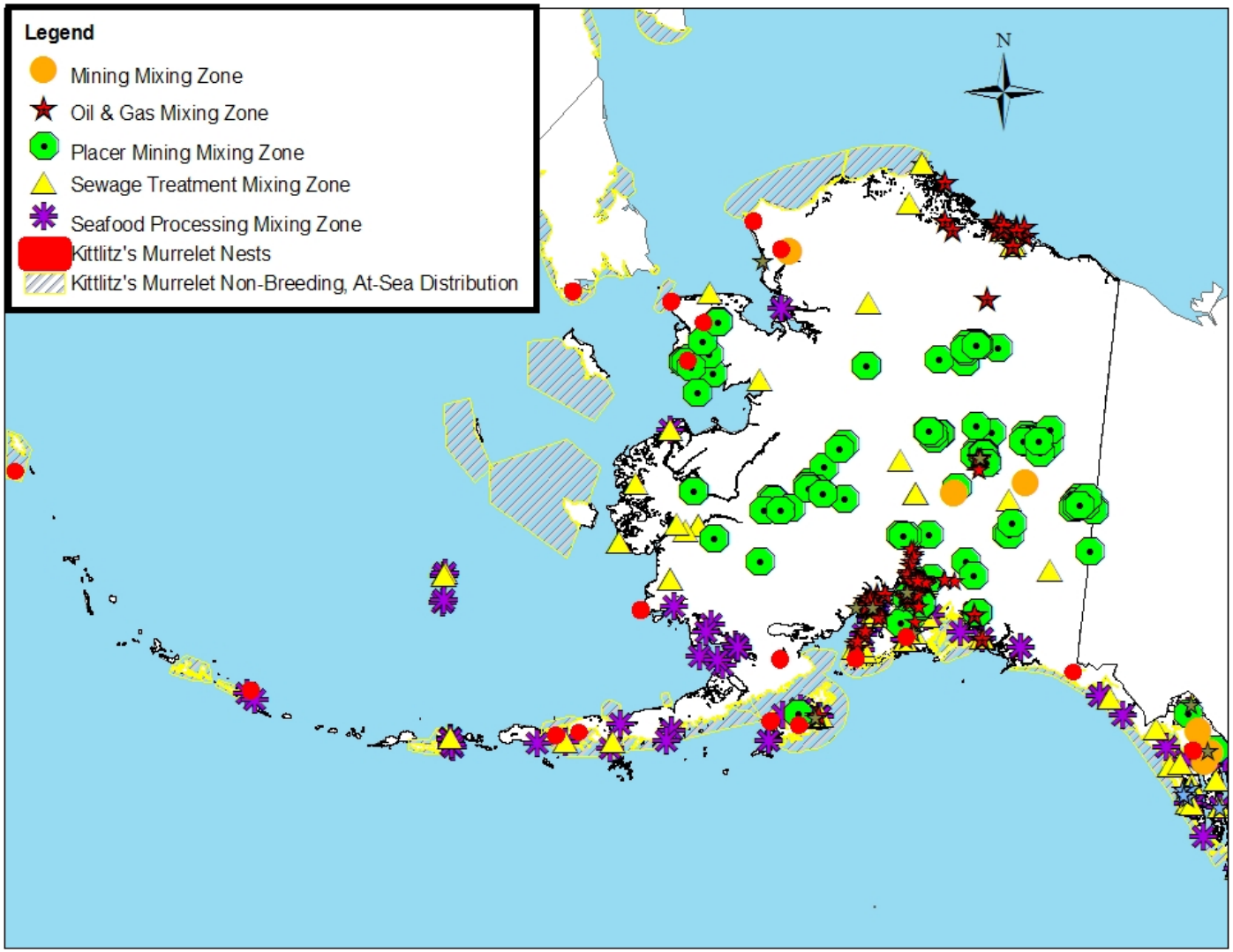

Figure 4d. Distribution of mixing zones in relation to habitat used by Kittlitz's murrelets.

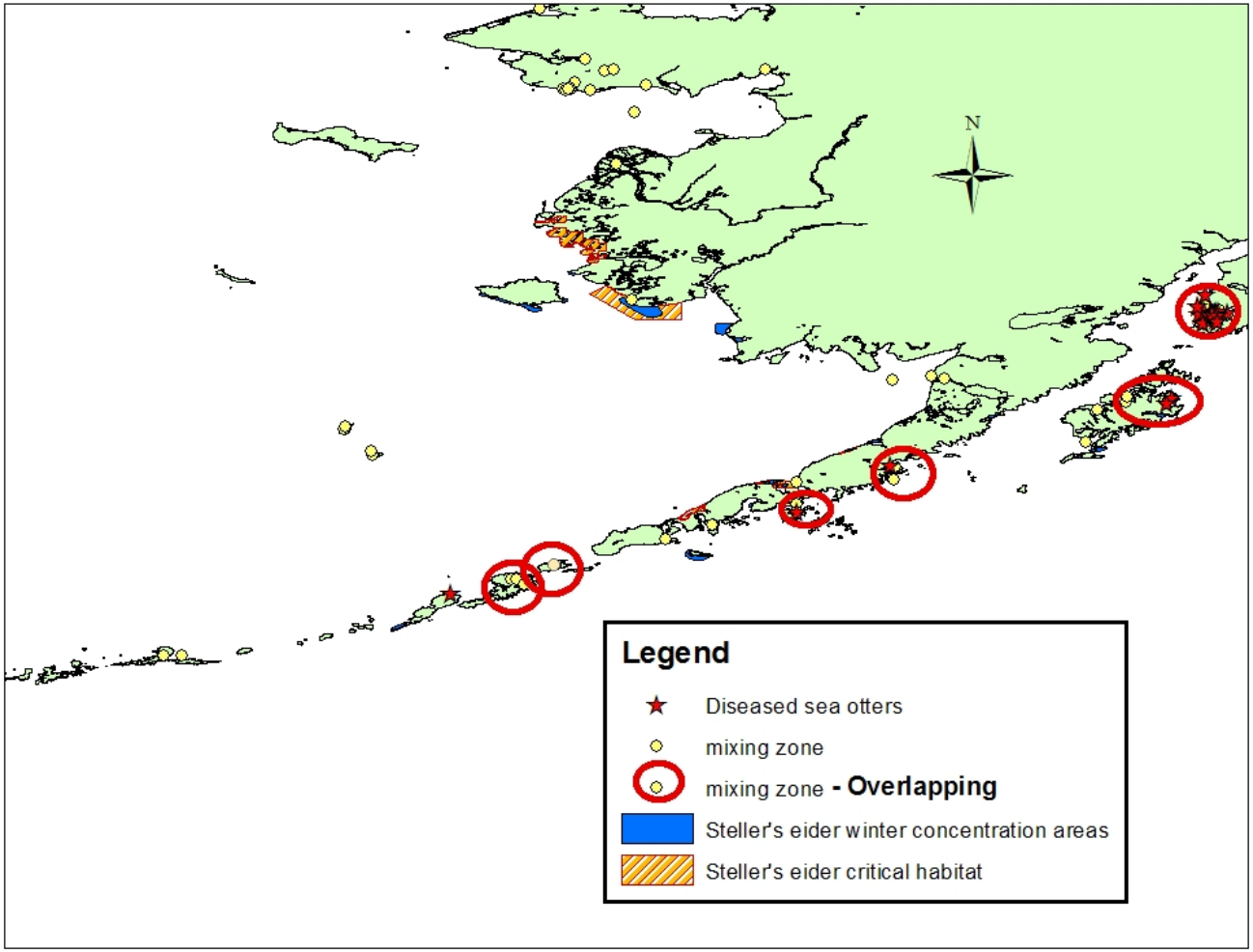

Figure 5. Overlapping or adjacent mixing zones within the range of wintering Steller's eiders and the southwest DPS of northern sea otter. Please see Figures 6(a-f) for detailed maps of each circled area (data sources: FWS, EPA, ADEC).

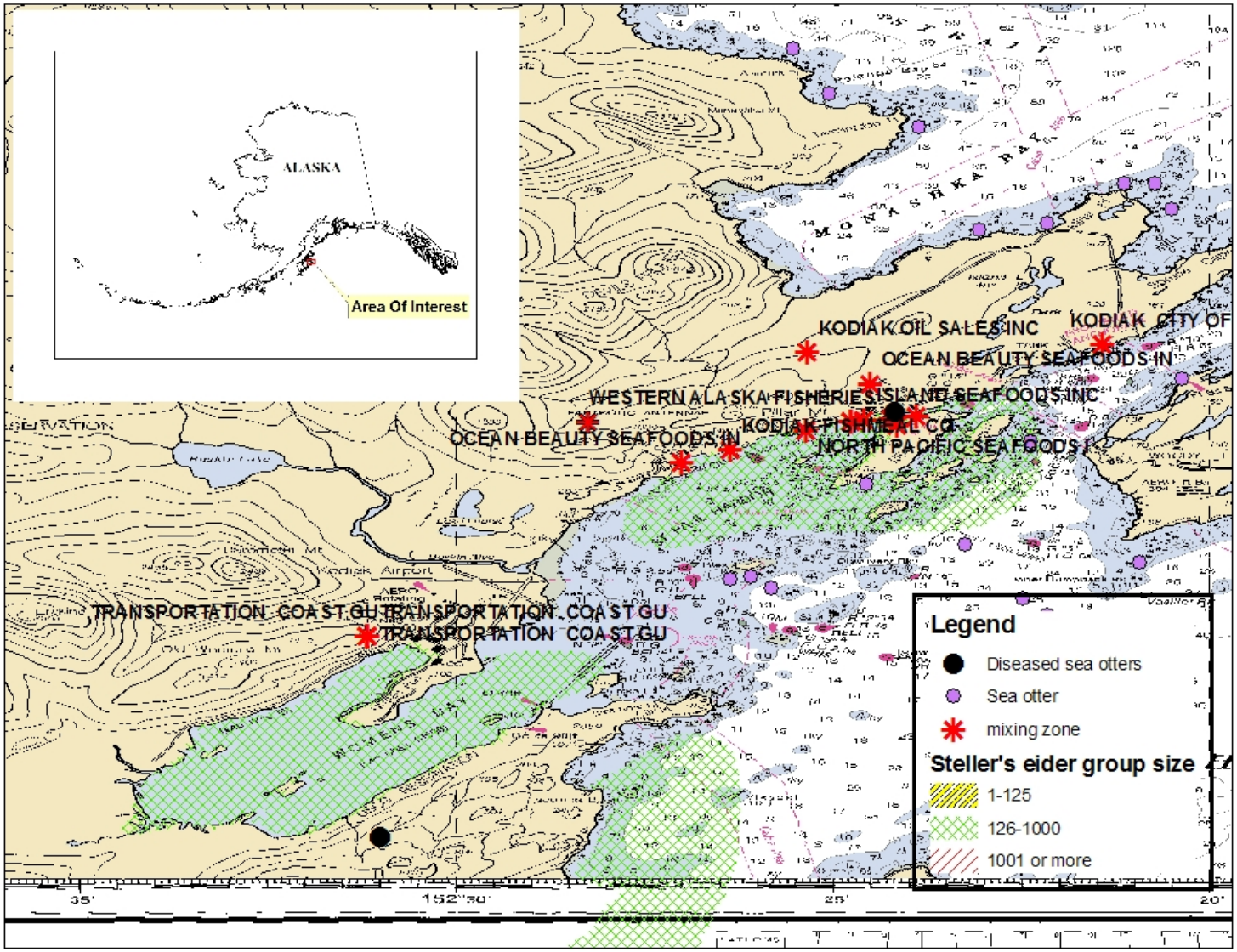

Figure 6a. Detailed map of the overlapping mixing zones in Chiniak Bay, Kodiak Island; includes range distributions of listed species and records of diseased sea otters (location data for diseased otters may not be exact).

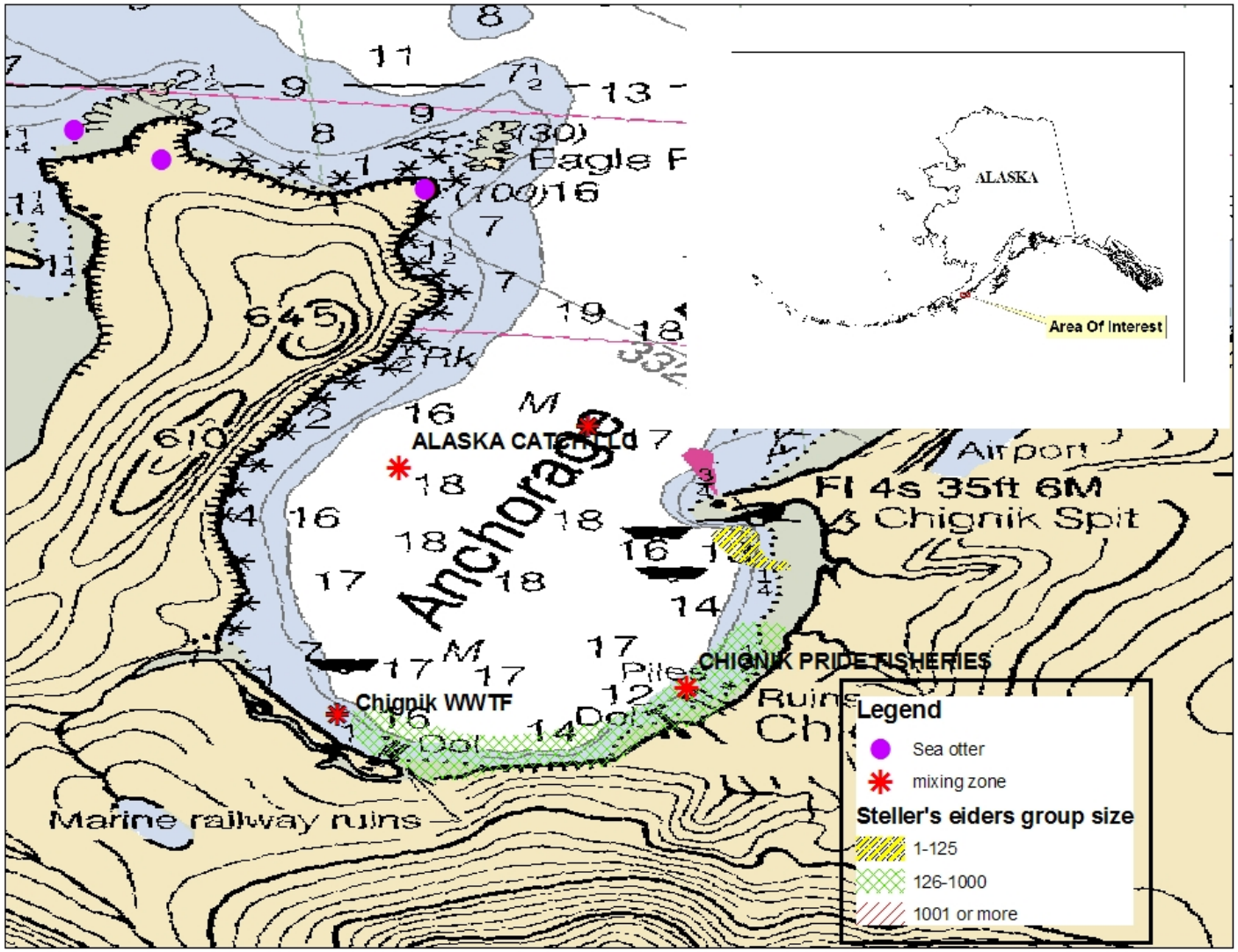

Figure 6b. Detailed map of the overlapping mixing zones in Chignik Bay, Alaska Peninsula; includes range distributions of listed species.

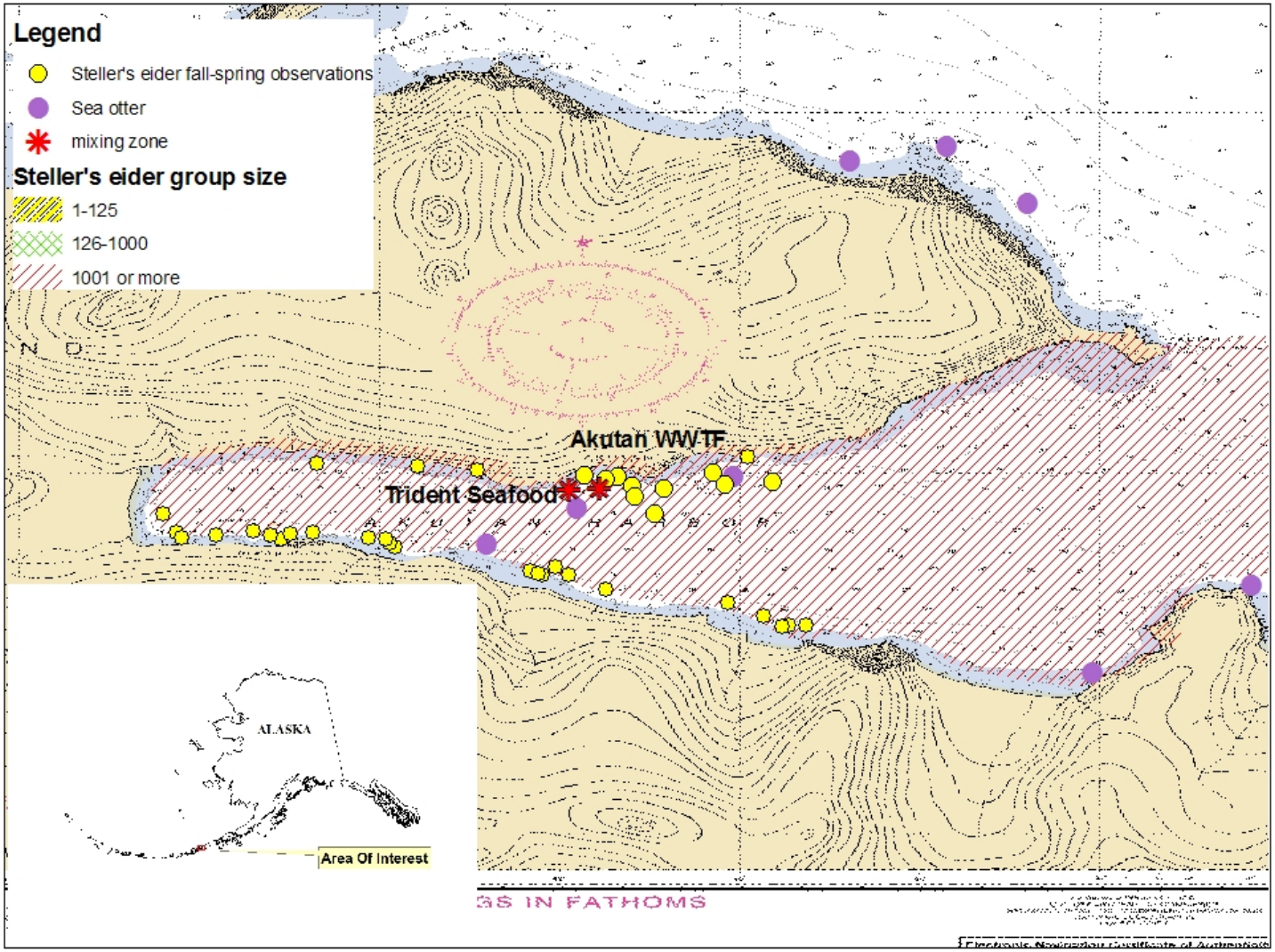

Figure 6c. Detailed map of the overlapping mixing zones in Akutan Harbor, Aleutian Islands; includes range distributions of listed species.

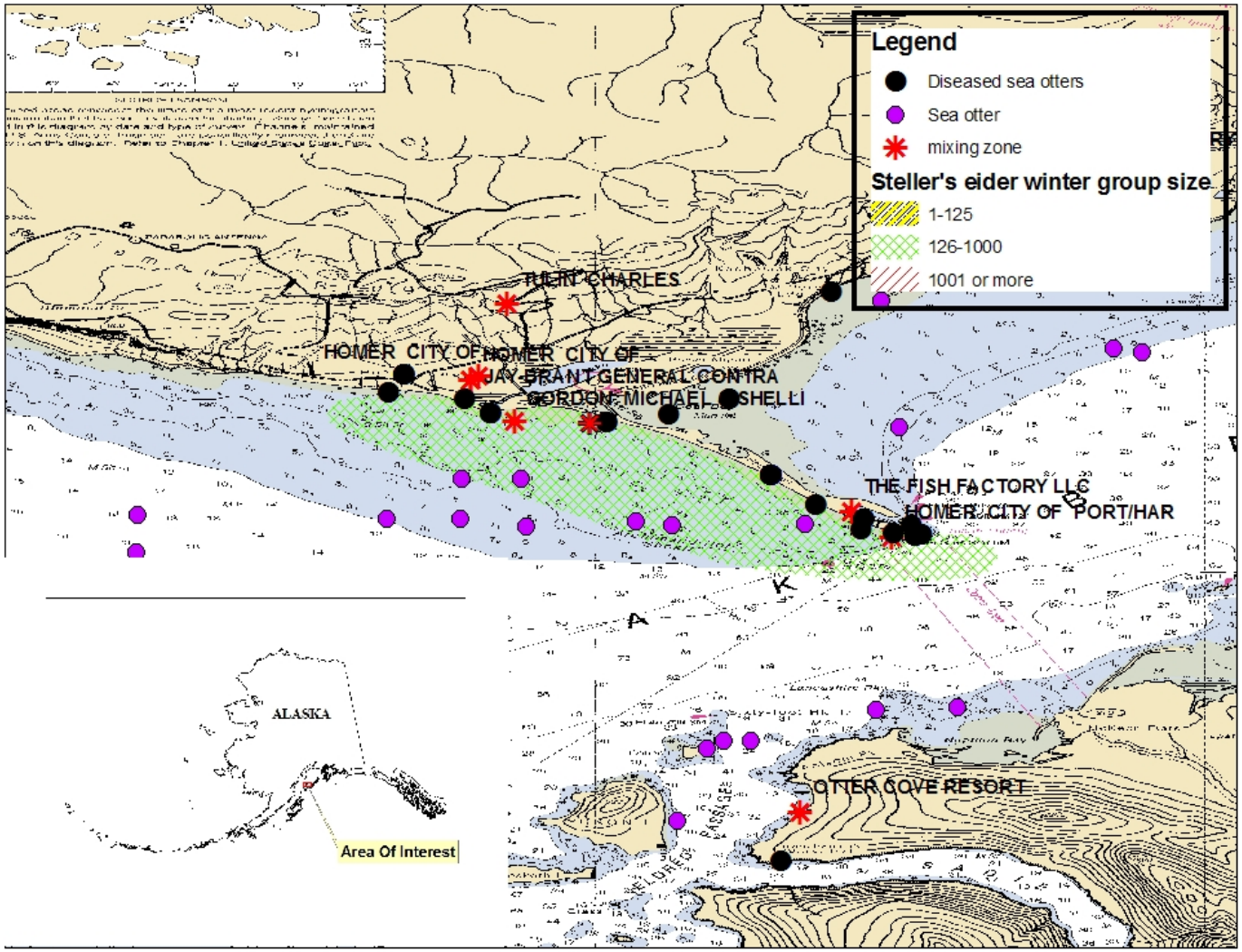

Figure 6d. Detailed map of the overlapping mixing zones in Homer, Alaska; includes range distributions of listed Steller's eiders, sea otters (not ESA-listed at this location), and records of diseased sea otters.

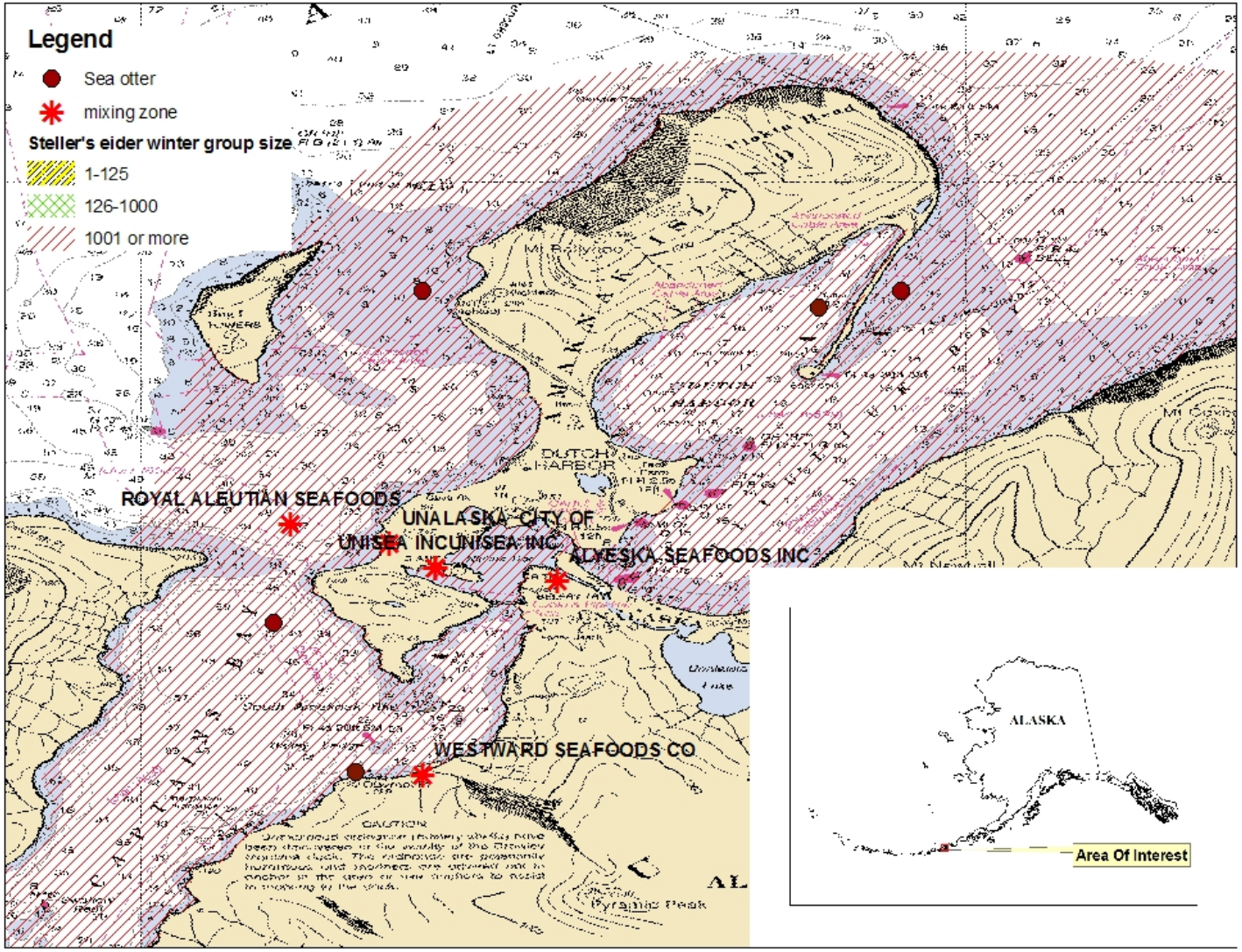

Figure 6e. Detailed map of the overlapping mixing zones in Unalaska, Aleutian Islands; includes range distributions of listed species.

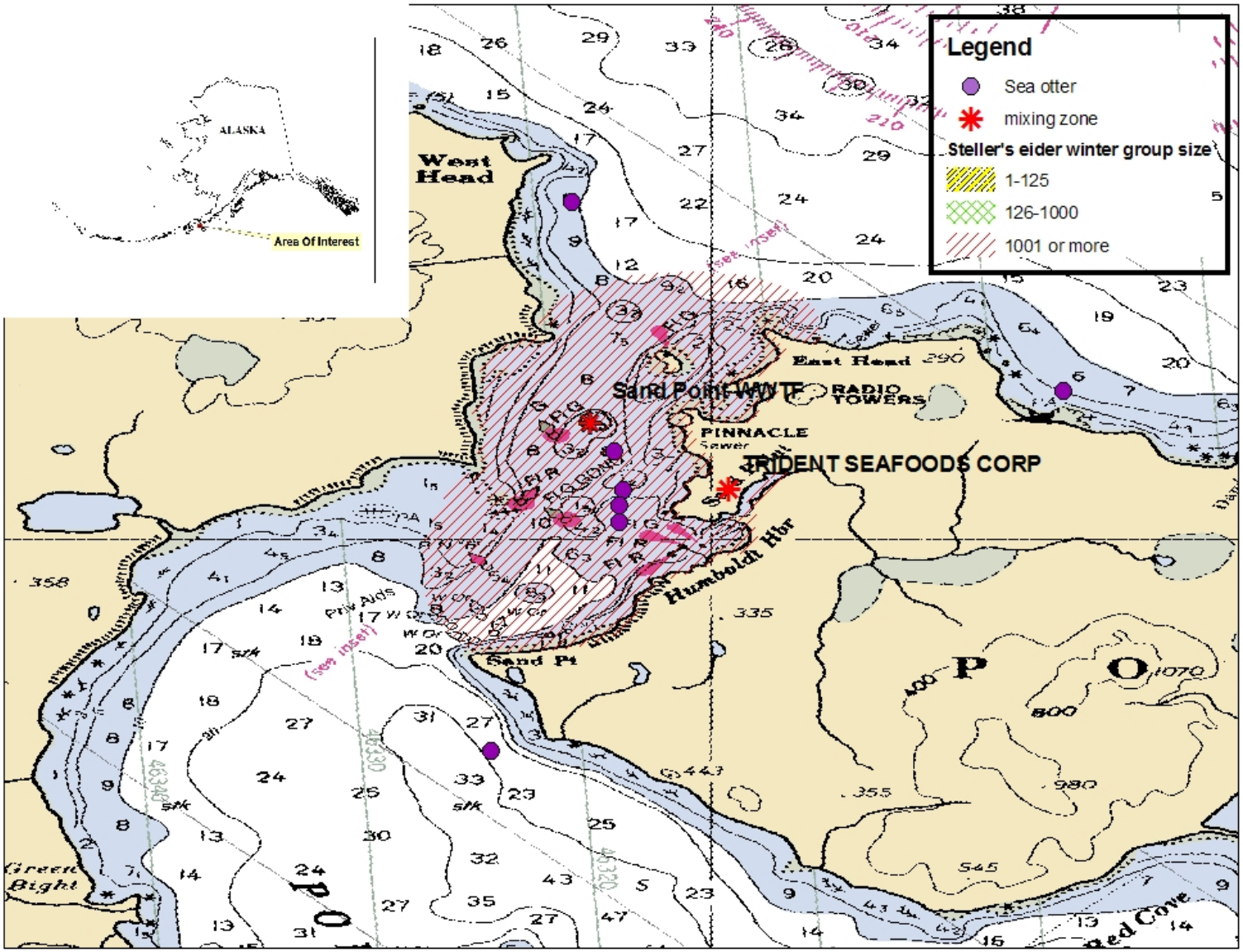

Figure 6f. Detailed map of the overlapping mixing zones in Sand Point, Aleutian Islands; includes range distributions of listed species.

Duration
The mixing zones policy was adopted in 1979 and last revised and fully approved in 1988. It is difficult to anticipate the next revision of the mixing zones policy, but based on the historical frequency of revisions, we assume the duration of this proposed action is 30 years.

Disturbance Frequency and Intensity
Potential disturbance effects are generally expected to be localized, and the frequency and intensity of the effects will depend on the type of discharge permitted, the timing of the various discharges, and compliance with the permit limits. Frequency and intensity of exposure to harmful contaminants is a function of the size of a mixing zone, the concentration of contaminants contained within the mixing zone, the amount of time that an individual from a listed population occupies the mixing zone, and the type of activity they exhibit there (e.g., feeding, resting).

The size of a mixing zone depends on physical parameters of the water body and the dilution factor that is necessary for a pollutant to meet WQS outside the area of the mixing zone. For example (EPA 2008a):

- a 30 m radius mixing zone for a seafood processing discharge was permitted for fecal coliforms, non-petroleum oil and grease, temperature, color, pH, chlorine, turbidity, and dissolved oxygen at a dilution factor of 30:1;
- a 588 m radius mixing zone for a mining facility was permitted to discharge nitrogen, cyanide, zinc, cadmium, lead, copper, and mercury at a dilution factor of 107:1;
- a 33 m radius mixing zone for an oil and gas facility was permitted to discharge dissolved oxygen, suspended solids, hydrocarbons, oil and grease, nitrogen, cyanide, sulfide, chromium, phenolics, 2 3 7 8-tetrachloro-dibenzo-p-dioxin and mercury at a dilution factor of 56:1; and
- a 30 m radius mixing zone for sewage treatment discharge was permitted for temperature, dissolved oxygen, pH, solids, nitrogen, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, sliver, zinc, chlorine, and mercury at a dilution factor of 880:1.

Mixing zones that allow exeedances of WQS associated with seafood processing discharges are generally an area of 30-meter radius, but tend to be larger for oil and gas discharges (e.g., 100 m radius), and are sometimes quite large for sewage treatment facilities (e.g., 1600 m radius) and mining operations (e.g., 588 m radius or up to 10% of the water body; ADEC 2008b, EPA 2008a). Thus, concentrations of pollutants in the receiving waters will vary, depending on the size of the mixing zone, effluent volume and effluent concentrations. Calculating the direct exposure of listed species to pollutants in a mixing zone relies upon the ability to accurately describe the overall spatial distribution of those animals, and to estimate the propensity for the listed species to occupy and feed within mixing zones over time.

Threats to Listed Species
Seafood Industry Discharges
Discharges by seafood processing plants are currently permitted by two General Permits and eight Individual Permits. The Seafood General Permit (SGP; AK-G520000), issued by EPA and expired in 2006, authorized processors to discharge seafood processing wastewater and wastes, washdown water, sanitary waste, and other wastewater generated in the seafood processing

operation from offshore seafood processors (operating and discharging more than one nautical mile from shore), near-shore seafood processors (operating and discharging between one-half and one nautical mile from shore), and shore-based seafood processors (operating and discharging within a half nautical mile from shore). The permit did not allow discharges to waters of the United States that are identified as protected, special, at-risk or degraded (i.e., excluded areas). Operators of seafood processors wishing to discharge into excluded areas may apply for an Individual Permits, or in some cases may request waivers under a SGP. Both Individual Permits and waivers that allow mixing zones in excluded areas (including critical habitat) may stipulate conditions and mitigation measures to avoid and reduce the potential to harm listed species occupying critical habitat. Under this SGP, mixing zones could be granted for dissolved oxygen, floating and suspended waste residues, color, turbidity, temperature, pH, fecal coliforms, and total residue chlorine. At worst case, dilution of these parameters would meet WQS within one nautical mile, and standards could not be violated outside the mixing zone. Further, the permit allowed a Zone of Deposit (ZOD) of one acre on the seafloor bottom. The SGP did not allow discharge of processing wastes that create an attractive nuisance situation whereby fish or wildlife are attracted to waste disposal or storage areas in a manner that creates a threat to fish or wildlife or to human health and safety. Generally, this was a self-monitoring reporting system. Although the permit has expired, dischargers continue to be covered by AK-G520000 under an administrative extension until a new permit is issued by ADEC.

Of the Individual Permits issued for seafood discharges, four are located in the waters of Unalaska Island: Alyeska Seafoods Unalaska Plant (AK0000272), Royal Aleutian Seafoods Unalaska Bay Plant (AK0026182), Unisea Unalaska Seafood Plant (AK0028657), and Westward Seafoods Captains Bay Facility (AK0049786). The remaining individual NPDES permits are Akutan Onshore Seafood Facility – Trident (AK0037303), Trident Seafoods Sand Point Plant (AK0052787), Peter Pan Seafoods King Cove Cannery (AK0052388), and MV Northern Victor (AK0052868). All of these Individual Permits authorize discharges within the range of listed Steller's eiders and sea otters. The Individual Permits in the vicinity of Unalaska required a smaller particle size to be discharged for finfish processing wastes (0.5 millimeter [mm] for one permit, and 1 mm for the rest). The size restriction for crab processing wastes is 0.5 inch, and at-sea disposal (outside one nm) restricts particle size to 0.5 mm for processing wastes, with a few providing the exception for bivalve shells. Mixing zones for seafood processing discharges generally allow exceedances of State WQS for temperature, color, turbidity, residues, non-petroleum oil and grease, dissolved oxygen, sediment and total residual chlorine.

The ADEC declared Akutan Harbor an impaired water body in 1994. The primary source of water quality degradation in the harbor is related to the discharge and accumulation of seafood processing wastes (USACE 2001). Accumulations of seafood waste particulates have been observed along the shoreline east and west of the Trident facility. The EPA has divided Akutan Harbor into two areas: the outer harbor (waters east of longitude 165°46' W) and the inner harbor (waters west of 165°46'W). The inner harbor is listed on the EPA's impaired water body list for total maximum daily load dissolved oxygen. Trident Seafoods usually operates 6 months a year: August, September, October, January, February, and March. There are four discharge lines, three of which discharge seafood-processing wastes into inner Akutan Harbor. Arctic Enterprise and Arctic Five are processing vessels that operate in the outer harbor under the conditions of the General Permit (AKG520000). Arctic Five barges its seafood waste to the

Trident facility for processing into fish meal and Arctic Enterprise barges its waste out of Akutan Harbor and discharges it according to General Permit conditions.

Based on a series of observations made while conducting dive surveys, Schroeder (2001 as cited in FWS 2002a) characterized degradation of habitat, due to the release of organic waste into the near-shore marine environment, reported degraded water quality and decreased biological productivity, especially at the head of the Bay where circulation is poor. According to dive surveys conducted in June 2000, conditions have improved since the 1980s, indicated by abundant marine organisms up to the anoxic seafood waste deposits. Additionally, polychaete worms occurred in dense concentrations, indicating that the site remains disturbed, and that new organic material is readily available. Schroeder (2001) concluded that sufficient oxygen was available for decomposition of the current waste input but not sufficient to aid in the decomposition of historic waste piles that remain on the Akutan Harbor seafloor. The deposition of residues on the sea bottom results in modification in the benthic community through smothering, creation of anoxic conditions due to high biochemical oxygen demand, changes in the microbial community, and a shift to a planktonic scavenger food web (Bluhm and Bechtel 2003). Seafood processing waste directly or indirectly serves as an attractant to Steller's eiders either by providing fish waste as an additional food source, or by increasing planktonic or benthic scavenger populations. An increased concentration of sea ducks likely also attracts higher trophic level predators (e.g., bald eagles) to this concentrated food source.

Seafood processing facilities are directly associated with the fishing industry. Infrastructure associated with the fishing industry includes fishing vessel and barge traffic, fueling operations, vessel maintenance and vessel mooring. This association increases the probability that petroleum hydrocarbons and other contaminants will be accidentally spilled into the marine environment in the vicinity of the seafood processing discharges (Day and Pritchard 2000). At South Unalaska Bay, Steller's eiders prefer mixing zones for winter foraging (Reed and Flint 2007), but this attractive habitat is compromised by biotic and abiotic pollutants (Miles et al. 2007; Hollmen et al. 2008, Hollmen et al. 2010) and concentrations of predators, thus creating an ecological trap (Battin 2004). We believe that this ecological trap scenario also occurs at locations other than South Unalaska Bay.

Within the range of Pacific wintering Steller's eiders, we have identified five harbors in which Steller's eiders have been either documented or anecdotally observed concentrating at seafood processing discharges. Furthermore, these five harbors are busy fishing ports, where petroleum hydrocarbon contamination is either known to occur, or presumed based on oil spill reporting. At these five harbors, approximately:

- 700 Steller's eiders winter in Akutan Harbor (Larned 2000).
- 1300 Steller's eiders winter around Unalaska (Larned 2000);
- 1000 Steller's eiders winter around Sand Point (Larned 2000);
- 1300 Steller's eiders winter at Kodiak Island's Chiniak Bay (Larned and Zwiefelhofer 2002); and
- 1000 Steller's eiders winter in Chignik Bay (Larned 2000).

As stated above, permits for seafood processing facilities include a mixing zone with a typical radius of 30 meters for floating and suspended residues.

The legal deposition of seafood processing waste solids, through a permitted ZOD, allows the accumulation of solids on the receiving water body, causing eutrophication. Grinding of seafood waste to smaller particle size as required in some individual NPDES permits (0.05 to 1.0 millimeter for finfish waste versus 0.5 inch in the general permit; 0.5 inch for crab processing wastes) would lessen the potential for the waste to form deposits on the bottom near the discharge, but the waste would remain suspended in the water column for further dispersion and wider exposure to food webs.

Small size particles (0.5 inch, 1 millimeter, or 0.5 millimeter) may be ingested by smaller organisms (e.g., filter feeders and detritivores), with bioaccumulated contaminants becoming incorporated into planktonic and benthic based food webs. There is potential for increased exposure to bioaccumulative contaminants contained in the discharged fish material (the amount will vary with the type and source of origin of the processed species; Ben-David et al. 2001; Jewett and Duffy 2007). Species harvested as seafood can amass bioaccumulative contaminants at the harvest location, and be processed at another location (the seafood processing facility), releasing those bioaccumulative contaminants in the processor's mixing zone. Concentrations of lipophilic contaminants such as planar PCBs are typically higher in liver and gonadal tissue of fishes, compared to muscle tissue (reviewed in Eisler and Belisle 1996). Liver tissues of walleye pollock (*Theragra chalcogramma*), the most commercially important fish in the Bering Sea, have been analyzed for organochlorine (OC) residues. PCB and DDT concentrations were greater than other OCs analyzed in these liver tissues, (de Brito et al. 2002). Therefore, it is reasonable to assume that seafood processing wastes, such as discarded fish parts like livers and gonads, may hold higher concentrations of contaminants than the parts processed for human consumption.

Finally, petroleum hydrocarbon spills, while they are illegal, are reasonably certain to occur at or in association with seafood processing facilities. There is the potential for petroleum leaks, spills, and chronic discharges due to the boat traffic associated with the off-loading vessels. Because attraction to some mixing zones leads to subsequent exposure to harmful agents such as petroleum hydrocarbons and bioaccumulative contaminants, we concur with EPA's determination that the implementation of the Mixing Zones Regulation is likely adversely affect listed species, particularly Steller's eiders. However, if the distribution of seafood processors changes in the future, for example in response to new or expanded fisheries that may result from climate change and reductions in the extent of sea-ice, then other listed species (e.g., spectacled eiders) may be adversely affected as well.

<u>Spectacled eiders</u> –Spectacled eiders are rarely observed in areas where seafood processors discharge and where large petroleum spills have occurred (e.g., around the Pribilof Islands). Recently, however, ADEC has permitted mixing zones within spectacled eider critical molting habitat in Norton Sound via a waiver under the SGP, raising concerns about habitat destruction, nuisance attraction, and contamination during a highly vulnerable time in the life history of this threatened species. Moreover, the potential development of groundfish fisheries within critical wintering habitat near St. Lawrence Island is of concern. Fisheries within this area will lead to

processing product and therefore discharging of waste, likely within a mixing zone. Direct or indirect attraction to this new protein source may expose spectacled eiders to contaminants such as petroleum hydrocarbons and bioaccumulative pollutants.

Steller's eiders -- A non-discretionary Term and Condition to allow Incidental Take, issued to EPA as part of a 2001 Biological Opinion on the reissuance of the SGP, directed EPA to implement a study to determine if Steller's eiders are attracted to the discharge from seafood processors and to determine the benefits and risks of such attraction to the birds and to the industry (FWS 2001). As agreed upon during the formal consultation process, EPA was to coordinate with the FWS and implement the study within 12 months of the issuance of the permit. To our knowledge, this study was never undertaken. Absent data from such a study, the FWS must use the best available information and conclude that attraction of Steller's eiders to seafood processing mixing zones results in increased exposure to contaminants, disease, and predation by bald eagles.

Sea otters – The distribution of sea otters from the southwest Alaska DPS includes numerous near-shore locations where seafood processors discharge, such as Akutan, Unalaska, Adak, Port Moller, and Kodiak. We do not believe the otters are directly or indirectly attracted to the seafood discharges in these locations, but rather their natural distribution overlaps the bays in which the seafood processors discharge. Exposure to contaminants, such as petroleum hydrocarbons and bioaccumulative pollutants, and disease and parasites associated with seafood processing discharges put sea otters at risk of adverse effects.

Polar Bears – At this time, the distribution of seafood processing discharges does not significantly overlap with the distribution of polar bears.

Kittlitz's Murrelets – In the Aleutians, glaucous-winged gull abundance may be unnaturally high due to perpetual availability of seafood processing waste for food (Gibson and Byrd 2007). Kittlitz's murrelet nest predation by gulls has been documented on Agattu Island in the Near Island group of the Aleutians. The rate of predation by glaucous-winged gulls on Kittlitz's murrelet eggs was high and accounted for the failure of 40% of nests observed (Kaler et al. 2009). Kittlitz's murrelets are present in the waters around Kodiak Island, where numerous mixing zones for seafood discharges are permitted. The distributional overlap of Kittlitz's murrelets and seafood processing discharges appears low at this time, but the indirect association between seafood discharges and increased localized predator populations may adversely affect Kittlitz's murrelets.

Sewage Treatment Discharges

Currently, sewage treatment facility discharges are covered by two General Permits and 14 Individual Permits. The two General Permits cover small publicly-owned treatment works and other small treatment works providing secondary treatment of domestic sewage and discharging to fresh or marine waters. Facilities must have a discharge flow under 1.0 million gallons per day and must not discharge to an impaired water body. Mixing zones for sewage treatment facilities may exceed WQS for arsenic, fecal coliforms, cadmium, chlorine, chromium, copper, iron, lead, manganese, mercury, nickel, nitrogen, pH, silver, zinc, and reductions in dissolved oxygen.

Untreated sewage discharge may adversely affect blue mussels, a primary food source for Steller's eiders (Moles and Hole 2003). When exposed to fecal bacteria, blue mussels lose their capability to resist pathogens (Akaishi et al. 2007). Further, sewage treatment discharges may contain bioaccumulative contaminants, infectious and pathogenic organisms, endocrine disrupting contaminants, pharmaceuticals, and personal care products (Kanda et al. 2003, Watkins and Cabelli 2005, Miller et al. 2006, EPA 2008a), all of which may directly or indirectly harm listed species.

Among the Individual Permits, discharges from the City of Unalaska's sewage treatment facility are authorized by the EPA. This sewage treatment facility has been granted a mixing zone that allows exceedances of the WQS for fecal coliform, pH, temperature, and dissolved oxygen within a 100 meter radius of the end of the pipe. A ZID is allowed for total residual chlorine.

The permit compliance history for the Unalaska facility is informative. Permit limitations for the wastewater effluent specify that the maximum daily concentration of fecal coliform bacteria may not exceed 15,000 colonies per 100 ml and the average monthly maximum may not exceed 10,000 colonies per 100 ml. On February 29, 2004, the month in which four Steller's eiders from South Unalaska Bay were found dead and had evidence of *E. coli* infections, monitoring reports reveal that fecal coliform levels at the wastewater effluent were 220,000 colonies per 100 ml. Subsequently, between December 2005 and September 2006 the monthly fecal coliform discharge limits were exceeded four times:

- February 2006 the average monthly maximum for fecal coliforms was 73,000 colonies per 100 ml;
- March 2006 the monthly maximum for fecal coliforms was 180,000 colonies per 100 ml;
- August 2006 the monthly maximum for fecal coliforms was 54,000 colonies per 100 ml;
- September 2006 the monthly maximum for fecal coliforms was 65,000 colonies per 100 ml.

We note that chlorination at the facility began in June 2006 and still fecal coliform discharge limits were exceeded in August and September of that year.

<u>Steller's eider</u> –Steller's eiders are attracted to wastewater discharges (Reed and Flint 2007) containing PAHs (Miles et al. 2007) and bacteria (EPA 2008b). As described in the *Case Study: Steller's Eider Wintering Around Unalaska Island in the Aleutians* (page 25), we hypothesize that attraction to seafood waste discharges that are: 1) co-located with other waste discharges; and are 2) located in water bodies that are polluted by non-point source discharges, results in an ecological trap whereby Steller's eiders are adversely affected. There is strong evidence that some mixing zones that permit exceedance of WQS for residues cause eutrophication of the benthic marine environment, attracting organisms from many trophic levels (e.g., mobile benthic scavengers, Steller's eiders, gulls, and bald eagles). Steller's eiders are preferentially attracted to the eutrophied, nearshore marine waters that serve as reservoirs for legally or illegally discharged pollutants. Steller's eiders' risk of exposure to harmful contaminants may be elevated in the presence of mixing zones within water bodies that are impaired, or have multiple, overlapping or adjacent mixing zones. Besides Unalaska, we have identified four other water bodies where the scenario is similar: Akutan Harbor, Sand Point Harbor, Kodiak Island-Chiniak Bay, and Chignik Bay.

Sea otters - Sea otters feeding in the vicinity of wastewater treatment facility discharges may be exposed to *T. gondii*. Because sea otters feed on marine macroinvertebrates such as bivalves, snails and crustaceans, ingestion of oocytes indirectly when eating filter feeders seems to be the most likely mode of transmission. *T. gondii* oocytes may remain viable and infective even after water chlorination or sewage processing (Wainwright et al. 2007). Concentration of oocytes by clams, mussels and oysters during filter-feeding activity has been shown in numerous studies cited by Conrad et al. (2005). Therefore, raw shellfish could be a source of pathogenic protozoal infection for both marine mammals and humans. Other possible routes of exposure and subsequent *T. gondii* infection include ingestion of oocytes through seawater, by grooming and ingesting oocytes collected in sea otter fur or by ingestion of oocytes in prey other than bivalves (Conrad et al. 2005).

Recent disease-screening of sea otters in Alaska confirmed exposure to *T. gondii* (V. Gill, Marine Mammals Management, Anchorage, Unpublished Data). Four of 84 salvaged sea otter carcasses tested positive for *T. gondii*. Those animals were from Kachemak Bay[2] and Resurrection Bay (not the listed DPS of northern sea otter). Of 87 live sea otters tested for *T. gondii* titers, two animals from the waters around Kodiak Island (the listed DPS of northern sea otter) were positive. All three areas where the animals tested positive for *T. gondii* (Kachemak Bay, Resurrection Bay, and Kodiak Island) represent water bodies in which mixing zones are permitted for sewage treatment facilities. One animal positive for *T. gondii* was from Seldovia, which discharges sewage effluent into Kachemak Bay. These data confirm that northern sea otters including the listed DPS of sea otters in Alaska are exposed to *T. gondii*, and we cannot rule out the possibility that exposure results from discharges from sewage treatment facilities (Figure 7a, Figure 6d).

Spectacled eiders, Polar bears and Kittlitz's murrelets - While exposure to contaminants and pathogens associated with sewage treatment plant discharges could be harmful to all marine species protected under the ESA, few wastewater mixing zones are currently permitted within the ranges of spectacled eiders, polar bears or Kittlitz's murrelets (3, 4, and 9 wastewater mixing zones, respectively; Figures 4a,b,c,d, and 7a,b). Notably, a recent waiver under the SGP allowing discharges into a mixing zone within spectacled eider critical habitat allows the co-mingling of sewage with seafood processing waste, and has raised concern. However, to avoid harming spectacled eiders, the FWS is working closely with ADEC to monitor amounts of fecal waste and seafood offal discharged into critical habitat, and the timing of those discharges relative to occupancy by spectacled eiders during the molt. Therefore, we conclude that mixing zones for sewage treatment discharges do not currently put spectacled eiders, polar bears and Kittlitz's murrelets at risk of harm.

Oil and Gas Discharges

Oil and gas discharges are currently regulated by three General Permits and six Individual Permits. The General Permits cover oil and gas facilities of the Outer Continental Shelf and Contiguous State Waters, the Federal and State Waters of Cook Inlet, and the North Slope Borough. These General Permits allow discharges of drilling fluids and drill cuttings, deck

[2] Diseased sea otters have been recovered from Kachemak Bay (Figure 6a, Appendix VId), but the otters from this location do not comprise the listed stock and are not protected under the ESA.

drainage, sanitary wastes, domestic wastes, desalination unit wastes, blowout preventer fluid, boiler blow-down, fire control system test water, non-contact cooling water, uncontaminated ballast water, bilge water, gray-water discharges, gravel pit dewatering, construction dewatering, hydrostatic test water, storm water, mobile spill response, excess cement slurry, mud, cuttings, cement at seafloor, and test fluids. The discharge of water-based drilling fluids and drill cuttings is not allowed in waters less than 5 meters in depth. The mixing zones for oil and gas discharges allow discharges of effluents with antimony, aromatic hydrocarbons, arsenic, cadmium, chromium, copper, cyanide, lead, manganese, mercury, nickel, oil and grease, selenium, silver, 2, 3, 7, 8-tetrachloro-dibenzo-P-dioxin, thallium, and zinc at concentrations that exceed the WQS. A number of these (dioxin and mercury in particular) are known to biomagnify within food webs. Selenium, copper, and cadmium have been found to be elevated in liver and kidney tissues of listed eiders, relative to other waterfowl, and may warrant concern (Stout et al. 2002). Mixing zones also allow for sanitary waste discharges associated with the oil and gas infrastructure and permit exceedances of the WQS for fecal coliform bacteria, chlorine, pH, and dissolved oxygen.

Dioxin -- The EPA and ADEC have approved mixing zones for 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD), the most toxic congener of dioxin, for oil and gas related discharges. In humans, exposure to persistent organic pollutants (POPs) such as dioxin causes among other conditions, cancer, birth defects, immune system defects, and altered sex hormone balance (EPA 2010). In birds, chicken embryos are much more sensitive than other species tested, with embryonic mortality, edema and malformations observed during egg injection studies (Hoffman et al. 1996). Species high in the aquatic food chain (polar bears, seals, piscivorous birds and cold-water fish species) with high exposure potential through biomagnification are particularly vulnerable to dioxin exposure and effects (Rice et al. 2003). Only limited sampling of dioxins have been conducted in polar bears from Alaska, with dioxin concentrations generally increasing with age of the bears (Kumar et al. 2002). Estimates of 2,3,7,8-TCDD equivalents (TEQs) of polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs) and dioxin-like PCBs in polar bears were close to those that may cause adverse health effects (Kumar et al. 2002). Therefore, increased exposures to dioxins and dioxin-like PCBs from mixing zones are of particular concern for this species.

While we are unaware of dioxin data for listed eiders in Alaska, common eiders from the Baltic region readily bioaccumulate PCDDs and PCDFs (Broman et al. 1992). Rozemeijer et al. (1995) dosed common eiders with CB 77, a TCDD-type inducer, eliciting a cytochrome P450 response. As mentioned above (page 7), elevated levels of P450 indicate exposure to contaminants. Exposure to dioxin-like compounds in other birds has elicited a reduction in vitamin A and altered thyroid hormone levels (related studies are cited in Rozemeijer et al. 1995).

Bacon et al. (1999) sampled sea otters from the western Aleutian Islands, Southeast Alaska and California. While concentrations of PCDDs and PCDFs were greater in California sea otters, relative to the Alaska samples, they reported that concentrations were very low and likely not of toxicological significance. During this study, the sea otters in the western Aleutians had total PCB concentrations 1.7 times greater than those observed in California otters, while non-ortho (coplanar) PCBs (generally among the most toxic PCB congeners) were greatest in California, but not statistically different from the other two populations sampled.

Kannan et al. (2004) found elevated concentrations of dioxin-like PCBs (non-ortho and mono-ortho PCBs) in California, with estimated TEQs exceeding toxicological thresholds. This study did not, however, measure PCDDs or PCDFs, so the total TEQ estimates may actually be low. California sea otters that were classified as having died from infectious disease had significantly higher PCB concentrations, relative to the non-disease-exposed population (Kannan et al. 2007a).

As oil and gas development expands into new areas such as the North Aleutian Basin, Chukchi Sea, and the Beaufort Sea region, the potential for listed species (i.e., spectacled eider, Steller's eider, sea otter, and polar bear) exposure to this hazardous class of contaminants will increase.

Harmful physiological effects have been documented for some aquatic mustelids that experimentally ingested controlled concentrations of 2,3,7,8-TCDD (Kannan et al. 2000). According the EPA's modeling of effects from exposure to dioxin, which they provided to the FWS in support of their Biological Evaluation (see detailed discussion of EPA model on page 68), concentrations exceeding 0.000004 ppm per day (NOAEL; no observed adverse effects level; the highest concentration in a test with a mean response that does not differ significantly from the mean response of the control) would result in adverse reproductive and growth effects to juvenile sea otters. In contrast, concentrations exceeding 1.45 ppm per day would result in adverse reproductive and growth effects to adult Steller's eiders (based on the NOAEL; EPA 2008a).

Mercury -- Wildlife species occupying higher trophic levels, such as polar bears, are especially vulnerable to the toxic effects of mercury because methyl mercury. Methyl mercury is the most bioavailable form of mercury, and can biomagnify at successive trophic levels in the aquatic food chain (Strom 2008). Atmospheric mercury enters aquatic systems primarily in the inorganic form and is methylated to the more toxic methyl mercury in some aquatic systems by sulfate-reducing bacteria. Exposure to methyl mercury is usually by ingestion, and it is absorbed more readily and excreted more slowly than other forms of mercury. Animals that prey on mollusks have lower concentrations of mercury than those that prey on fish (Dehn et al. 2005, 2006 as cited in Jewett and Duffy 2007). Shark, swordfish, king mackerel, and tilefish contain high levels of mercury, and the EPA has advised limiting human consumption of these fish species. Mink and river otter accumulated about ten fold more mercury that did predatory fish from the same drainage areas, suggesting that these species can serve as sensitive indicators of mercury exposure (Eisler 1987).

Polar bears are known to bioaccumulate mercury and other contaminants at concentrations that exceed those found in ringed seal, their primary prey (Woshner et al. 2001, Kucklick et al. 2002). Hair from 397 Greenland polar bears sampled between 1892 and 2001 was analyzed for temporal trends in mercury concentration. In East Greenland the concentrations showed a significant increase of 3.1%/year in the period 1892-1973. The mercury concentration during 1985-1991 from Northwest Greenland was more than 14-fold higher than the assumed baseline level, derived from two hair samples from 1300 A.D. from the same region (Dietz et al. 2006).

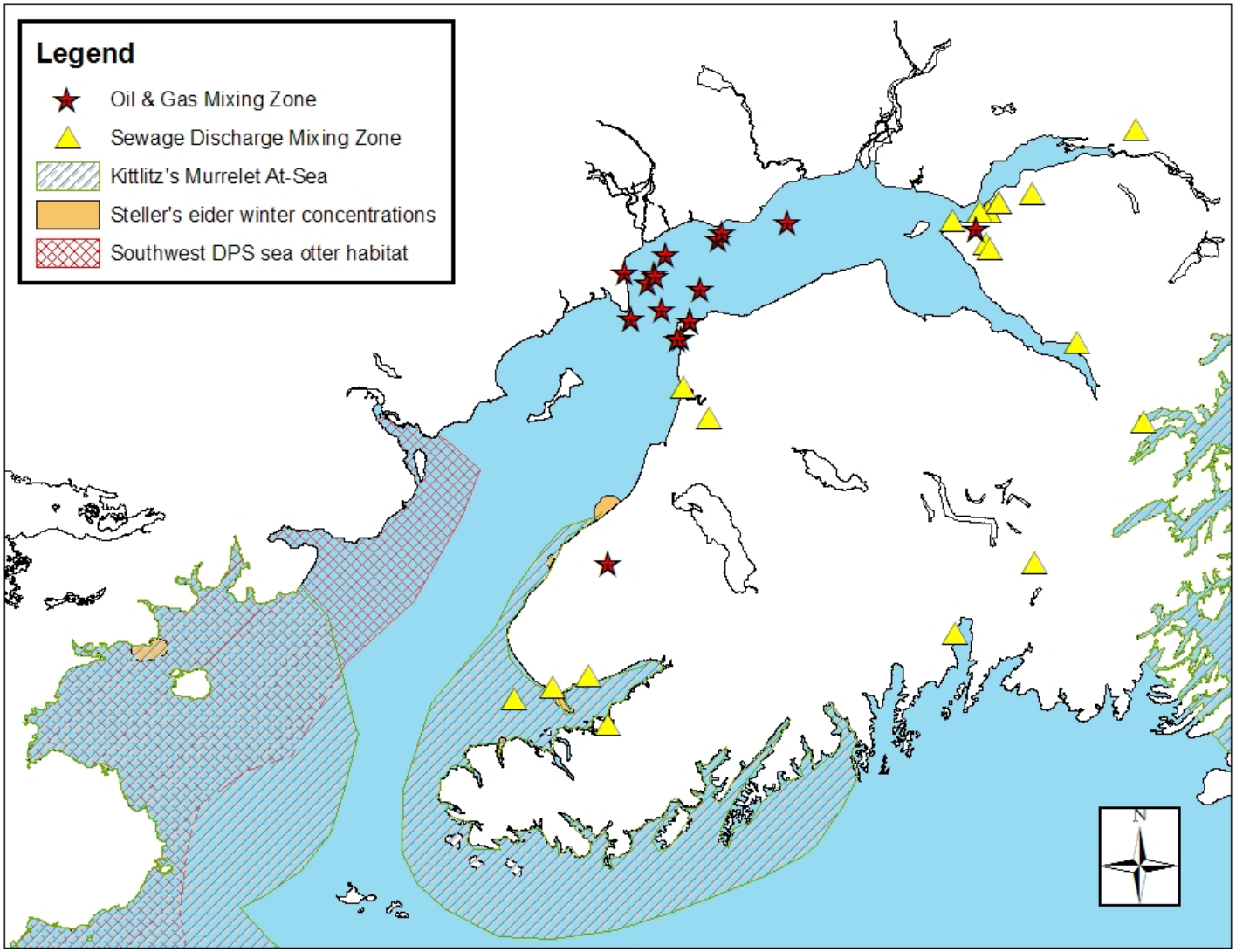

Figure 7a. Oil and gas and wastewater mixing zones currently permitted within the distribution of wintering Steller's eiders, sea otters, and Kittlitz's murrelets around Cook Inlet (ADEC 2007).

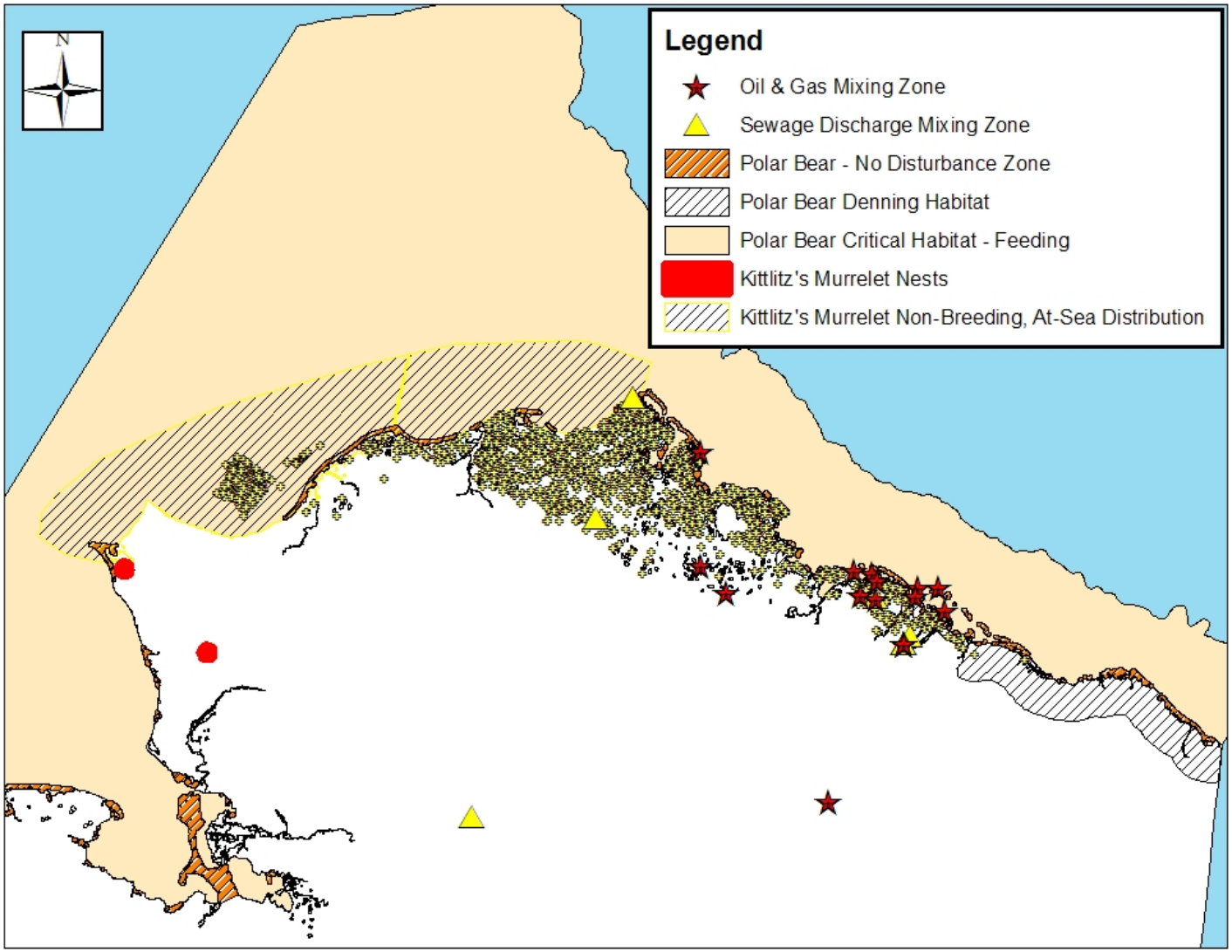

Figure 7b. Oil and gas and wastewater mixing zones currently permitted within the distribution of polar bears, and spectacled eider nesting habitat on the North Slope.

Hepatic mercury concentrations in polar bears increase with age (Rush et al. 2008), and measured concentrations often exceed levels that would be considered high or even toxic to domestic animals (Woshner et al. 2001). Kannan et al. (2007b) studied trace metal concentrations in the livers of polar bears in both the Chukchi/Bering Sea population, which is shared with Russia, and the Southern Beaufort Sea population, which is shared with Canada. Concentrations of mercury were significantly higher in the Beaufort Sea subpopulation than in the Chukchi Sea subpopulation (33.1 vs. 10.1 ug/g dry weight (dw)). Another study found that mercury in polar bears from Alaska varied widely, from 3.5 to 99 ug/g dw, with mean concentrations in polar bears being lower than reported previously for several other species of marine mammals (Evans 2004), and generally lower than the concentration thresholds associated with liver damage in marine mammals (Law 1996). But the physiological mechanism by which polar bears undergo mercury detoxification is more like that of terrestrial mammals than marine mammals.Therefore, comparison with marine mammals may not be appropriate (Woshner et al. 2001).

Unlike most mammals, polar bears accumulate mercury in kidneys in higher concentrations than in liver. As discussed above, polar bears appear to resemble terrestrial mammals more closely than pinnipeds or cetaceans in metal detoxification. They appear to bioaccumulate mercury, but not cadmium, which may make them more vulnerable to toxic effects of mercury than are pinniped or cetacean species (Woshner et al. 2001).

In most mammals, concentrations of mercury are highest in the liver (Dehn et al. 2005). Sea otters in Alaska followed this pattern (Comerci et al. 2002). The concentration of mercury in the livers of northern sea otters in Alaska averaged 1.55 ppm dry weight (dw), with otters from southcentral Alaska having significantly higher concentrations than those from southeast Alaska. The highest mercury concentration documented (15.7 ppm dw) was from an animal from Resurrection Bay in southcentral Alaska, followed by an animal from Kodiak Island (12.8 ppm dw; Comerci et al. 2002).

Methyl mercury had detrimental effects on mink (*Musela vison*) in controlled laboratory trials (Wobeser et al. 1976), and significant mercury exposure has been documented in wild mink (Wobeser and Swift 1976). Histopathological evidence of injury occurred at the lowest methyl mercury chloride dosages of 1.1 ppm per day. Clinical intoxication, resulting inanorexia, weight loss, head tremor, wobbliness, and eventually neurological and renal damage, and death, occurred at all higher doses (1.8ppm to 15.0 ppm, daily ration) with onset of effects directly related to the dose. Wobeser and Swift (1976) evaluated a mercury-contaminated wild mink, and although it was in good body condition with no gross lesions visible, it exhibited behavior modifications consistent with mercury toxicity. The total mercury concentration of its liver was 58.2 ppm (Wobeser and Swift 1976). Mink and sea otters are from the same taxonomic family, Mustelidae, but differ in size, sea otters being over 20 times heavier than mink.

According the EPA's model of effects from exposure to mercury, concentrations exceeding 0.09 ppm per day (NOAEL) would result in adverse reproductive and growth effects on juvenile sea otters, and concentrations exceeding 0.03 ppm per day (NOAEL) would result in adverse reproductive and growth effects on adult Steller's eiders (EPA 2008a).

The food web is the main pathway for exposure to mercury (Jewett and Duffy 2007; Beckvar et al. 1996). Higher trophic level species, such as polar bears and sea otters, tend to accumulate the highest concentrations of mercury, with concentrations highest in fish-eating predators. Seabirds are known to have higher concentrations of mercury than non-marine bird species (Thompson 1996). Among marine bird species, mid-pelagic feeding birds have higher concentrations of mercury than those that feed in shallow water (Thompson et al. 1998). For example, mercury concentration in feathers of the epipelagic (shallow-water) feeding great skua (*Catharacta skua*) from the British Isles was 7.0 ppm, whereas the feather-mercury concentration in mesopelagic (mid-depth) feeding Bulwer's petrel (*Bulweria bulwerii*) from the North Atlantic was 21.6 ppm (Thompson et al. 1998). Measuring feather-mercury concentrations in seabirds may be a valuable tool for monitoring changes in mercury concentrations through time (Thompson et al. 1998). However, in seabirds, feather-molt and egg production may eliminate toxic methyl mercury, while inorganic forms from demethylation may remain in the liver and other internal tissues (Bond and Diamond 2008).

Eider species studied in Alaska had mean liver mercury concentrations less than 5 ppm and most were less than 2 ppm (Stout et al. 2002). Almost all adult spectacled eiders sampled at both the Prudhoe Bay Oil Fields on the North Slope and on the Yukon-Kuskokwim Delta had blood mercury levels above the lower detection limits, but concentrations were very low (Wilson et al. 2004). Blood mercury levels in spectacled eider ducklings on the Prudoe Bay Oil Fields were also measured above the lower detection limits (mean blood levels of 0.07 ppm), suggesting that either: 1) mercury was transferred from a reproductive female to her egg; or 2) a source of mercury was available to ducklings on the North Slope nesting grounds. Regardless, concentrations of mercury were at levels (< 1 ppm) thought to be low risk for juvenile common loons and other piscivorous birds (Evers et al. 2004; Wilson et al. 2004).

Cadmium -- Cadmium is a ubiquitous heavy metal occurring naturally in the earth's crust. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. It enters water and soil from waste disposal and spills or leaks at hazardous waste sites. Fish, plants, and animals take up cadmium from the environment and it can reside in the body for a very long time. Excessive amounts of cadmium in wildlife can lead to liver failure, and nerve or brain damage. Sublethal effects of cadmium toxicity include retardation of growth, renal dysfunction, testicular damage, and hypertrophy of the heart (Eisler 1985). According to the EPA's modeling of effects to listed Alaskan species from exposure to cadmium (submitted in support of their Biological Evaluation), the NOAEL would result in reproductive and growth effects on juvenile sea otters at 0.43 ppm per day and reproductive effects on Steller's eiders at a dosage of 1.4 ppm per day (EPA 2008a).

Cadmium biomagnifies in the kidneys of Alaskan mammals (Dehn et al. 2006), including polar bears and ringed seals (Dehn et al. 2005, 2006), and is well known to accumulate in a great number of marine invertebrates, especially bivalves and gastropod mollusks (Bustamante et al. 1998). In turn, a large number of seabirds, including listed eiders, feed on these invertebrates.

There is evidence for bioaccumulation in some biota. For example, shellfish can concentrate cadmium from 900 to 4000 times above the levels found in seawater. Evidence for biomagnification within food webs is mixed, but has been observed in some systems (Burger

2008). In general, aquatic invertebrates are most at risk because they bioaccumulate cadmium and are far more sensitive to this exposure than are vertebrates. Given their reliance on aquatic invertebrates as a food source, listed eiders and sea otters could potentially experience reductions in prey availability, if preferred food items are affected by cadmium discharges associated with mixing zones.

Elevated levels of toxic metals such as cadmium may contribute to compromised immunological function in sea otters (Kannan et al. 2006). Cadmium concentrations in Alaskan northern sea otters averaged 18.70 ppm dw (5.24 ppm ww) in kidney samples (Comerci et al. 2002), with the highest concentration reported from the animals around Adak Island in the Aleutians (176 and 179 ppm dw, kidney (42 and 91 ppm ww, respectively). Cadmium residues exceeding 10 ppm ww are evidence of contamination in an organism. By this measure, the Adak and Aleutian sea otters are "contaminated" by cadmium. Cadmium residues exceeding 200 ppm ww in kidneys are thought to be life-threatening (Eisler 1985).

Spectacled eiders appear to accumulate higher cadmium concentrations than most marine bird species. Spectacled eiders are benthic feeders, eating mainly bivalves, gastropods, and crustaceans, along with some plants, algae, insects and polychaetes. Elevated concentrations in the kidneys of spectacled eiders from St. Lawrence Island and blood-cadmium levels on the North Slope, along with levels measured in other seaducks and seaduck prey (blue mussels) in Alaska, suggest a chronic exposure to cadmium in Alaskan waters (Franson et al. 1995; Henny et al. 1995; Trust et al. 2000a; Stout et al. 2002; Wilson et al. 2004). While kidney cadmium concentrations in spectacled eiders were similar to toxicological thresholds proposed by previous researchers (Stout et al. 2002), Trust et al. (2000) noted a lack of kidney tubule damage, despite renal cadmium concentrations that were almost three times greater than liver concentrations. It is believed that physiological mechanisms facilitate the sequestration of trace metals in eiders, which renders the metals incapable of interacting with enzymes. Acute exposure to cadmium, however, may swamp this protective mechanism, and result in increased toxicity (Henny et al. 1995).

Concentrations of cadmium in polar bear liver samples from Alaska were approximately three-fold lower than concentrations observed in livers of polar bears from the eastern Canadian Arctic (Kannan et al. 2007b). Alaskan animals have lower cadmium body burdens compared to Canadian animals, likely reflecting the geologic gradient of cadmium, which decreases from east to west across North America (Wagemann et al. 1996). Woshner et al (2001) found that cadmium concentrations in kidney tissue from Alaska polar bears were 8.69 ug/g ww, which was at least 15 times greater than in the next highest tissue, liver. Concentrations of cadmium in polar bear kidney, liver and muscle samples were much lower than comparable tissues of ringed seals, their primary prey. Therefore, it is unlikely that cadmium would biomagnify or otherwise present a toxicologic risk to polar bears (Woshner et al. 2001).

<u>Petroleum Hydrocarbons</u> -- Oil and gas mixing zones may also be authorized for a variety of hydrocarbon-related discharges, including hydrocarbons in water, oil and grease (total), aromatic hydrocarbons, and visual oil and grease.

Effects of hydrocarbon exposure to Steller's eiders are discussed elsewhere in this biological

opinion (e.g., pages 7 and 25). Chronic oiling of sea ducks has been investigated in Alaskan harbors (Miles et al. 2007), but the potential effects of permitted and legal hydrocarbon discharges associated with mixing zones at oil and gas production facilities has not been studied in Alaska. Flint et al. (2003) investigated contaminants in common eider eggs from industrial and reference areas in northern Alaska, and found low PAH concentrations in all samples, but this study was not designed to evaluate other potential impacts including ingestion of contaminated prey or potential for feather oiling. Similarly, while the effects of oil spills in northern Alaska have been evaluated for polar bears (Amstrup et al. 2006a), the potential implications of chronic oil exposure from these types of discharges are unknown. Any discharges that generate surface sheens or slicks would be of greatest concern for both listed bird species and marine mammals, which could be exposed through preening/grooming.

Summary of Potential Impact of Oil and Gas Mixing Zone Discharges on Listed Species

Overlap between the ranges of spectacled eiders, Steller's eiders, northern sea otters, polar bears and Kittlitz's murrelets and mixing zones permitted for oil and gas discharges appear to be limited at this time (Figure 7a, b). In Cook Inlet, the footprint of current oil and gas-related mixing zones does not overlap with threatened and endangered species ranges (Figure 7a); however PAH concentrations there are considered relatively high (EPA 2003). The source of the PAH compounds in Cook Inlet is unknown, but oil and gas development is one potential source of petroleum hydrocarbons. On the North Slope, some oil and gas-related mixing zones overlap with spectacled eider, Steller's eider, and polar bear distributions (Figure 7b), and while some individuals likely will, to some degree, be exposed to mixing zone-related contaminants, several factors may limit the exposure:

- home range sizes for female polar bears from the Beaufort Sea vary, but average 149,000 km^2), while female bears from the Chukchi Sea population average 5,542 km movement in a year (Schliebe et al. 2006b). The largest oil and gas mixing zone permitted in Alaska is 1420 m radius (ADEC 2007). Research has suggested that polar bears were attracted to drilling sites in the eastern Beaufort Sea (Stirling 1988), but did not usually remain in the area long. There is no evidence that attraction to oil and gas mixing zones is occurring, but there has been no systematic study of this issue. Collectively the available information suggests the probability of direct exposure to oil and gas mixing zones is limited but not completely discountable:
- the distribution of nesting spectacled eiders is rather sparse where oil and gas development occurs on nesting grounds (0.409 birds per km^2; FWS 2008b);
- if spectacled eiders stage off the North Slope shoreline, they do so for brief staging periods, pre- and post-nesting;
- if Steller's eiders nest near oil and gas development, they would be expected to do so at very low densities (0.0058 birds per km^2; Larned et al. 2007);
- if Steller's eiders stage off the North Slope shoreline, they do so for brief staging periods, pre- and post-nesting.

Future permits issued in the Beaufort, Chukchi and Bering seas could further expose listed species to harmful contaminants in permitted mixing zones. Direct and indirect exposure to contaminants is a function of the probability of exposure to the mixing zone. Indirect exposure of listed species to contaminants via the ingestion of prey that have bioaccumulated contaminants such as dioxins and mercury is a likely pathway to harmful effects. This could be of particular

concern for polar bears, which also carry body burdens of other bioaccumulative contaminants as discussed below:

PCB concentrations in polar bear adipose (fat) tissues were greatest in western Russia, followed by east Greenland and Norway (Svalbard), and then decreased toward the east (in Siberia and Alaska) and to the west (Canada), with the Chukchi Sea having the lowest PCB concentrations (Norstrom et al. 1998; Anderson et al. 2001; Kucklick et al. 2002; Lie et al. 2003; Verreault et al. 2005).

Concentrations of chlordane, a persistent pesticide, were fairly uniform in polar bears across the Arctic (Canada, Greenland, Norway), except Alaska, where levels were about 40% lower. DDT concentrations were more variable, but the values were again greatest in east Greenland and Svalbard (Norstrom et al. 1998; Kucklick et al. 2002; Lie et al. 2003; Verreault et al. 2005).

Hexachlorocyclohexane, or HCH, another insecticide, showed a different pattern, with the highest concentrations in Alaska, and the lowest in Svalbard (six-fold lower). This west-east gradient for HCH in polar bears is consistent with contaminant concentrations found in seawater and ringed seals. Some authors have attributed these HCH patterns to transport from source areas in China, southeastern Asia, and North America.

While use of most of these bioaccumulative pesticides (e.g., DDT, chlordanes) and industrial chemicals (PCBs) have been limited or banned in the United States, currently used chemicals are also showing up in Arctic wildlife, including polar bears. These include brominated flame retardants, which are added to commercial products, including electrical equipment, electronics, textiles and paints, to reduce fire risk. Brominated flame retardants are currently the most widely used group of flame retardant, due to their high performance and low cost, and their use has increased over the past 20 years. Various brominated flame retardants have been found in biota, with polybrominated diphenyl ethers (PBDEs) being the best studied.

In polar bears, total PBDE concentrations (Muir et al. 2006) were much higher in animals from East Greenland and Svalbard, and lowest in the Bering/Chukchi Sea bears (approximately 10 times lower).

Perfluorinated compounds are another “new” class of chemicals that are showing up in Arctic wildlife. Different fluorinated organic compounds have been used since the 1940’s, commonly in clothes, carpets and furniture for water and stain repellency. Presence in wildlife was little studied until recently. Perfluorooctanesulfonate (PFOS) and related compounds are of concern due to their chemical stability and extremely long persistence.

Presence of PFOS was first reported in polar bears by Giesy and Kannan (2001). PFOS and related compounds have since been found in a wide range of wildlife, documenting the global distribution of these perfluorinated compounds. Initial testing showed that PFOS concentrations were greater in species near urban/industrial areas. For example average concentrations in mink liver from the U.S. Midwest were more than seven times those found in Alaska polar bear liver samples. Also, concentrations in seals from the Baltic Sea were greater than in seals from the Arctic Ocean (Giesy and Kannan 2001).

Martin et al. (2004) evaluated perfluorinated compounds in polar bears, ringed seal, Arctic fox, mink, several bird species, and fish at several Arctic locations. Of these species, polar bears had the highest concentrations. PFOS was the primary fluorinated compound detected, and PFOS concentrations were greater than those of PCBs, HCH or chlordane-related compounds.

Smithwick et al. (2005) studied perfluorinated compounds in polar bear livers at seven locations across the Arctic. PFOS concentrations in eastern Canada, Greenland, and Svalbard were significantly higher than Chukchi Sea bears. This pattern is similar to what has been found in PCBs.

There was an exponential increase in PFOS and related perfluorinated compounds at Baffin Island in Canada, and at Barrow, Alaska based on an analysis of archived samples from 1972 to 2002. Concentrations in the Baffin Island polar bears doubled in 3.6 years compared to a much slower doubling rate of 13.1 years for Barrow polar bears (Smithwick et al. 2006). Given the high persistence of PFOS, exponential increases in tissue concentrations are a concern.

Kannan et al (2005) examined chlorinated, brominated, and perfluorinated contaminants in polar bear liverfrom the Beaufort Sea vs. Chukchi Sea region. In Beaufort Sea polar bears, chlordanes were the most abundant contaminant, followed by PCBs and PFOS (roughly equal), then HCH, DDT, and finally PBDEs. In Chukchi Sea liver samples, PFOS was the most abundant compound, followed by PCBs, chlordanes, HCH, DDT and PBDEs. While PFOS was the most abundant contaminant found in the Chukchi Sea polar bears, their PFOS concentrations were still lower than those in Beaufort Sea polar bears, and lower than PFOS concentrations in bears from other Arctic locations sampled to date.

Study of the biological effects of contaminants exposure in polar bears has been conducted mostly in Norway and Greenland. Little is known about potential contaminant effects in polar bears from Alaska. Such studies have shown that the thyroid is one of the endocrine systems affected by exposure to PCBs. Braathen et al. (2004) concluded that PCBs interfere with thyroid hormone balance in polar bears from Svalbard, Norway, and that female polar bears seem to be more susceptible than males. Bernhoft et al. (2000) found a negative relationship between organochlorines and immunoglobulin class G (IgG) in blood plasma from Svalbard polar bears, indicating a contaminant-associated suppression of their immune system. Exposure to high PCB concentrations at Svalbard was correlated with increased progesterone (P4) concentrations (Haave et al. 2003). However it is not possible to make a causal link between the low reproduction rate in the Svalbard population of polar bears and PCB exposure.

Sonne et al. (2006) found a significant inverse relationship between organohalogen contaminants and testis length, baculum length and weight, in both subadult and adult polar bears from the East Greenland subpopulation. Baculum bone mineral densities decreased with increasing levels of chlordane, DDTs, and HCB in subadults and adults. In females, a significant inverse relationship was found between ovary length and levels of PCBs and chlordanes, between ovary weight and PBDE levels, and between uterine horn length and hexachlorobenzene levels (Sonne et al. 2006). These researchers suggest that exposure to xenoendocrine pollutants may pose a risk to this polar bear subpopulation in the future because of reduced sperm and egg quality/quantity

and uterus and penis size/robustness. Exposure to organochlorine contaminants may also have reduced skull bone mineral deposition in polar bears from Greenland (Sonne et al. 2004).

Polar bears store lipophilic contaminants in adipose tissue, which can be drawn upon during fasts. Paradoxically, however, at least one study has indicated that fasting does not necessarily increase contaminant body burdens. During a 56 day fast, the burden of some organochlorines (OCs) like PCBs generally remained unchanged, while some other contaminants actually declined during the fast (Polischuk et al. 2002). For example chlordanes in adipose tissue, mostly oxychlordane, declined approximately 50% in adult and subadult males during the fast, possibly due to metabolism. Whole body concentrations of total DDTs also decreased in all bears by 35-47%. It appears that polar bears may be fairly unique in their capacity to metabolize *p,p'*-DDE, which is very recalcitrant in most other species. Plasma concentrations of OCs generally did not vary during fasting. Females with yearling cubs had higher OC concentrations in their milk than females with cubs-of-the-year. Most notably, polar bear cubs, which are likely more sensitive to organochlorine exposure than their mothers, increased their whole body concentrations during the fast, because of increased OC concentrations in the mother's milk. Exposure to higher contaminant loads via their mother's milk during this important phase of their development may be of particular concern (Polishchuk et al. 2002). Since exposure to high OC concentrations has been shown to potentially affect the polar bear immune system, bone density and certain characteristics of their reproductive organs (see discussion above), this increased exposure of young cubs may be detrimental.

Collectively these data establish that polar bears, as the apex predator in the Arctic, are particularly prone to bioaccumulation of various contaminants. Discharge of bioaccumulative pollutants from permitted mixing zones may add to existing body burdens and potentially result in adverse biological effects in some individuals. Uncertainties regarding the sizes of home ranges of ringed seals in Alaska, and the lack of data regarding the use of mixing zones by ringed seals and other polar bear prey, makes the assessment of impacts to polar bears particularly challenging.

Placer Mining

Currently, there are three General Permits and three draft Individual Permits covering placer mining activities in Alaska: 1) Alaskan Small Suction Dredge Placer Mines; 2) Alaskan Medium Size Suction Dredge Placer Mines; and 3) Mechanical Placer Mining in Alaska. Mixing zones are permitted downstream in fresh water and in marine waters, exceeding the State WQS for turbidity. Some special conditions apply for these WQS exceedances (e.g., turbidity cannot exceed 100 Nephelometric Turbidity Units[3] in more than one-half of the cross-sectional area of anadromous fish migration corridors).

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[3] A Nephelometric Turbidity Unit (NTU) is a measurement the lack of clarity of water. Water containing 1 milligram of finely divided silica per liter has a turbidity of 1 NTU. The NTU is measured with an electronic instrument called a nephelometer.

While turbidity may negatively affect foraging habitat in marine waters, most of the permitted placer mining activities occur in terrestrial habitats and affect fresh water. Thus the likelihood of adverse effects to listed species that spend most of their lives at sea is low. Placer mining within Steller's and spectacled eider terrestrial breeding habitat appears to be so infrequent that its effects can be considered discountable. Placer mining may occur in the vicinity of Kittlitz's murrelet breeding habitat; however disturbance from the mining activity itself would be more likely to cause harm than would the discharges into freshwater.

Mining (Non-Placer)
At least seven Individual Permits have been issued for discharges associated with gold and other ore mining activities. Mixing zones have been granted for mining operations, allowing the exceedance of WQS for nitrogen, cyanide, zinc, cadmium, lead, copper, and mercury. One permit contained a ZID that allowed exceedance of the acute State WQS for zinc and chlorine.

Zinc contamination alters the abundance and composition of the benthic community (Watzin and Roscigno 1997). Abundance of most macroinvertebrates declines in the presence of zinc, regardless of the concentration (Eisler 1993); therefore listed species that feed on invertebrates (eiders and sea otters) could be indirectly affected by zinc discharges through prey reductions. Furthermore, zinc tends to follow a bioaccumulation pattern similar to silver and copper, where benthic and invertebrate-feeding predators, such as eiders and otters, are more at risk of exposure than piscivorous and pelagic feeders (Dehn et al. 2005).

As an essential element, zinc is regulated by the body and is relatively nontoxic in mammals. Sensitive terrestrial wildlife and domestic animals were adversely affected when dosed with 90-300 mg Zn/kg in their diet, and dietary concentrations as low as 100 mg/kg in chicks caused pancreatic abnormalities under conditions of selenium deficiency. Excessive zinc intake can result in a wide variety of neurological, hematological, immunological, renal, hepatic, cardiovascular, developmental, and genotoxic effects (Eisler 1993).

Zinc concentrations in polar bear livers and muscle tissue were greater than those of ringed seal (Woshner et al 2001). Various studies (Woshner et al. 2001; Kannan et al. 2007b; Rush et al. 2008) have noted a positive correlation between silver, cadmium, copper and zinc in polar bears, and Woshener et al. (2001) attributed this to the common binding of these elements to the protein metallothionein. Of 20 trace elements analyzed in polar bear liver samples, zinc concentrations were higher than all other elements, but the concentrations were in the mid-range of values that have been reported for marine mammals (Kannan et al. 2007b).

At this time, exposure of listed species to mining discharges is limited. However, within the 30-year life of this project, mixing zones may be permitted for large mining operations such as the Pebble Mine, which is expected to be one of the largest copper, gold and molybdenum mining operations in the world. A mixing zone or multiple mixing zones permitted for a large mining operation like Pebble Mine may overlap with the ranges of Steller's eider and sea otter. However, at this time we lack the data to analyze potential impacts of future mixing zones permitted for mining discharges.

Interaction of Multiple Mixing Zones
Overlapping or adjacent mixing zones within listed species habitat can increase the potential for adverse effects (Figure 8). The co-occurrence of eutrophication and contaminants may create a situation which leads to serious environmental effects that may not seem obvious when considering just one input (Skei et al. 2000). Overlapping mixing zones with common contaminants could theoretically result in WQS violations outside the designated mixing zones (Figure 6a-f). The same concerns are raised by adjacent mixing zones and locations where there are multiple mixing zones in a water body. Of equal or greater concern are the overlapping and adjacent mixing zones involving combinations of discharges, which may serve as attractants subsequently leading to exposure to bioaccumulative and petroleum contaminants and infectious agents (e.g., seafood processors and sewage outfalls).

When multiple mixing zone discharges co-occur in time and space, physical and complex biogeochemical, biological, or toxicological interactions may adversely affect listed species. For example, a mixing zone calculated to be appropriate for a wastewater treatment facility could be substantially influenced by the presence of seafood gurry (fish offal, as from a cannery) in the water column. Gurry may provide substrate for growth of bacteria or pathogens released in the effluent. The high lipid fish wastes would also have an affinity for lipid-soluble chemicals in the waste stream. The lipid and nutrient-rich gurry could become contaminated and enhance chemical uptake into the food chain. These interactive effects have been discussed in previous section 7 consultations with the EPA (e.g., SGP and Unisea Seafood Processor Individual Permit). Steller's eider mortalities documented in South Unalaska Bay in 2004, lend strength to the hypothesis that interactions among mixing zones compromise the survivorship of listed species and the integrity of the habitat occupied by them.

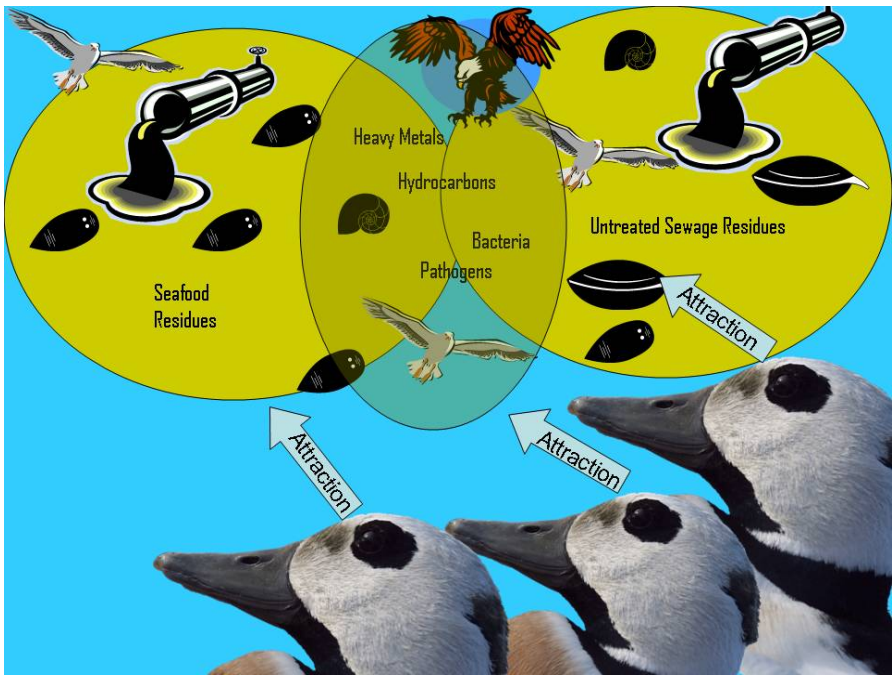

Figure 8. A cartoon depiction of the harmful attraction of Steller's eiders to multiple mixing zones.

Permit Compliance
In analyzing permit data acquired from EPA, we found that out of 14 permitted mixing zones for domestic wastewater treatment plants, seven violated permitted effluent limits and at least one had never monitored their effluent. Violations of effluent permits included exceedances for biological oxygen demand (BOD), total suspended solids (TSS), fecal coliform, dissolved oxygen (DO), pH, hydrocarbons, chlorine, and solids. Of 10 oil and gas permits with mixing zones that we reviewed, three had reported effluent exceedances for BOD, fecal coliform, TSS, copper, chronic toxicity and chlorine, four had reported no effluent violations, and three had reporting violations (i.e., they had not complied with reporting requirements). One hundred and ninety-three (193) seafood processors in Alaska have mixing zones and fall under the SGP. The SGP has no monitoring requirements. Individual Permit data we obtained showed numerous effluent violations for exceedances of BOD, TSS, oil and grease, pH, settleable solids, and floating solids. It seems reasonable to assume that if these operators exceeded their permits, others may have as well.

Generally, the permits we examined had expired; some had been expired for over 10 years and the facilities are still in operation. Many facilities had not been inspected in the past 5 years and some had never received an inspection. The probability of violation of State WQS outside of mixing zones is significantly elevated for facilities that experience repeated permit noncompliance (e.g., Unalaska wastewater treatment facility). When discharge limitations are exceeded, the calculated dilution factor is no longer sufficient to reduce contaminant concentrations outside the mixing zone to permitted levels. Because section 7 consultations on the effects of water quality criteria for pollutants legally discharged into marine waters have not yet occurred, take of listed species may be the eventual outcome of a discharge permit, and is even more likely when permit limitations are violated.

Analyses for Effects of the Action
"Effects of the action" refers to the direct and indirect effects of the action on the species or its critical habitat. The effects of the action will be evaluated together with the effects of other activities that are interrelated or interdependent with the action. These effects will then be considered with the environmental baseline in determining the proposed action's overall effects upon the species or its critical habitat (50 CFR Part 402.02).

Beneficial Effects
Beneficial effects are those effects of an action that are wholly positive, without any adverse effects, on a listed species or designated critical habitat. Mixing zones allow exceedances of WQS, and therefore permit pollution to enter surface waters where listed species occur. No wholly positive effects are anticipated as a result of this action.

Direct Effects
Direct effects are the direct or immediate effects of the agency action on the species or its habitat. Direct effects of the proposed approval of revised mixing zone regulations include: 1) loss of thermal capacity from exposure of listed species to both natural and petroleum oils in the mixing zone; and 2) ingestion of discharges. We do not consider direct effects of acute toxic compound spills (i.e., petroleum hydrocarbons) associated with oil and gas development, because those effects are considered during consultations on oil and gas activities.

Direct Contact and Loss of Thermal Capacity -- The Alaska State WQS for Petroleum Hydrocarbons, Oils and Grease for Freshwater Uses (18 AAC 70.020(b)(5)(C)) and Marine Uses (18 AAC 70.020 (b)(17)(C)) for the Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife Use allows total aqueous hydrocarbons in the water column (not to exceed 15 µg/l) and total aromatic hydrocarbons in the water column (not to exceed 10 µg/l). The standard does not allow for concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.

Surface accumulations of oils and residues may negatively impact birds by affecting thermoregulatory properties of their plumage, leading to hypothermia and death (Hannan 2005 as cited in EPA 2008a; Figure 9). Oiling from residues can lead to a number of adverse effects on northern sea otters including matting of fur and removing natural oils that provide buoyancy and water repellency. The probability that an eider or otter will come in contact with oils and residues is a function of the time an individual spends in a mixing zone with surface oils and residues. Based on radio telemetry data, we know that Steller's eiders occupy South Unalaska Bay on a regular basis. We assume all Steller's eiders in South Unalaska Bay will be exposed to one or more mixing zones, but we do not know if they are in direct contact with oils and residues. Further, we do not have data available to allow modeling of this probability in other areas for eiders or otters at the present time or into the future.

Ingestion of Discharges -- Observations of sea otters feeding on fish waste discharged by seafood processors has been reported (A. Doroff, FWS, Marine Mammals Management, Anchorage, Pers. comm.; King et al. 2000). During the winter of 1995-96, residents of Cordova, Alaska, observed a high number of sea otters dead or dying in the harbor and on local beaches. A total of 68 sea otter carcasses were found on beaches in March and April of 1996; nine were collected for necropsy (Ballachey et al. 2002). The necropsies indicated that all nine sea otters were emaciated and exhibited intestinal disorders associated with helminth parasite infestation. Parasite loads were much heavier than seen previously in sea otters from eastern and western PWS. The most severe pathologies were associated with nematodes and heavy cestode infections causing a blockage of the GI tract. The gastric nematodes in the nine otters from Orca Inlet were identified as *Pseudoterranova decipiens*, an Anisakid nematode, which has rarely been observed in PWS otters (Kenyon 1969, Margolis et al 1997). Then, in winter of 1999-2000, another mass die-off of sea otters was reported in Orca Inlet; 126 sea otter carcasses were retrieved (King et al. 2000). During that winter, sea otters were observed aggregating around discharges from a seafood processor. In general, sea otter carcasses collected in close proximity to the seafood discharges, had high intestinal parasite loads, both nematodes and tapeworms, and some were noted with intestinal fish-bone impaction (King et al. 2000).

Figure 9. Seafood effluent residues floating on the surface of marine waters of Akutan. This photo was taken outside the Village of Akutan's boat moorage. Photo taken by Ellen Lance in June 2008.

Fish are known to serve as an intermediate host for Anisakid nematodes. Anisakid nematodes, commonly known as sealworm or codworm, are rarely found in PWS otters because otters typically feed on invertebrate species, not fish (Calkins 1978, Garshelis et al. 1986, Doroff and Bodkin 1994; FWS & USGS-BRD Unpublished Data). But during the winters of 1995-96, and 1999-2000, sea otters were observed foraging on fish offal discharged from the fish processing plant near Cordova harbor (King et al. 2000), suggesting fish parts were a likely vector for the parasitic infections. It was concluded that parasites, particularly *P. decipiens*, were present in otters at higher than normal levels because of consumption of fish parts. Further, it was noted that fish bone impactions may have also contributed to their deaths (Ballachey et al. 2002, King et al. 2000).

Although fish are not considered a typical dietary item for the sea otter, they may be consumed when sea otter populations become locally abundant, as was the case in Orca Inlet in the 1990s (Ballachey et al. 2002). The listed sea otter population, which is found from Kodiak Island out the Aleutian chain, could hypothetically, reach carrying capacity, concentrate in specific locations where fish processors discharge fish waste, and prey switch to offal. The locations where this scenario is most likely include Port Moller, Sand Point and Chignik Bay, where otter concentrations are high relative to other areas and where seafood processors currently discharge into marine waters (A. Doroff, FWS, Marine Mammals Management, Anchorage, Pers. comm.). Harmful effects from ingesting fish waste could result from bone impactions in the gut, increased infection with intestinal nematodes, and exposure to bioaccumulative contaminants, and

pathogens (particularly in areas where seafood processing discharges overlap other mixing zones such as sewage treatment discharges). Thus, we believe listed otters could be adversely affected by consuming fish processing discharges. However, because the southwest Alaska DPS sea otter stock has declined by as much as 70% and animal densities are low, it is unlikely that they will reach carrying capacity in the reasonably foreseeable future, and thus the scenario seems improbable.

Exposure to contaminants

The proportion of direct overlap between the footprint of mixing zones and the habitat of the polar bear, Kittlitz's murrelet, Steller's eider, spectacled eider, or southwest Alaska DPS sea otter and mixing zones is currently very low. Based on percent overlap alone, it seems unlikely that exposure to mixing zones would occur. Using data provided by ADEC, we calculated the area of overlap between nearshore marine habitat of listed species and mixing zones as an approximation of the probability of exposure to contaminants. The area of each mixing zone in marine waters ranged from 0.03 hectare to greater than 80 hectares. Where data were missing we assumed the size of the mixing zone was similar to those in like-industry permits. We estimated the total area of marine habitat occupied by mixing zones that overlapped with known and presumed occupied habitat for Steller's eider, spectacled eider, or southwest Alaska DPS sea otter.

The greatest area of overlap between mixing zones and the southwest stock of sea otters is in the nearshore waters in the vicinity of King Cove, where 4% of the 460 hectares of sea otter habitat intersects one or more mixing zones. The greatest area of overlap between mixing zones and Steller's eiders is in the nearshore waters of Sand Point, where 2% of the 975 hectares of Steller's eider wintering habitat intersects one or more mixing zones. Overall, mixing zones overlap with less than 1% of sea otter and Steller's eider habitat. Overlap with spectacled eider habitat was less than 1% and overlap with Kittlitz's murrelet or polar bear habitat was not quantified, but is assumed to be of minor proportion relative to their overall range (less than 1%).

We used an alternative approach to further consider potential exposure of Steller's eiders to mixing zones. Because Pacific wintering Steller's eiders tend to concentrate in predictable locations, we estimated the proportion of eiders that might be exposed to mixing zones based on the numbers of individuals counted in specific geographic locations during winter aerial surveys. During winter of 2000, Larned (2000) conducted aerial surveys of the majority of Steller's eider winter concentration areas along the Aleutian Islands, Alaska Peninsula, Kodiak Island, and Cook Inlet. Most of the surveys were conducted in February of 2000, but when data from known concentration areas were missing, we used: 1) data from March 2000 aerial surveys (Larned 2000); 2) data from winter 2004-2005 aerial surveys (Larned 2006); or 3) data from February 2001 aerial surveys (Larned and Zwiefelhofer 2001). We assumed that all data (even if they were not collected during the same survey effort) were comparable for this calculation of the proportion of Pacific wintering Steller's eiders that concentrate in marine waters where there are mixing zones.

We calculated the proportion of Steller's eiders that occupied waterbodies where there are mixing zones relative to all Steller's eiders wintering in Alaskan waters. We assumed that: 1) occupancy of a water body that has one or more mixing zone infers exposure; 2) listed Steller's

eiders exhibit the same patterns of occupancy in their winter range as all other Pacific wintering Steller's eiders; and 3) Pacific wintering Steller's eiders have an equal probability of being in any location within the winter range. We estimated that approximately 30% (18,210 of 62,307) of Steller's eiders winter in waterbodies with mixing zones. We conclude that 30% of the listed Steller's eider population is exposed to one or more mixing zones during winter.

If there is no attraction or fidelity to a specific geographic location, and assuming a generally uniform distribution of individuals within their geographic range, the percentage of overlap between currently permitted mixing zones and habitat used by Steller's eider, spectacled eider, and the southwest Alaska DPS sea otter is small. We believe these assumptions are appropriate for spectacled eiders and sea otters. However, because Pacific wintering Steller's eiders tend to concentrate in geographic areas where mixing zones are permitted, and because the North American breeding Steller's eiders are a subset of the Pacific wintering birds, we conclude that 30% of listed Steller's eiders could be exposed to contaminants in mixing zones.

Disease and Pathogens -- When sea otter home ranges overlap with sewage and seafood offal discharged into mixing zones, exposure to infectious agents such as *Toxoplasma gondii* (Conrad et al. 2005; Dubey et al. 2003) and other protozoan, bacteria such as *Vibrio sp*., and viral pathogens (Dubey et al. 2003) may result in reduced survivorship (Conrad et al. 2005; Dubey et al. 2003). Furthermore, a rapidly warmingclimate, which may result in warmer waters in the range of the northern sea otter, is expected to increase exposure to such pathogens as *Vibrio spp.* Gastroenteritis linked to an Alaskan oyster farm was thought to be a result of water temperature rising above 15° C (59 °F) for a thirtyeight-day period (McLaughlin et al. 2005). The coupling of the effects of climate change (e.g., warming and acidification of the seas, variation in the distribution of rainfall, etc.) and the anticipated continued development of southwestern Alaska (e.g., oil and gas development in Bristol Bay) implies an increased probability of passive exposure of listed sea otters to infectious diseases.

Natural and Petroleum Oils and Chronic Oiling -- Exposure to oils in a mixing zone may be a direct result of permitted and legal discharges. To assess the potential for adverse effects of exposure to oils on individual animals, the following must be considered: 1) amount and type of oil released; 2) pathway to exposure; 3) extent of exposure to an individual; and 4) effect of the exposure. The probability that listed species will be directly exposed to floating oils on the surface, as well as petroleum oils released from boats and infrastructure associated with some industrial activities, will increase when they occupy mixing zones. Occupancy by an eider or sea otter may be either passive (i.e., within their home range) or intentional (e.g., attracted by a food resource).

Based on overlap between currently permitted mixing zones and the ranges of spectacled eiders, polar bears and Kittlitz's murrelets, there is a possibility for passive exposure to oils as a result of discharges permitted by the mixing zones regulation. There is no evidence, that spectacled eiders, polar bears, or Kittlitz's murrelets preferentially select habitat where there are mixing zones. Thus, the probability that these species will be exposed to oils is considered discountable, based on the low (<1%) percentage overlap between permitted mixing zones and current habitat of these species.

The polar bear's range overlaps with some active and planned oil and gas operations with mixing zones within 40 km (25 mi) of the coast or offshore (Schliebe et al. 2006a), so their degree of exposure may increase in the future. Exposure of polar bears to petroleum hydrocarbons can result when these products spilled at oil and gas operations or discharged in a mixing zone. The at-ea distribution of Kittlitz's murrelets overlaps with municipal, seafood processing, and oil & gas discharges but the area with mixing zones still represents a small portion of their range.

Bioaccumulative Contaminants -- Alaska's mixing zone regulations state that within a mixing zone, the pollutants discharged will not *bioaccumulate, bioconcentrate or persist above natural levels in sediments, waters or biota to significantly adverse levels* (18 AAC 70.240). Furthermore, the regulation states that *a mixing zone will not adversely affect threatened or endangered species*. We know that many bioaccumulative contaminants are harmful to wildlife, some in very low concentrations, and we know that some listed species harbor relatively high body burdens of some of these contaminants. Nowhere in the State's WQS is there a procedure to identify what the "natural" level of the bioaccumulative pollutant is; therefore, it is impossible to assess the incremental contribution resulting from a permitted discharge. Moreover, monitoring for bioaccumulative contaminants is not discussed or required in the mixing zone regulations.

The EPA provided FWS with toxicity reference values (TRV) for the exposure of listed species to mercury, dioxin, and cadmium. TRVs are species-specific and single-chemical specific estimates of exposure levels that cause unacceptable adverse effects on growth, reproduction, or survival. The EPA provided analyses for both the no observed adverse effect level (NOAEL) and the lowest observed adverse effect level (LOAEL). The NOAEL is the highest concentration in a test with a mean response that does not differ significantly from the mean response of the control, and the LOAEL is the lowest test concentration having a mean response that differs significantly from that of a control (Crane and Newman 2000). In fact, there may be effects, even at the NOAEL (Crane and Newman 2000). Evidence for this statement comes from Moore and Caux (1997), who examined 198 toxicity data sets with adequate replication (n=24), and were able to assess the performance of the hypothesis testing approach. They found that most NOAEL's (76.9%) exceeded a 10% adverse effect level, and a majority differed from the control response by 10-30%, suggesting that the NOAEL often does not represent a true "no effect" concentration. All (100%) of LOAELs exceeded a 15% adverse effect level, and most LOAEL's (62.4%) exceeded a 30% effect level. Furthermore, because the NOAEL analysis only considers the effects of single-toxins on a taxon, it misses the potentially significant, synergistic effects of multiple toxins acting in concert (Laetz et al. 2009).

Single-chemical risk assessments are likely to underestimate the impacts of toxins in the environment (Springman et al. 2005; Laetz et al. 2009). Significant synergistic effects were documented for 4 of 10 pairings of pesticide chemicals on salmonids, and for 3 combinations of chemicals, the salmon died within 24 hours (Laetz et al. 2009). No deaths were reported when each pesticide was testing singly. Laetz et al. (2009) concluded that the synergistic effects of pesticides are harmful to salmonids, and further concluded that these effects may impede the recovery of endangered salmonids.

For the purposes of this biological opinion, however, we cautiously use the NOAEL as a reasonable measure by which we can assess potential harm to listed species, particularly since available data are so limited on the topic of exposure of Alaska's listed, marine species to harmful pollutants. Therefore, we used the NOAEL to interpret hazard quotients (HQs) and for evaluating potential risk. An HQ less than or equal to 1 indicates the species is not expected to be affected by exposure at that concentration. An HQ greater than 1 indicates the species is at risk for harmful effects from the exposure to the chemical of concern.

When sea otters and Steller's eiders occupy mixing zones where mercury, cadmium and/or dioxin exceedances are permitted, the hazard quotients of these contaminants are expected to exceed toxicological thresholds that affect reproduction of these species (Table 3). Discharges containing concentrations of mercury, cadmium and/or dioxin above the limits established under the State's WQS can be permitted in mixing zones for sewage treatment plants, mining, and oil and gas operations, as well as for seafood processing discharges, which may contain bioaccumulative contaminants. EPA's analysis suggests that for juvenile sea otters and adult Steller's eiders, spending even 5% of their time feeding within these mixing zones is sufficient to expose them to harmful levels of mercury and dioxin. Cadmium exposure was also evaluated, with juvenile sea otters at risk when spending 5% of their time feeding in the modeled mixing zones, while adult Steller's eider were at risk when spending 25% of their time feeding in the mixing zones. There is potential overlap between these mixing zones and the range of listed sea otters and Steller's eiders; however, we lack feeding behavior (e.g., time budget analysis) and spatial data that would enable us to quantify the amount of exposure.

Table 3. Hazard quotient (HQ) for the reproductive no observed affect level (NOAEL) for sea otters and Steller's eiders by chemical (EPA 2007). A HQ less than 1 indicates the species is protected. A HQ above 1 indicates the species is at risk of reproductive impairment. Polar bears were not listed at the time EPA provided these modeling data to the FWS in support of their Biological Evaluation. Given the trophic position of polar bears and the bioaccumulative nature of these contaminants (particularly mercury and dioxin), we would expect hazard quotients that greatly exceed 1.0.

	Occupancy Time	HQ:Mercury	HQ:Cadmium	HQ:Dioxin
Juvenile Sea Otter*	5%	35.5	3.0	108.5
Juvenile Sea Otter*	100%	706.2	60.7	2170.0
Adult Sea Otter	5%	12.8	1.1	39.2
Adult Sea Otter	100%	255.0	21.9	783.6
Adult Steller's eider	5%	39.0	0.4	1.1
Adult Steller's eider	25%	194.3	2.2	5.3
Adult Steller's eider	100%	776.4	8.9	21.2

Calculations for juvenile sea otters were made by the FWS by extrapolating from data provided by the EPA. This was accomplished by substituting adult body weight with juvenile body weight and recalculating the hazard quotients.

Indirect Effects
Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Indirect effects of the proposed approval of revised mixing zone regulations include: 1) habitat degradation; 2) attraction; and 3) exposure to contaminants.

Habitat Degradation -- We believe the proposed approval of revised mixing zone regulations will result in continued degradation of foraging habitat, especially for the Pacific population of Steller's eiders (including ESA protected Steller's eiders), and the southwest DPS of northern sea otters, because they are so closely associated with nearshore environments. As noted elsewhere in this document, pollutants such as petroleum hydrocarbons are toxic to marine invertebrates (e.g., amphipods and snails; Newey and Seed 1995 as in Glegg et al. 1999, Finley et al. 1999), and could cause a reduction in prey availability for some listed species.

Based on current, georeferenced discharge data provided by ADEC, proportionally, the area of that degradation relative to eider and otter habitat appears to be limited. Habitat degradation is also expected where spectacled eider, polar bear and Kittlitz's murrelet distributions overlap with mixing zones. At this time there is, based on proportion of area of the mixing zone to species habitats, very little overlap. However, we are unable to anticipate how many, what types, and where mixing zones will be permitted in the future under this proposed regulation. Additionally, this type of analysis (proportional area of mixing zone to habitat) does not consider species' attraction to waterbodies containing one or more mixing zones. As described throughout this document, 30% of Pacific wintering Steller's eider occur in waterbodies with mixing zones, and they are attracted to some mixing zones (Reed and Flint 2007).

Attraction -- Under State regulations, floating solids, debris, sludge, deposits, foam, or scum (a.k.a. residues; 18 AAC 70.020(b)(20)(C)) may not, alone or in combination with other substances, be present in concentrations or amounts that form objectionable deposits or result in undesirable or nuisance species. The mixing zone regulation allows for the exceedance of WQS for residues and:

- research indicates this condition has resulted in the attraction of Steller's eiders to waters where mixing zones occur (Reed and Flint 2007);
- seafood may attract sea otters under certain circumstances (King et al. 2000, Ballachey et al. 2002);
- seafood discharges attract avian predators that potentially prey on the listed taxa (Furness and Ainley 1984).

Attraction to mixing zones, particularly in areas with overlapping, adjacent or multiple discharges into a single water body, can result in increased likelihood of exposure to contaminants. Steller's eiders and, in some cases, sea otters, are attracted to nutrient-rich discharges, such as seafood effluent or some correlated factor associated with these discharges such as higher prey productivity. This attraction leads to an increased probability of chronic exposure to pathogens and agents of infectious disease agents, bioaccumulative compounds, endocrine disrupters, oils, and increase predation.

As documented in Unalaska, large numbers of seaducks, including Steller's eider, use South Unalaska Bay, where both seafood processing facilities and the municipal sewage facility discharg effluent. Birds are attracted to these outfall areas due to improved feeding opportunities that are likely associated with invertebrate abundance enhanced by eutrophication (Reed and Flint 2007). This effect may also occur for the northern sea otter if nutrient enrichment also results in an increase in their prey items, or if they prey-switch to seafood processing waste under a starvation scenario.

Steller's eiders: In South Unalaska Bay, where multiple adjacent or overlapping mixing zones exist, the prevalence of potentially pathogenic bacteria *E. coli* is 14% greater than in Izembek Lagoon, where there are no mixing zones (Hollmen et al. 2008). We assume that prevalence of bacteria is related to exposure rate. Exposure of Steller's eiders to pathogenic bacteria such as *E. coli* may have serious detrimental effects on their survivorship. Avian pathogenic strains of *E. coli* are associated with lower serum protein and albumin levels in Steller's eiders (Hollmen et al. 2008), suggesting poor health or imminent morbidity (Peralta and Rubery 2008).

A study of the synergistic effects of environmental contaminants and pathogens was conducted in salmonids (Springman et al. 2005). They found that exposure to a stressor (e.g., petroleum hydrocarbons) that causes cytochrome P450 induction (see page 7 for explanation of significance) is an important factor to the viability of juvenile rainbow trout (*Oncorhyncus mykiss*) when they were simultaneously exposed to an infectious virus. The relationship between mortality and exposure to the environmental stressor was strong (R^2=0.9944). Average time to death and cumulative mortality were dependent on the dose of the environmental stressor, but were not significantly related to viral dosage. They concluded that while the environmental contaminant exerted only indirect, sublethal effects at the individual level, the synergistic effects between the immusnosuppressive and viral agents could have population level effects (Springman et al. 2005). We believe that the combination of disease and interactions with potentially immunosuppressive contaminants (e.g., petroleum hydrocarbons) is influencing Steller's eider survival on their wintering grounds (see page 14; Hollmen et al. 2008, Hollmen et al. 2010), but at this time we are unable to quantify the reduction in survivorship as a result of exposure to a single pathogen (e.g., *E. coli*).

Sea otters: Attraction to seafood discharges has been documented in the non-listed, southcentral stock under a starvation scenario. If local population increases lead to exceeding carrying capacity, and a starvation scenario similar to that observed in Orca Inlet were to occur in some bays along the Alaska Peninsula, Aleutian Islands or Kodiak Island, listed northern sea otters could be attracted to seafood discharges and harmed by ingestion of fish parts or exposure to contaminants and pathogens.

Spectacled eiders, Kittlitz's murrelets and Polar bears: Like Steller's eiders, spectacled eiders may be attracted to eutrophied benthic environments. As the seafood industry moves north in response to sea-ice reduction and greater fishing opportunities, the probability that seafood processing discharges will overlap with spectacled eider habitat is greater. Recent permits that allow discharges of seafood offal and sewage into mixing zones within spectacled eider critical habitat has elevated this concern for the FWS.

We are unable to predict how Kittlitz's murrelets and polar bears might respond to mixing zones that may be permitted within their distribution in the future, but increased exposure to bioaccumulateive contaminants would be of particular concern.

Acute and Chronic Exposure to Oils -- Exposure to oils in a mixing zone may be an indirect result of a legal and permitted mixing zone that is located within a water body that has either legally or illegally received oils (e.g., petroleum hydrocarbons or fish oils) from other sources.

A main prey component of Steller's eiders and the northern sea otter is shellfish. Shellfish can bioaccumulate PAHs and increase exposure to listed species. Increased exposure to PAHs that have bioaccumulated in the food chain could result in the following adverse effects in Steller's eiders and sea otters: immunological suppression, hemolysis, cancer, and interference with reproduction (Springman et al. 2005).

Chronic petroleum hydrocarbon releases are illegal, but they are certain to occur at harbors in Alaska, particularly in busy fishing harbors (Day and Pritchard 2000). Listed species may passively occupy benthic environments that have been contaminated by petroleum hydrocarbon releases, but we lack data to quantify exposure rates. Attraction to some mixing zones increases the probability of exposure to harmful oils within some benthic environments (e.g., when Steller's eiders preferentially occupy mixing zones that are discharged to waterbodies that are also contaminated with petroleum hydrocarbons).

Steller's eiders: In the marine waters of Unalaska, chronic exposure to petroleum hydrocarbons is expected to reduce the survivorship of Steller's eiders by 5.7% per year. This conclusion is based on the study of harlequin ducks in Prince William Sound, Alaska. Esler et al. (2000) reports population declines resulting from long-term releases of petroleum hydrocarbons originating from the degradation of residual crude oil on the beaches following the *Exxon-Valdez* Oil Spill. Because estimates of reduction in survivorship from chronic exposure to petroleum hydrocarbons are not available for Steller's eiders, and since harlequin ducks occupy similar nearshore habitats as Steller's eiders during winter in Alaska, we use the Esler et al. (2000) estimate of reduction in survivorship as a reasonable proxy for petroleum hydrocarbon exposure effects to Steller's eiders.

We estimate that over a 30-year period, in the waters of Unalaska alone, 1104.6 Steller's eiders or 8.8 listed Steller's eiders (1104.6 * 0.008) will be lethally taken as a result of chronic oiling (Appendix VII). Survey data from the vicinity of South Unalaska Bay generally support this estimate. Steller's eiders wintering in the vicinity of South Unalaska Bay have decreased by 9.4% in recent years (Chris Hoffman, US Army Corps of Engineers, Anchorage, Unpublished Data; Paul Flint, US Geological Survey, pers. comm.). This reduction is 3.5 times greater than the estimated annual population decline for Pacific wintering Steller's eiders (-2.7%; Larned and Bollinger 2011). We believe that the increased rate of decline of Steller's eiders in the vicinity of Unalaska is at least in part a result of exposure to petroleum hydrocarbons.

Four additional fishing harbors are similar to Unalaska in that they are:

- winter concentration areas for Steller's eider;
- water bodies where mixing zones permit discharges of seafood processing and/or sewage wastes at levels that exceed WQS;
- busy fishing harbors;
- water bodies where accidental petroleum hydrocarbon spills have occurred (Day and Pritchard 2000; ADEC 2008b; U.S. Coast Guard, National Response Center, http://www.nrc.uscg.mil, accessed 12/23/2008);

Those harbors include: 1) Akutan Harbor; 2) Kodiak-Chiniak Bay; 3) Sand Point Harbor; and 4) Chignik Bay. Extrapolating the estimated 5.7% reduction in survivorship for Steller's eiders exposed to petroleum hydrocarbons in Unalaska, we calculate that an additional 27 listed Steller's eiders will die as as a result of attraction to mixing zones in these four other harbors (Appendix VII). The total anticipated take as a result of attraction to mixing zones across five harbors of concern is 36 listed Steller's eiders over 30 years.

This take estimate does not include the potential harm resulting from the synergistic effects of toxins that are discharged into the marine environment via permitted mixing zones. We believe there is high potential for lethal take resulting from the mixture of toxins. But at this time, we are unable to enumerate such take.

Sea Otters: Unless a starvation scenario occurs within the range of the southwest DPS of northern sea otter, resulting in attraction to seafood processing discharges, we assume that sea otters will be exposed to oils (including petroleum hydrocarbons) in a passive way (i.e., incidentally as they utilize that portion of their range). Sea otters are observed in the vicinity of busy fishing harbors such as around Unalaska and Kodiak, but they do not occur there in high densities and do not concentrate around seafood discharges. The listed DPS does occur in high densities in the Port Moller area, but we do not believe this concentration is associated with the seafood discharges. Moreover, we have found the waters in the vicinity of the Port Moller-Nelson Lagoon complex to be relatively free of petroleum hydrocarbon contamination (Lance et al. 2007).

Bioaccumulative Contaminants -- Indirect exposure to bioaccumulative contaminants may occur via the food chain. This accumulation in the prey items of listed species will result in a greater probability of exposure to bioaccumulative contaminants. For example, the accumulation of metals (Gagnon et al. 2006) and organic contaminants that are discharged in sewage residues has been documented in mussels (Moles and Hole 2003). But, because monitoring for bioaccumulation in prey items found within mixing zones has not been a requirement in the current or proposed revised regulation, we are unable to assess the risk to listed species.

Interrelated and Interdependent Actions

Interdependent actions are defined as actions having no independent utility apart from the proposed action, while interrelated actions are defined as actions that are part of a larger action and depend upon the larger action for their justification (50 CFR §402.02).

The analysis of whether other activities are interrelated to, or interdependent with, the proposed mixing zone regulation was conducted by applying a "but for" test. We asked whether another activity in question would occur "but for" the regulation. We consider the potentially adverse effects of placer mining in this section because we believe that harm may result from the mineral extraction activity rather than from the discharge. Given the current technology for this type of mining operation, we believe it is reasonable to assume that if a placer mining operation was not allowed a mixing zone, it would not be able to legally operate.

Kittlitz's murrelets nest in remote, high elevation areas, where placer mining activities occur. Disturbance to Kittlitz's murrelets during breeding season could cause them to forego nesting or abandon their nest. But Kittlitz's murrelet nests are difficult to find and we have only recently begun to conduct intensive surveys to locate nests. Therefore, we lack the data to analyze how much nest disturbance has taken place in the past and might be reasonably certain to occur in the future as a result of placer mining.

Species Response to Proposed Action

Because authorization of mixing zones regulations has never undergone section 7 consultation, and because the changes in the proposed revisions are so vastly different from the current regulation, this analysis is inclusive of all potential effects that arise from allowing WQS exceedances in listed species habitats, not just the incremental effects of the 2006 proposed revisions. We have identified potential adverse effects to all listed species via exposure to harmful pollutants as a result of the mixing zones regulation. As described in the general description of the effects of the action (on page 30), we have limited the scope of this analysis to mixing zones allowed for discharges from the following industries: 1) oil and gas; 2) seafood processing; 3) sewage treatment; 4) placer mining; and 5) mining. Adverse effects from mixing zones allowed for these industries are probable within the 30-year life of this project to the listed species shown in Table 4.

Table 4. Matrix of listed species and industrial category with permitted mixing zones that may, depending on exposure rate, adversely affect them in the next 30 years. An X indicates the species that may be adversely affected by a mixing zone by the indicated industry.

	Oil and Gas	Seafood Processing	Sewage Treatment	Placer Mining	Mining* (non-placer)
Steller's eider	X	X	X		X
Spectacled eider	X	X	X		
Sea otter	X	X	X		X
Polar bear	X		X		
Kittlitz's murrelet	X	X	X	X	

** includes hardrock mining (e.g., the proposed for Pebble Mine)*

Number of Individuals in the Action Area Affected

Because mixing zones may be permitted anywhere in the action area, which includes all surface waters in Alaska, we consider all individuals of the listed populations potentially affected. With that said, we consider individuals occupying near-shore marine habitats more susceptible to the adverse effects of mixing zones from most industrial categories than individuals occurring farther off-shore. The populations that may be affected include:

- approximately 577 individuals of the Alaska breeding population of Steller's eiders (see pages 7 and 108);
- 375,000 spectacled eiders that breed in Alaska and/or occupy US waters (see page123);
- nearly 47,000 individuals from the southwest DPS of northern sea otters (see page 138);
- approximately 3,600 polar bears that occur in Alaska and surrounding US waters (see page 150); and
- between 40,000 and 57,000 Kittlitz's murrelets (see page 156).

Sensitivity to Change

The life-history strategy of a long-lived animal with low annual reproductive effort would be expected to evolve under conditions of predictable and stable environments (Stearns 1992). Both eider species have shown high fidelity to terrestrial breeding and marine molting, wintering and staging areas. Fidelity to these sites may make them highly sensitive to localized contamination or habitat modification. It is unknown how these threatened seaducks will respond to climate change.

Sea otters are highly mobile within their territories, but show fidelity to their feeding grounds. Some individuals also have been known to move great distances. It is unknown how they would respond to chronic contamination of localized areas or to changes in foraging habitat due to discharges. We also do not know how they might respond to climate change.

Polar bears show some fidelity to their denning and feeding areas, but as sea-ice distribution changes, their distribution must change as well. It is widely believed that polar bears will suffer severe population declines due to their particular habitat needs (FWS 2007a). Loss of sea ice habitat may also result in increased onshore denning and potentially more time spent in the vicinity of discharges with mixing zones.

Because so little is known about Kittlitz's murrelets including their winter distribution and their breeding biology, it is difficult to assess their sensitivity to localized, chronic contamination. However, changes in forage quality and quantity as a result of large-scale shifts in the marine climate, and changes to the glacially-associated summer and breeding habitat are suspected causes for their population decline**.**

Resilience

Low fecundity and recruitment rates, as well as adult mortality pressures, contribute to the continued decline of the listed eiders. Based on rates of population decline and reproductive outputs in recent years, spectacled eiders may be somewhat more resilient than Steller's eiders.

Because the Steller's eider is relatively small-bodied and winters at northern latitudes, it may be near the limits of its energetic threshold. Furthermore, evolutionary theory predicts that as

population numbers decrease, the population becomes more susceptible to extinction from stochastic factors (Gilpin and Soulé 1986). Ecological traps, such as those that we believe exist for Steller's eiders in at least five harbors in Alaska, can lead to rapid extirpation (Schlaepfer et al. 2002); particularly, when population size is low (Battin 2004).

In a model of the population trajectory of Alaska breeding Steller's eiders, there is a high probability that Steller's eiders will go extinct in the reasonably foreseeable future (Swem and Matz 2008). This model prediction suggests that the Alaska breeding population of Steller's eiders is not very resilient to population pressures. The population model is more sensitive and responsive to changes in adult survival rates and is less responsive to changes in reproductive output.

Reduction in survivorship due to exposure to petroleum hydrocarbons will make listed Steller's eiders even less resilient to population pressures. With additive, stochastic breeding propensity (i.e., when North Slope breeding eiders do not attempt to nest), the reduction in survivorship is compounded. Moreover, currently immeasurable synergistic effects of multiple environmental contaminants and disease agents may decrease the Steller's eider's ability to survive stresses in the future (Springman et al. 2005) and limit its ability to recover (Laetz et al. 2009).

The southwest DPS of northern sea otter once contained more than half of the world's sea otters, but has undergone an overall population decline of at least 55–67% since the mid-1980s. In some areas within southwest Alaska, the population has declined by over 90% during this time period (FWS 2005a). The cause for the precipitous decline is unclear, but is probably linked to predation (Estes et al. 1998; Springer et al. 2003). Their previous rebound from over-harvest suggests some resilience to negative population pressures once that pressure is alleviated.

Polar bears are long-lived, and they have an intrinsically low reproductive rate characterized by late age of sexual maturity, small litter sizes, and extended parental investment in raising young. Resilience to negative population pressures is expected to be low.

Historically, Kittlitz's murrelets were estimated to number in the hundreds of thousands (Isleib and Kessel 1973). Now their numbers are only a mere fraction of that. Kittlitz's murrelets are believed to exhibit the characteristics of a k-selected species, like other seabirds (MacArthur and Wilson 1967; Beissinger 1995). K-selected species are long-lived, are highly adapted to their environment and have low rates of reproduction. We assume that like other k-selected species, Kittlitz's murrelets have low resilience to negative population pressures.

The location, timing, and characteristics of any toxic substance introduced into the marine environment will determine the severity of impacts to listed species. For any of the listed species, exposure to pathogens, petroleum hydrocarbons, and bioaccumulative pollutants can reduce resilience to other factors that negatively influence population growth.

Recovery Rate

The natural recovery rate of Steller's and spectacled eiders is not known. Long-lived species with low annual fecundity (i.e., k-selected) have a relatively slow recovery rate compared to short-lived species with high annual fecundity (i.e., r-selected). Given the eider's observed low

fecundity (small clutch sizes, high variability in nesting attempts, and generally low nest success; Moran and Hardwood 1994, Quakenbush et al. 1995, Moran 1996a, 1996b, Grand and Flint 1997), the recovery rate for these species is expected to be quite slow.

To recover a threatened or endangered species is to increase their numbers and improve their management to the point where they can be removed from the list. A 5.7% reduction in survivorship for birds wintering at South Unalaska Bay, Akutan Harbor, Sand Point Harbor, Kodiak-Chiniak Bay, and Chignik Bay will reduce the number of individuals of the listed population of Steller's eiders over time. Given the propensity of the North American breeding population of Steller's eiders to completely forego breeding in a given year, and for this pattern to sometimes continue for numerous years in a row, any perturbation to the breeding population will have compounded repercussions. Furthermore, it is believed that synergistic effects of environmental contaminants may impede the recovery of other listed taxa (Laetz et al. 2009).

The history of sea otters in southwest Alaska is one of commercial exploitation to near extinction (1742 to 1911), with recovery following the implementation of the International Fur Seal Treaty (1911). By the mid-to late-1980s, sea otters in southwest Alaska had grown in numbers and recolonized much of their former range (FWS 2005a). The recovery of sea otters following the cessation of commercial hunting demonstrated that the species has the potential for recovery once the cause of its decline has been removed. As the cause of the current decline is not known with certainty, the future recovery of the southwest Alaska DPS of the northern sea otter is likewise uncertain (FWS 2005a).

Worldwide, polar bear populations suffered severe losses due to over-harvest during the 1960s and 1970s. The International Agreement on the Conservation of Polar Bears was signed in Oslo, Norway, on November 15, 1973 by the five nations with polar bear populations: Canada, Denmark, Greenland, Norway, the U.S., and the former U.S.S.R. (Polar Bear International 2008). Climate changes are predicted to have the most profound effects on polar bears and their sea-ice habitat. Given their low reproductive potential, survivorship of adults during this warming trend will be a key determinant of the species' ability to recover. Contamination by bioaccumulative pollutants, hunting pressures, and increased human development in polar bear habitats are other stressors which may hamper recovery of this species.

The National Audubon Society considers the Kittlitz's murrelet one of the top ten most imperiled birds in the U.S. (Audubon 2008). Climate changes are predicted to have profound effects on Kittlitz's murrelet survivorship, and release of contaminants from melting glaciers and ice fields has the potential to add stress to some individuals. Because so little is known about this rare bird, predicting their ability to recover from population level effects is difficult. However, because they occupy nearshore marine habitats during much or all of the annual cycle, and because many of the pollutant exceedances permitted in the mixing zone regulation can cause harm to them given appropriate exposure, we conclude that the mixing zone regulation may adversely affect the recoveryof Kittlitz's murrelet in the future.

CUMULATIVE EFFECTS

Cumulative effects include the effects of 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 in this section because they require separate consultation pursuant to section 7 of the ESA.

Until recently EPA administered the entire NPDES Program in Alaska. NPDES permits were issued and enforced by EPA under the CWA. When EPA is the permitting authority, States must certify that permits issued by EPA will ensure protection of water quality based upon State WQS. Under this scenario, ADEC would certify that the general and individual NPDES permits issued by EPA were consistent with Alaska's WQS and that designated uses would be maintained. As part of the EPA permit issuance process, EPA has consulted with FWS as required by §7(a)(2) of the ESA on general and individual permits.

On October 31, 2008, EPA approved the transfer of permitting authority to the State of Alaska for the implementation of the NPDES program, as part of three-year phased process. Through this program assumption, the State of Alaska was delegated the authority to issue new permits and re-issue NPDES permits, as well as to assume compliance monitoring and enforcement responsibilities. The State's issuance of Alaska Pollution Discharge Elimination (of APDES) permits is no longer considered a discretionary federal action subject to section 7 consultation under the ESA. Nor was the transfer of authority for the NPDES program from EPA to the states subject to section 7 consultation, as per a recent Supreme Court decision (National Association of Home Builders v. Defenders of Wildlife, 127 S. Ct. 2518 2007).

EPA's role will become much reduced in serving an oversight function; however all NPDES permits outside of State waters (3 nm and beyond) and various other permits (e.g., Denali National Park, Alaskan Native Village sewage exemptions) will be retained under EPA authority. Furthermore, EPA will still maintain the authority to object to and Federalize any State permit that does not comply with the CWA (e.g., adversely affect species and habitat protected under the ESA), and they still maintain enforcement authority throughout the State.

As part of its Triennial review process, the State will continue to change and revise State WQS and submit those proposed changes to EPA for approval. EPA's approval of the State WQS constitutes a discretionary federal action and still requires section 7 consultation. WQS revisions are largely driven by the acquisition of new information and knowledge.

With the State's assumption of management authority of the APDES permit program, we expect the development of more efficient treatment technologies that will achieve lower pollutant loading in discharges, leading to lower effluent limits allowed in APDES permits. We also expect opposing pressures on facilities and water bodies via increased development (e.g., increasing population size and industrial development as a result of coastal and offshore oil development) and the increased cost of building new, and upgrading existing, facilities. The discharge of bioaccumulative pollutants, pathogens, and "emerging contaminants" such as endocrine disrupting chemicals and pharmaceuticals, is reasonably certain to occur in Alaskan waters at current or increased rates. However, specific locations, volumes and concentrations are

impossible to predict with certainty for the next 30 years. A water pollution control program, conducted to insure compliance with issued permits and State WQS might minimize future impacts to listed species by preventing WQS violations inside and outside of mixing zones.

In an effort to catch up with a surplus of expired and administratively extended general and individual permits, the ADEC is seeking ways expedite the issuance permits to dischargers. In so doing, waivers to discharge waste into mixing zones within waterbodies previously excluded from General Permits (e.g., federally designated critical habitat), have been issued over the objection of the FWS (e.g., Norton Sound, MV RM Thorstenson, permit # AKG520425). With the expectation that these procedures willwane as ADEC catches up with its permitting workload, the FWS will continue to work with ADEC on a permit-by-permit basis to try and avoid adverse effects to listed species. If adverse effects to listed species or their federally designated critical habitat are reasonably certain to occur as a result of the direct, indirect or interrelated and interdependent effects resulting from a permitted mixing zone, the FWS intends to request EPA to formally object to any such permit, unless the State seeks a section 10 permit for take via the Habitat Conservation Planning process.

The MOA (see Appendix I), which will take effect once the mixing zones regulation is approved by EPA, assigns roles and responsibilities to ADEC, EPA, and FWS for the purpose of protecting and conserving Steller's eiders in specific areas of concern. The FWS believes that with added oversight and information gathering and reporting resulting from implementation of the MOA, survivorship of Steller's eiders occupying mixing zones will be improved.

CONCLUSION

This biological opinion assesses the environmental baseline (status of listed species and factors affecting them) within the action area for the proposed federal activity, plus the direct, indirect, and cumulative effects of the federal activity. The action is the approval of revisions to Alaska's Mixing Zone Regulation (MZR) section (18 AAC 70.240) of the Alaska Water Quality Standards (18 AAC 70; WQS). A mixing zone is an allocated impact zone where water quality criteria can be exceeded, but may not result in acutely toxic conditions that are harmful to aquatic life.

Because Alaska's Mixing Zone Regulation has not undergone section 7 consultation for previous approval actions related to the mixing zone regulations, in this biological opinion we consider the effects of the entire regulation, not just the proposed changes to the existing regulation. Based on this analysis, the FWS will determine whether this proposed action is likely to jeopardize the continued existence of listed species, or destroy or adversely modify designated critical habitat.

Regulations (51 FR 19958) that implement section 7(a)(2) of the Act define "jeopardize the continued existence of" as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." A conclusion of "jeopardy" for this action means that the action could reasonably be expected to reduce appreciably the likelihood of both the survival and recovery of the Alaska breeding population of Steller's eider, the Southwest DPS of northern sea otter, the spectacled eider, or the

polar bear. The analysis for determining if an action may jeopardize is not appropriate for a candidate species. The adverse modification or destruction analysis focuses on how the features of the critical habitat are likely to be affected by the proposed action, and how that will influence the function of the critical habitat unit. These conclusions are based on a synthesis of information provided in previous sections of this document.

Steller's eider

The Steller's eider recovery team has determined that recovery for the listed Alaska breeding population will be achieved when the subpopulation is stable or increasing and has < 1% probability of extinction in the next 100 years (FWS 2002b). While the population growth rate estimates are equivocal, (Mallek at al. 2007; Larned et al. 2008; Obrischkewitsch et al. 2008; Stehn and Platte 2009), deterministic model predictions based on best available vital rates (Appendix VIII) indicate that there is 100% probability of extinction in the next 100 years (Runge 2004; Swem and Matz 2008). Furthermore, the criteria for reclassifying Steller's eiders from threatened to endangered has been defined by the Steller's eider recovery team as when the Alaska-breeding population has > 20% probability of extinction in the next 100 years for 3 consecutive years; or the population has > 20% probability of extinction in the next 100 years and is decreasing in abundance. In May of 2009, the Steller's eider recovery team recommended that the FWS uplist the Alaska breeding population from threatened to endangered (Swem 2009). Furthermore, the Recovery Team recommended that a costly reintroduction and/or artificial augmentation program was potentially necessary to recover the species (Swem 2009).

We have considered the baseline condition of the Alaska breeding Steller's eider within the action area, as well as the direct, indirect, and cumulative effects of the revised MZR. We have considered the probability that individual Steller's eiders will be taken as a result of the action and have applied the estimated impact of those takings to the projected population growth rate (Appendix IX). We recognize there is considerable uncertainty regarding parameters used in model predictions for both the model calculating reduction in survivorship at five harbors of concern and for population growth model. For example, the population growth model: which: (1) assumes that the population of Alaska breeding Steller's eiders is closed with no immigration or emigration (thought to be a faulty assumption but necessary for the model), (2) considers only birth and death, (3) uses parameter estimates that have not been updated since 2002, and (4) does not consider augmentation through reintroduction. Therefore, while the FWS recognizes that estimated mortality resulting from the action is likely to be significant, the uncertainty in our estimates precludes our ability to conclude that the action will jeopardize the continued existence of this listed population. This significant uncertainty, coupled with the likelihood of sizeable incidental take, inspired the development of the MOA (Appendix I) intended to reduce risk to Steller's eiders. The MZR fails to protect Steller's eiders from the harmful and adverse effects that result from attraction to residues and indirect exposure to contaminants. However, low confidence in our model predictions, paired with the added measures taken in the MOA to assure greater oversight of permits with mixing zones in the five harbors of concern, lead us to conclude that this action will not jeopardize the continued existence of listed Steller's eiders or result in adverse modification of critical habitat.

Spectacled eider
The FWS believes that this proposed action is not likely to jeopardize the continued existence of the spectacled eider, and is not likely to destroy or adversely modify designated critical habitat. This conclusion is based on the following information:

- there is little historical overlap of spectacled eider distribution and most mixing zones; therefore there is only a very small probability of exposure to pollutants;
- spectacled eider populations on the North Slope and Y-K Delta both appear to have stable populations; and
- the population size of the listed entity is over 375,000 individuals.

The conclusion that this proposed action is not likely to jeopardize spectacled eiders is based on the current distribution of mixing zones in Alaska, and status and distribution of the listed population. We cannot anticipate the location of mixing zones that might result from future expansions of industries such as oil and gas development and seafood processing, which could overlap more substantially with the distribution of spectacled eiders.

Northern sea otter
The FWS believes that the mixing zones regulation will not jeopardize the continued existence or the recovery potential of the southwest DPS of northern sea otter, and based on the degree of overlap, is not likely to destroy or adversely modify designated critical habitat. This conclusion is justified by the following:

- where mixing zones are currently permitted, sea otter densities are often low, and because their home range size is quite large, the probability of exposure to mixing zone effluents is considered to be limited;
- we believe that sea otters are not attracted to mixing zones, except in cases of severe, localized overpopulation, which seems improbable for the listed DPS within the reasonably foreseeable future;
- while it appears that the listed population of sea otters are not attracted to mixing zones, some otters may be exposed to pollutants associated with mixing zones. Such pollutants could include petroleum hydrocarbons, bioaccumulative elements, trace elements, and pathogens. When exposed to bioacumulative compounds like mercury and dioxin, EPA's modeling suggests that feeding within mixing zones for as little as 5% of the time can result in exposure that exceeds toxicological thresholds. While we have considered the implications of such exposure, we lack the ability to quantify the impacts to individuals that may come in direct or indirect contact with pollutants discharged into a mixing zone; and
- *Vibrio* sp. has been associated with fish waste, and *T. gondii* has been associated with sewage discharges. Both of these pathogens can cause harm to sea otters, but their prevalence in Alaskan waters is currently low. While prevalence of these pathogens may increase with warming sea temperatures, it is difficult to predict when and to what extent this exposure will increase in the future.

Polar bear
While it is possible that polar bears may be directly or indirectly exposed to pollutants discharged to mixing zones, we are currently unable to clearly define the pathway to harm or to

quantify the extent of exposure. Thus, the FWS concludes that the mixing zones regulation, as proposed, is not likely to jeopardize the continued existence of the polar bear, and based on the degree of overlap, is not likely to destroy or adversely modify designated critical habitat. We base our conclusions on the historic distribution of mixing zones permitted within the range of polar bears, coupled with the regulatory oversight that will come in the eventuality of increased oil and gas development in polar bear habitat. It is reasonable to expect that future proposed oil and gas development will be independently evaluated under the Marine Mammal Protection Act and the ESA. Therefore, cumulative effects, such as ADEC issuance of APDES permits for mixing zones should be considered during any future jeopardy determinations.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 to attempt to engage in any such conduct. "Harm" is further defined by the FWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined by the FWS 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, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by U.S. Environmental Protection Agency (EPA) so that they become binding conditions of the exemption in section 7(o)(2). The FWS has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the EPA fails to assume and implement the terms and conditions, the protective coverage of section 7(o)(2) will lapse.

While the incidental take statement provided in this consultation satisfies the requirements of the ESA, it does not constitute an exemption from the prohibitions of take of listed migratory birds under the more restrictive provisions of the Migratory Bird Treaty Act. However, the FWS will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712) if such take is in compliance with the terms and conditions specified herein.

AMOUNT OR EXTENT OF TAKE

Steller's eiders

The FWS anticipates that 36 Steller's eider from the Alaska breeding population will be taken incidentally, as a result of mixing zone regulations under the CWA over the next 30 years (see page 162 for details).

Spectacled eider

Based on the similarity of life history to Steller's eiders, there is potential for spectacled eiders to be harmed by contaminants permitted by the mixing zone regulation. However, the range of spectacled eiders does not currently significantly overlap with these types of mixing zones, and we cannot speculate where mixing zones may be permitted in the future. We do not anticipate incidental take of spectacled eiders due to this action within the next 30 years.

Northern sea otter

The FWS believes there is potential for this action to result in take of sea otters from exposure to bioaccumulative contaminants, petroleum hydrocarbons and pathogens associated with mixing zones permitted for oil and gas development, seafood processing, and sewage treatment discharges; however, we lack the ability to quantify the extent of harm to individuals. Thus, we do not speculate on an amount of incidental take because:

- the linkage between transmission of pathogens and mixing zones in Alaska has not been substantiated;
- attraction to seafood discharges has not been observed within the range of the listed sea otter; and
- although permitted oil and gas discharges are the most likely sources of bioaccumulative pollutants that can harm sea otters, there is currently no significant overlap between the listed otter's range and mixing zones for oil and gas discharges and non-placer mining discharges.

We cannot speculate where mixing zones may be permitted in the future. Further, the FWS can not authorize incidental take for marine mammals without previous authorization under section 101(a)(5) of the Marine Mammal Protection Act and/or its 1994 Amendments. Therefore, the FWS will not estimate or permit incidental take of the southwest DPS of northern sea otters for this action.

Polar bear

Because of their life history characteristics (i.e., apex predator, long life, low reproductive rates), and the contaminants burdens they already carry, we believe any added exposure to bioaccumulative pollutants can only further harm polar bears. Given the range of polar bears and the locations of permitted mixing zones, we believe that some individuals may be exposed to harmful pollutants. However, we lack the data to clearly define the pathway to exposure or to enumerate extent of harm. Discharges from oil and gas development in particular have the potential to adversely affect polar bears, since this industry has been permitted mixing zones for bioaccumulative pollutants such as mercury and dioxins, and for petroleum hydrocarbon releases (including oil and grease, hydrocarbons in water, and aromatic hydrocarbons). We are unable, however, to predict the location of future discharges, the specific parameters permitted to be discharged in those mixing zones, and the degree to which WQS will be exceeded in those mixing zones. Further, the FWS cannot authorize incidental take for marine mammals without previous authorization under section 101(a)(5) of the Marine Mammal Protection Act and/or its 1994 Amendments. Therefore, the FWS will not estimate or permit incidental take of polar bears for this action.

EFFECT OF THE TAKE

As described in the *Effects of the Action* section, the activities described and assessed in this BO may adversely affect Steller's eiders through attraction to mixing zones and subsequent exposure to contaminants, diseases, and other sources of threat.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of Steller's eider:

EPA shall use their discretionary authority to eliminate the attraction of Steller's eiders to mixing zones.

EPA shall use their discretionary authority to minimize the risk of exposure of Steller's eiders to harmful contaminants while they occupy mixing zones.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the EPA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. The following terms and conditions shall implement Reasonable and Prudent Measure No.1. "EPA shall use their discretionary authority to eliminate the attraction of Steller's eiders to mixing zones."

1.1 EPA shall fund and/or otherwise engage in efforts to ensure completion of a study of Steller's eider attraction to seafood and municipal waste water treatment plant discharges with an objective to identify the precise pathway of the attraction. EPA shall coordinate with the FWS on study design and implement it within six months of the issuance of this biological opinion or as soon as possible.

1.2 EPA shall use its discretionary authority, in overseeing the Alaska Department of Environmental Conservation's (ADEC) Alaska Pollutant Discharge Elimination System (APDES) program, to consider the impact of permitted discharges with mixing zones on listed Steller's eiders in the five harbors of concern identified in the December 17, 2010 Memorandum of Agreement (MOA) Among USFWS, EPA, and ADEC. EPA's review shall include ADEC's APDES permitting efforts to reduce or eliminate the attraction of Steller's eiders to mixing zones, and to minimize the risk of exposure of Steller's eiders to harmful contaminants in mixing zones.

1.3 As part of EPA's oversight of ADEC's permit issuance program, EPA will meet with FWS on an annual basis to review upcoming ADEC permits with mixing zones as they pertain to attraction and adverse affects to Steller's eider, and to assess the progress made under the MOA regarding identifying and reducing or eliminating attraction of Steller's eiders to mixing zones. This annual FWS-EPA meeting will be scheduled after FWS has met with ADEC, on an annual basis, to discuss the upcoming ADEC permits with mixing zones and to assess progress under the MOA regarding identifying and reducing or eliminating attraction of Steller's eiders to mixing zones.

2. The following terms and conditions shall implement Reasonable and Prudent Measure No.2. "EPA shall use their discretionary authority to minimize the risk of exposure of Steller's eiders to harmful contaminants while they occupy mixing zones."

1.1 EPA shall use its discretionary authority, in overseeing the Alaska Department of Environmental Conservation's (ADEC) Alaska Pollutant Discharge Elimination System (APDES) program, to consider the impact of permitted discharges with mixing zones on listed Steller's eiders in the five harbors of concern identified in the MOA. EPA's review shall include reviewing ADEC's permits for consistency with 18 AAC 70.240(c)(4)(F) which provides that "…the mixing zone will not adversely affect threatened or endangered species except as authorized under 16 U.S.C. § 1531-§ 1544 (Endangered Species Act)."

1.2 As per the MOA, if EPA determines that a draft APDES permit is not in compliance with Alaska's mixing zone regulation at 18 AAC 70.240(c)(4)(F), EPA intends to use its discretion under the Clean Water Act to formally object to the proposed permit as per the procedures outlined in the NPDES Memorandum of Agreement (October 29, 2008) between the State of Alaska and EPA.

1.3 As part of EPA's oversight of ADEC's permit issuance program, EPA will work with ADEC to avoid adverse affects to Steller's eiders in the five harbors of concern. In accordance with the MOA Section V. F, EPA will consider FWS's written comments to ADEC, ADEC's written responses to comments, and the proposed permit conditions. As appropriate, and on a permit by permit basis, the EPA may recommend the following permit conditions to avoid adverse effects to Steller's eiders:

2.3.1. Permits shall not authorize mixing zones for fecal coliforms or other pathogenic bacteria when there is a potential for interaction or comingling with other discharges that cause Steller's eider attraction;

2.3.2. Permits with mixing zones that are suspected to cause attraction to Steller's eiders shall include regular monitoring for bioaccumulative pollutants, fecal coliform bacteria and petroleum hydrocarbon pollutants both inside and outside mixing zone;

2.3.3. Permits with mixing zones that are suspected to cause attraction to Steller's eiders shall include requirements to sample and analyze the invertebrate biota inhabiting mixing zones to assess potential biomagnification for pollutants of concern (bioaccumultive pollutants, bacteria, and petroleum hydrocarbons) in Steller's eider's prey.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act 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.

1. EPA should play a strong role in recovery efforts for the Alaska breeding population of Steller's eider. EPA should provide funding to the FWS or the Alaska SeaLife Center (or other suitable entity) toward the Steller's eider reintroduction/augmentation program. Increased

funding should compensate for lost breeding potential of individual Steller's eiders taken as a result of the mixing zones regulation.

2. Dischargers should not be authorized to exceed WQS for bioaccumulative pollutants (i.e., mercury, and 2,3,7,8-TCDD in a mixing zone where any listed species occur.
3. Dischargers should not be authorized to exceed WQS for petroleum hydrocarbons and cadmium in a mixing zone where any listed species occur.
4. Within the range of listed species, studies should validate the extent and performance of each mixing zone before a permit is reissued for that mixing zone.
5. EPA should ensure that permits and mixing zone regulations are properly enforced.

REINITIATION NOTICE

This concludes formal consultation on the proposed action. 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 retained (or is authorized by law) and if: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action.

Appendix I. Tri-agency Memorandum of Agreement regarding protecting Steller's eiders in five harbors of concern

December 17, 2010

MEMORANDUM OF AGREEMENT

AMONG

THE DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

AND

THE ENVIRONMENTAL PROTECTION AGENCY

AND

THE STATE OF ALASKA
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

REGARDING PROTECTING THREATENED STELLER'S EIDERS
(*POLYSTICTA STELLERI*) IN FIVE HARBORS OF CONCERN IN ALASKA

This MEMORANDUM OF AGREEMENT (MOA) is hereby entered into by and between the U.S. Fish and Wildlife Service, hereinafter referred to as the FWS, the Environmental Protection Agency, hereinafter referred to as the EPA, and the State of Alaska, Department of Environmental Conservation, hereinafter referred to as the ADEC.

I. PURPOSE

The purpose of this agreement is to identify the roles of each agency to ensure that implementation of Alaska's mixing zones regulation at 18 AAC 70.240 is consistent with protecting Alaska breeding Steller's eiders listed as threatened under Section 4 of the federal Endangered Species Act (listed Steller's eiders). In particular, 18 AAC 70.240(c)(4)(F) requires that "…the mixing zone will not adversely affect threatened or endangered species except as authorized under 16 U.S.C. § 1531-§ 1544 (Endangered Species Act)." The focus of this agreement is implementation of Alaska's mixing zones regulation to prevent adverse affects to listed Steller's eiders, in five harbors of concern identified in section II.B below.

II. BACKGROUND

A. All parties recognize that while there may be other significant threats to the Alaska breeding population of Steller's eiders, we agree this MOA will focus specifically on reducing risk of harm associated with regulated mixing zones in five harbors of concern in Alaska (listed in II.D, below).

B, The FWS, using the best available science (i.e., relevant scientific and commercially available data), believes there will likely be adverse affects to threatened Alaska breeding Steller's eiders as a result of their attraction to and preferential feeding in the areas of certain seafood wastewater discharges. FWS believes Steller's eiders are directly or indirectly attracted to areas where seafood waste is discharged into marine waters. Some seafood discharges are located at industrialized fishing harbors, within the post-breeding range of Steller's eiders. As a result of the attraction to areas in the vicinity of busy fishing harbors, Steller's eiders may be exposed to contaminants, including petroleum hydrocarbons and fecal bacteria that are discharged into those same marine waters (Miles et al. 2007; Reed and Flint 2007). Most hydrocarbon sources are from non-permitted, non-point-source discharges. Exposure to pollutants such as petroleum hydrocarbons can result in increased mortality and reduction in reproductive potential of the Alaska breeding population of Steller's eider (Fox et al. 1997; Springman et al. 2005).

C. Seafood processing facilities are directly associated with the fishing industry. Infrastructure associated with the fishing industry includes fishing vessel and barge traffic, fueling operations, vessel maintenance and vessel mooring. (Note: Not all of this infrastructure and/or facilities discharge wastewater that is permitted by the Alaska Department of Environmental Conservation (ADEC)). This association increases the probability that petroleum hydrocarbons and other contaminants will be accidentally spilled into the marine environment in the vicinity of the seafood processing discharges (ADEC 2008; Day and Pritchard 2000). Within the range of Pacific wintering Steller's eiders, the FWS identified five fishing harbors where Steller's eiders have been either anecdotally observed concentrating at seafood processing discharges or documented as such by wildlife researchers. At these five harbors, approximately:

- 700 Steller's eiders winter in Akutan Harbor (Larned 2000).
- 1300 Steller's eiders winter around Unalaska (Larned 2000);
- 1000 Steller's eiders winter around Sand Point (Larned 2000);
- 1300 Steller's eiders winter at Kodiak Island's Chiniak Bay (Larned and

Zwiefelhofer 2002); and

- 1000 Steller's eiders winter in Chignik Bay (Larned 2000).

D. Five harbors of concern have been identified by FWS where: 1) there are permitted mixing zones for seafood waste discharges; 2) Steller's eiders concentrate at the seafood waste discharge locations; and 3) petroleum hydrocarbons have been spilled or discharged. The five water-bodies are: 1) portions of Unalaska Bay, Amaknak and Unalaska islands (Dutch Harbor and the City of Unalaska); 2) Humbolt Harbor-Popof Strait, Popof (Sand Point); 3) St. Paul Harbor, Kodiak Island (Kodiak City); 4) Akutan Harbor, Akutan Island (Village of Akutan); and 5) Anchorage Bay, Chignik.

III. SCOPE

A. All parties of this MOA recognize that ensuring the continued existence of species protected under the Endangered Species Act is a shared responsibility among all federal agencies as set forth in Section 7 of the Endangered Species Act, and that under Section 9 of the Endangered Species Act, no federal, state or private action may result in the *take*[1] of a listed endangered species unless specifically exempted by the FWS.

B. All parties to this MOA understand that Section 303(c) of the Clean Water Act (CWA) requires that all states adopt Water Quality Standards, and that EPA review and approval of those standards in accordance with CWA Section 303(c) and its implementing regulations at 40 CFR Part 131 is necessary before those standards are in effect for CWA purposes.

C. All parties of this MOA understand that in 2006 the State of Alaska formally revised the Mixing Zones Regulation that is the subject of this MOA.

D. ADEC administers the approved state National Pollutant Discharge Elimination System (NPDES) program as the Alaska Pollutant Discharge Elimination System (APDES) program in Alaska. The NPDES program is being transferred to ADEC in phases. ADEC is responsible for the implementation of the Mixing Zones Regulation.

E. EPA is the federal agency with authority, under CWA section 402(d), to review and object to any APDES permit in the event that EPA finds that the permit does not comply with the Clean Water Act.

F. FWS is responsible for implementing the Endangered Species Act, and is authorized to protect the Alaska breeding population of Steller's eider, listed as threatened in 1997.

IV. AUTHORITIES

A. Endangered Species Act of 1973, (as amended 16 U.S.C. 1531 et seq.)
B. Clean Water Act (33 U.S.C. 1251 et seq.)
C. 18 AAC 70 Alaska Water Quality Standards and 18 AAC 83 (APDES)
D. MOA between FWS and EPA (66 Federal Register 11202, (February 22, 2001))

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[1] Take as defined in the Endangered Species Act is "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." [16 U.S.C. §1532(19)].

E. NPDES MOA between EPA and ADEC, October 29, 2008.

V. RESPONSIBILITIES

A. Appendix A includes a copy of the 2010-2012 schedule of anticipated permit issuance in the five harbors of concern (listed in II.D). FWS shall provide input to ADEC regarding the annual permit plan (permit issuance schedule). ADEC's goal is to issue permits that cover the seafood processors in the five harbors of concern during the next 5-year period. Multiple facilities may be covered under a single general permit such as seafood processing general permits. ADEC agrees to follow this MOA in the permit issuance process for facilities in the five harbors of concern, for the purposes of reducing or eliminating adverse effects to Steller's eiders.

B. ADEC shall notify FWS when work begins on a seafood processing permit (individual or general) in one of the five harbors of concern and, for anticipated individual permits, shall provide a copy of the permit application to FWS. ADEC and FWS will meet as necessary to exchange information and discuss FWS concerns about potential impacts to Steller's eiders from proposed wastewater discharges. The FWS input on development of APDES permits and/or mixing zones will focus on the reduction or elimination of adverse effects to Steller's eiders.

C. FWS shall provide ADEC with written comments during ADEC development of the preliminary draft permit, and any related mixing zones, including but not limited to information regarding Steller's eider biology and suggested permit conditions that would avoid adverse effects to the listed species. FWS comments shall focus on those constituents in the wastewater discharge that both directly and indirectly have the potential to impact Steller's eiders. The goal of these discussions is to develop permit conditions to reduce or eliminate those adverse effects.

D. When ADEC releases a preliminary draft APDES permit containing a mixing zone for a facility in any of the five harbors of concern listed in II.D, it will include a rationale in the Fact Sheet describing supporting data and technical justifications for how any proposed mixing zone has no anticipated adverse impacts or will avoid adverse effects to Steller's eiders. Consistent with the NPDES Memorandum of Agreement (October 29, 2008) between the State of Alaska and EPA, when ADEC transmits any preliminary draft APDES permit to the applicant for any facility in any of the five harbors of concern listed in II.D that includes a mixing zone, ADEC will notify FWS via email and identify the website where the proposed permit and supporting material is available for review.

E. When ADEC proposes a mixing zone in a draft APDES permit, EPA and the FWS agree to follow a process consistent with the coordination procedures in Section IX, Permitting Program Activities, of the Memorandum of Agreement (dated January 10, 2001) between EPA and the FWS (*See* 66 Fed. Reg. 11202, February 22, 2001). EPA and FWS will follow a process consistent with the coordination procedures referenced above to evaluate whether a proposed mixing zone meets the requirements of Alaska's mixing zone regulation at 18 AAC 70.240(c)(4)(F) that stipulates "…the mixing zone will not adversely affect threatened or endangered species except as authorized under 16

U.S.C. 1531-1544 (Endangered Species Act)." If the FWS determines that a mixing zone in a draft APDES permit is likely to result in adverse effects to listed Steller's eiders, FWS may write a letter to EPA, with a copy to ADEC, no later than 5 days prior to close of the public comment period documenting why adverse effects to Steller's eiders are likely, and request that EPA object to the proposed permit.

F. If notified by FWS as described in V.E above, EPA will review information in the draft APDES permit, Fact Sheet, and FWS' letter and any other relevant information to determine if the proposed APDES permit meets the requirements of Alaska's mixing zone regulation at 18 AAC 70.240(c)(4)(F). If EPA determines that the draft APDES permit is not in compliance with Alaska's mixing zone regulation at 18 AAC 70.240(c)(4)(F), EPA intends to use its discretion under the CWA to formally object to the proposed permit as per the procedures outlined in the NPDES Memorandum of Agreement (October 29, 2008) between the State of Alaska and EPA.

G. If EPA objects to a proposed APDES permit as described in V.F above, ADEC and EPA agree to resolve EPA's objection in accordance with the procedures outlined in the NPDES Memorandum of Agreement (October 29, 2008) between the State of Alaska and EPA. Under these procedures, ADEC can only issue the final APDES permit after EPA's objection has been rectified and withdrawn. FWS agrees to continue to provide timely technical assistance to both agencies, as needed, through this process.

H. ADEC, FWS and EPA recognize that a permittee may submit an application to FWS for an Endangered Species Act §10 permit (i.e., via a Habitat Conservation Plan) for a mixing zone that adversely affects listed Steller's eiders. ADEC, FWS, and EPA recognize that issuance of an Endangered Species Act §10 permit from the FWS satisfies 18 AAC 70.240(c)(4)(F).

I. EPA, FWS and ADEC agree to collaborate on additional activities to assist in the conservation of listed Steller's eiders in the five water bodies identified above, as resources and authorities allow. Such activities may include: identifying data and research gaps; monitoring studies for pollutants identified as harmful to listed Steller's eiders; studying attraction of listed Steller's eider to areas with discharges from seafood processing activities; educating dischargers about adverse effects to listed species as a result of discharging pollutants; investigating and promoting the transition to economically sound alternatives for seafood waste disposal that results in reduced discharges; restoring the benthic environment where past or existing discharges attract and adversely affect listed Steller's eiders; and, as needed, to jointly carrying out a public process to include seafood processors, local governments, and other wastewater discharge permittees to evaluate potential conservation measures for listed Steller's eiders.

J. Within one year of the effective date of this agreement, ADEC shall provide FWS and EPA with precise locations of all end-of-pipe discharge locations with permitted mixing zones, within the five harbors of concern.

K. On an annual basis, ADEC shall report to FWS and EPA the results of effluent testing, and receiving water monitoring when applicable, for all mixing zones (including but not limited to seafood and sanitary waste discharges) within the five harbors of concern, noting all exceedances and the compliance and enforcement actions that were taken.

VI. FINANCIAL COMMITMENTS

This MOA does not constitute a financial commitment on the part of any party. The MOA is designed to serve as a mechanism under which each party will work cooperatively to insure that the subject action will not jeopardize the continued existence of Alaska breeding Steller's eiders.

As required by the Antideficiency Act, 31 U.S.C. 1341 and 1342, all commitments made by EPA and FWS in this MOA are subject to the availability of appropriated funds and budget priorities. Nothing in this MOA in and of itself obligates EPA, ADEC, or FWS to expend appropriations or to enter into any contract, assistance agreement, interagency agreement, or incur other financial obligations. Any transaction involving transfers of funds between the parties to the MOA will be handled in accordance with applicable laws, regulations and procedures under separate written agreements.

VII. PERIOD OF AGREEMENT

This agreement becomes effective on the date of signature by all parties and remains in effect until terminated. This MOA may be amended at any time, by mutual written consent of the parties. Additionally, a party may terminate its participation in this MOA at any time by providing written notice to the other parties at least 60 days in advance of that party's termination of participation. This agreement will be incorporated as part of the action being considered under section 7 consultation for EPA's proposed approval of Alaska's revised mixing zones regulation, and thus termination of a party's participation in the MOA or amendments to the MOA may result in the need to reinitiate formal Section 7 consultation under the ESA.

VIII. OTHER PROVISIONS

This MOA does not create any right or benefit, substantive or procedural, enforceable by law or equity, by persons who are not party to this agreement, against FWS, ADEC, or EPA, their officers or employees, or any other person. This MOA does not direct or apply to any person outside of FWS, ADEC, and EPA.

This Agreement may be executed in counterparts, each of which shall be deemed an original, but which together shall constitute one and the same instrument. A signed copy of this Agreement in .pdf format shall be considered an original signed version of the Agreement.

IX. LITERATURE CITED

[ADEC] Alaska Department of Environmental Conservation. 2008. Spreadsheet of reported contaminant spills from 1993-2008 along the Alaska Peninsula, Aleutian Islands, Cook Inlet and Kodiak Island. Unpublished report.

Day RH, AK Pritchard. 2000. Task 2C. Estimated future spills. Prepared for the U.S. Army Engineer District, Alaska. ABR, Inc., Fairbanks, Alaska.

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Larned WW. 2000. Aerial surveys of Steller's eiders and other water birds and marine mammals in southwest Alaska areas proposed for navigation improvements by the U.S. Army Corps of Engineers, Alaska. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska.

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Springman KR, G Kurath, JJ Anderson, JM Emlen. 2005. Contaminants as viral cofactors: assessing indirect population effects. Aquatic Toxicology, 71:13-23.

X. APPROVALS

Geoffrey L. Haskett, Regional Director, FWS Date 1/3/11

X. APPROVALS

Dennis J. McLerran, Regional Administrator, EPA

1/18/2011
Date

X. APPROVALS

Notwithstanding Section VII. Period of Agreement, this ADEC signature approval of the MOA becomes effective upon EPA approval of ADEC's 2006 amendments to mixing zone regulations at 18 AAC 70.240.

Lawrence Hartig, Commissioner, ADEC

April 15th 2011
Date

Appendix II. Status of the species: Steller's eider (*Polysticta stelleri*)

Steller's eider (*Polysticta stelleri*)

Species Description

The Steller's eider is the smallest of the eiders. The average weight of adult male and female Steller's eiders is 1.94 pounds (Bellrose 1980). Adult male Steller's eiders in breeding plumage have a black back, white shoulders, and a chestnut brown breast and belly. The males have a white head with black eye patches; they also have a black chin patch and a small greenish patch on the back of the head. Females and juveniles are mottled dark brown until the fall of their second year, when they acquire breeding plumage (Fredrickson 2001).

Life History

Longevity

Steller's eiders are long lived, with individuals known to have lived at least as long as 21 years and 4 months in the wild (band number 647-66747). Other ages recorded for this species in the wild are 20 years, 4 months (band numbers 647-66757 and 1077-13265), 19 years, 3 months (band number 647-64547), and 16 years (band numbers 1157-01787 and 1157-01876)(Chris Dau, FWS, pers. comm.).

Energetics

Goudie and Ankney (1986) suggest that small-bodied seaducks such as harlequin and long-tailed ducks (*Clangula hyemalis*) that winter at northern latitudes do so near the limits of their energetic threshold. These species have little flexibility in regards to caloric consumption or in their opportunity to rely on caloric reserves. Under this life history strategy, such species are vulnerable to perturbations within their winter habitat. Because the Steller's eider is relatively small-bodied, being intermediate in size to the harlequin and long-tailed ducks (Bellrose 1980), and because it overlaps with harlequins and long-tailed ducks in its choice of foraging areas and prey items, the species may, like the harlequin and long-tailed ducks, exist near its energetic limits. Unlike other larger eiders, Steller's eiders must continue to feed upon reaching their nesting areas, to build up enough energy reserves to breed (D. Solovieva, Zoological Institute, Russian Academy of Science, pers. comm.). In addition, female Steller's eiders must continue to feed during incubation.

Age to Maturity

Sexual maturity is believed to be deferred to the second year (Bellrose 1980).

Reproductive Strategy

Pair formation for most seaducks occurs in fall and spring (Johnsgard 1994). Metzner (1993) hypothesized that Steller's eiders at Izembek Lagoon and Cold Bay paired in the spring because they were apparently too preoccupied with feeding during the fall and winter to form pair bonds. The length of time that Steller's eiders remain paired is unknown. However, long-term pair bonds have been documented in other ducks (Bengtson 1972, Savard 1985).

Pairs of Steller's eiders arrive at Point Barrow as early as June 5 (Bent 1987). While nesting, Steller's eiders often occupy shallow coastal wetlands in association with tundra (Bent 1987, Quakenbush et al. 1995, Solovieva 1997), although we have records of aerial observations of

Steller's eider pairs well inland on the Arctic Coastal Plain. This species establishes nests near shallow ponds or lakes, usually close to water.

Clutch size has been reported to range from two to ten eggs (Bent 1987; Bellrose 1980; Quakenbush et al. 1995) with an average of 5.8± 1.1 (Rojek 2008). The average clutch size of successful nests near Barrow is reported as 4.6 (n = 8), while on the Lena Delta in Russia, clutch size varied between five and eight eggs with an average of 6.1 (n = 32; Solovieva 1997). Nesting success near Barrow (percent of nests where eggs hatch) is variable (Quakenbush et al. 1995). During some years, the species apparently does not even attempt to nest near Barrow (Quakenbush et al. 1995; Rojek 2008). Mayfield estimate of nest success over a 16-year period (1991-2007) is 23% (17-32, 95% CI; Rojek 2008).

Recruitment

Steller's eider recruitment rate (the percentage of fledged birds that reach sexual maturity) is unknown. However, there is limited information regarding Steller's eider fledging rate. Near Barrow, 83.3% (five of six) of Steller's eiders nests with eggs hatched in 1991, 20.0% (four of 20) hatched in 1993 (Quakenbush et al. 1995), 15% (three of 20) hatched in 2000 (Philip Martin, FWS, pers. comm.), and 58% (seven of 12) hatched in 2007 (Rojek 2008). In other years, Steller's eiders do not even attempt to breed near Barrow (Philip Martin, FWS, pers. comm., Quakenbush et al. 1995). We conclude that the annual recruitment rate for this species is variable.

Seasonal Distribution Patterns

Banded and Satellite-Tagged Alaskan Breeding Birds -- Little is known of the distribution of Alaska breeding Steller's eiders outside of the breeding season. A few band recoveries indicate that birds that breed near Barrow undergo molt in Izembek Lagoon. A satellite telemetry study was initiated in 2000 to investigate the molting and wintering locations of the Alaskan population of Steller's eiders. Satellite transmitters were placed on three Steller's eiders captured in Barrow. Two Steller's eiders (one male and one female) spent the molting season on the Kuskokwim Shoals, while a third (a male) molted near the Seal Islands (Philip Martin, FWS, pers. comm.). Both birds that molted at Kuskokwim Shoals moved on to the Hook Bay portion of Bechevin Bay in November. The male remained in Hook Bay at least until late December when his transmitter stopped working. The female remained at Hook Bay until early February, at which time she returned to Izembek Lagoon and remained there into spring. The bird that molted near the Seal Islands moved west to Nelson Lagoon in October. After spending approximately 3 weeks at Nelson Lagoon, this bird moved west to Sanak Island at the end of November. The bird remained at Sanak Island for 3 months. During this time his use area was small, only a few square kilometers. By March 4, he had moved back to Izembek Lagoon in the vicinity of his November locations (Philip Martin, FWS, pers. comm.).

Breeding Distribution -- The exact historical breeding range of the Alaska-breeding population of Steller's eiders is not clear. The historical breeding range may have extended discontinuously from the eastern Aleutian Islands to the western and northern Alaska coasts, possibly as far east as the Canadian border. In more recent times, breeding occurred in two general areas, the Arctic Coastal Plain, and western Alaska, primarily on the Yukon-Kuskokwim (Y-K) Delta. Currently,

Steller's eiders breed on the western Arctic Coastal Plain in northern Alaska, from approximately Point Lay east to Prudhoe Bay, and in extremely low numbers on the Y-K Delta.

On the Arctic Coastal Plain, anecdotal historical records indicate that the species occurred from Wainwright east, nearly to the Alaska-Canada border (Anderson 1913; Brooks 1915). There are very few nesting records from the eastern Arctic Coastal Plain, however, so it is unknown if the species commonly nested there or not. Currently, the species predominantly breeds on the western Arctic Coastal Plain, in the northern half of the National Petroleum Reserve - Alaska (NPR-A). The majority of sightings in the last decade have occurred east of the mouth of the Utukok River, west of the Colville River, and within 90 km (56 mi) of the coast. Within this extensive area, Steller's eiders generally breed at very low densities.

The Steller's eider was considered a locally "common" breeder in the intertidal, central Y-K Delta by naturalists early in the 1900s (Murie 1924; Conover 1926; Gillham 1941; Brandt 1943), but the bird was reported to breed in only a few locations. By the 1960s or 70s, the species had become extremely rare on the Y-K Delta, and only six nests were found in the 1990s (Flint and Herzog 1999). One to two nests continue to be found each year during the course of extensive ground-based waterfowl research and surveys. Given the paucity of early-recorded observations, only subjective estimates can be made of the Steller's eider's historical abundance or distribution on the Y-K Delta.

A few Steller's eiders were reportedly found nesting in other locations in western Alaska, including the Aleutian Islands in the 1870s and 80s (Gabrielson and Lincoln 1959), Alaska Peninsula in the 1880s or 90s (Murie and Scheffer 1959), Seward Peninsula in the 1870s (Portenko 1972), and on Saint Lawrence Island as recently as the 1950s (Fay and Cade 1959). It is unknown how regularly these areas were used or whether the species ever nested in intervening areas.

Post-Breeding Distribution and Fall Migration -- Following the breeding season, males and some nest-failed females, depart from their Russian nesting area and return to marine waters (Solovieva 1997). We know little of Steller's eiders use of marine waters adjacent to Alaska's Arctic Coastal Plain and along the west and southwest coast of Alaska during late summer and fall migration. Historical observations made by Murdoch (1885 as in Bent 1987) indicate that birds that have bred near Point Barrow begin to return to the coast from the first to the middle of July. In addition, he indicated that they disappear from the Barrow area from the first to the middle of August. Steller's eiders arrived at St. Michael around 21 September (Bent 1987). Late date of departure was as follows: Point Barrow, September 17; St. Michael, October 5; and Ugashik, November 28 (Bent 1987).

Over 15,000 Steller's eiders were observed on September 27, 1996, in Kuskokwim Bay (Larned and Tiplady 1996). Most (nearly 14,000) were located along the mainland side of barrier islands while about 1,100 were detected further offshore. Despite this species' apparent preference for near-shore habitats, several groups were detected over 10 km from shore and two groups were over 30 km from shore.

In late summer and fall, large numbers of Steller's eiders molt in a few lagoons located on the north side of the Alaska Peninsula (i.e., Izembek and Nelson Lagoon/Port Moller Complex, Seal Islands; Petersen 1980, 1981). Recent observations of over 15,000 Steller's eiders in Kuskokwim Bay, and the observation of two out of three satellite-tagged birds from Barrow molting there suggests that Kuskokwim Bay may also be a notable molting area for this species and for the listed entity (Larned and Tiplady 1996; Philip Martin, FWS, pers. comm.). Following the molt, large numbers of Steller's eiders are known to over winter in near-shore marine waters of the Alaska Peninsula, Aleutian Islands, Kodiak Archipelago, and the Kenai Peninsula (e.g., within Kachemak Bay).

Molt Distribution -- After breeding, Steller's eiders move to marine waters where they undergo a flightless molt for about 3 weeks. The majority is thought to molt in four areas along the Alaska Peninsula: Izembek Lagoon (Metzner 1993; Dau 1991; Laubhan and Metzner 1999), Nelson Lagoon, Herendeen Bay, and Port Moller (Gill et al. 1981; Petersen 1981). Additionally, smaller numbers are known or thought to molt in a number of other locations along the western Alaska coast, around islands in the Bering Sea, along the coast of Bristol Bay, and in smaller lagoons along the Alaska Peninsula (Swarth 1934, Dick and Dick 1971, Petersen and Sigman 1977, Wilk et al. 1986, Dau 1987, Petersen et al. 1991).

Winter Distribution -- Following the molt, many but not all Steller's eiders disperse from major molting areas to other portions of the Alaska Peninsula and Aleutian Islands. Winter ice formation often temporarily forces birds out of shallow protected areas such as Izembek and Nelson Lagoons. During the winter, this species congregates in select near-shore waters throughout the Alaska Peninsula and the Aleutian Islands, around Nunivak Island, the Kodiak Archipelago, and in Kachemak Bay (Larned 2000a, Bent 1987, Larned and Zwiefelhofer 1995).

Larned (2000b) did not see Steller's eiders along most of the Alaska Peninsula coastline he surveyed during winter. Most of the birds were concentrated within relatively small portions of the coastal waters. Much of the population, detected during spring migration, was not detected on this winter survey. We believe this was because many Steller's eiders winter farther west in the Aleutian Islands and/or along the south side of the Alaska Peninsula.

Spring Migration -- In the spring, Steller's eiders form large flocks along the north side of the Alaska Peninsula and move east and north (Larned et al. 1993, Larned 1998, Larned 2000b). Spring migration usually includes movement along the coast, although birds may take shortcuts across water bodies such as Bristol Bay (William Larned, FWS, pers. comm.). Interestingly, despite many daytime aerial surveys, Steller's eiders have never been observed during migratory flights (William Larned, FWS, pers. comm.). Larned (1998) concluded that Steller's eiders show strong site fidelity to "favored" habitats during migration, where they congregate in large numbers to feed before continuing their northward migration.

The number of Steller's eiders observed in each site during migration surveys should be considered a minimum estimate of the number of eiders that actually use these sites during migration. These data represent eider use during a snapshot in time, when in reality, a stream of eiders likely flows into and out of these sites throughout the migration season. The spring migration survey was not intended to document the intensity of use of any particular site by

Steller's eiders, but was designed to monitor the entire population of Steller's eiders and other seaducks during the spring migration.

Because the spring Steller's eider aerial survey was not intended to quantify use of any particular area by Steller's eiders during spring migration, care must be taken in interpreting the results with this purpose in mind. For example, Steller's eider use of habitat near Ugashik and Egegik Bays was documented in 1992, 1993, 1997, and 1998 (Larned et al. 1993, Larned 1998). However, in 2000, no Steller's eiders were observed there (Larned 2000b). In fact, no Steller's eiders were observed from the Cinder River Sanctuary to Cape Constantine; an expanse of approximately 110 miles of coastline which encompasses these bays and which has had several thousand Steller's eiders documented in previous years (Larned et al. 1993, Larned 1998). However, 15,000 Steller's eiders were observed south of this area and were distributed between Port Heiden and Port Moller (Larned 2000b). Three days later, about 43,000 Steller's eiders were observed south of Port Moller (Larned 2000b). The birds were, in essence, stacking up behind Port Moller, or were otherwise phenologically late in their migration relative to the previous few years. Regardless, survey results from that year suggested low use of habitats north of Port Moller, even though the birds that were counted south of Port Moller presumably used those more northerly habitats following the conclusion of the spring aerial survey.

Several areas receive consistent use by Steller's eiders during spring migration, including Bechevin Bay, Morzhovoi Bay, Izembek Lagoon, Nelson Lagoon/Port Moller Complex, Cape Seniavin, Seal Islands, Port Heiden, Cinder River State Critical Habitat Area, Ugashik Bay, Egegik Bay, Kulukak Bay, Togiak Bay, Nanwak Bay, Kuskokwim Bay, Goodnews Bay, and the south side of Nunivak Island (Larned et al. 1993, Larned 1998, and Larned 2000b).

Summer Distribution in Southern Alaska -- A small number of Steller's eiders are known to remain along the Alaska Peninsula and Kachemak Bay during the summer; approximately 100 have been observed in Kachemak Bay, while a few may spend the summer at Izembek Lagoon (Chris Dau, FWS, pers. comm.).

Site Fidelity

Steller's eiders appear to show site fidelity at different spatial scales during different times of the year. There is good evidence of fidelity to molting sites. About 95% of banded, molting Steller's eiders are recaptured at the same site at which they were banded (Flint et al. 2000). Flocks of Steller's eiders make repeated use of certain areas between years (Larned 1998), although it is unknown to what extent individuals display repeated use of these areas.

Female philopatry to breeding grounds in waterfowl species is high. Female waterfowl tend to return to the area where they hatched for their first nesting effort, and subsequently tend to return to the same area to breed in the following years (Anderson et al. 1992). Despite having had only a few opportunities to observe Steller's eiders breeding on the Y-K Delta, we have observed philopatry displayed by a female Steller's eider there; one individual chose nest sites in two consecutive years that were about 124 m apart (Paul Flint, U. S. Geological Survey (USGS), Biological Resources Division, pers. comm.). Banding data from the Barrow area suggests some level of site fidelity for Steller's eiders breeding there as well (Quakenbush et al. 1995; Phillip Martin, FWS, pers. comm.). Interestingly, natal philopatry has not been observed in Steller's

eiders nesting in Russia (D. Solovieva, Zoological Institute, Russian Academy of Science, pers. comm.).

Further evidence of breeding site fidelity is found in other seaducks. Female spectacled eiders did not move between general nesting areas (coastal versus interior) between years (Scribner et al. 2001). In addition, mitochondrial DNA analysis indicates that female spectacled eiders tend to return to their natal breeding area once they are recruited to the breeding population (Scribner et al. 2001). Natal, breeding, and winter philopatry in other seaducks has also been documented (Dow and Fredga 1983, Savard and Eadie 1989, Robertson 1997, Robertson et al. 1999).

Movement data from 23 Steller's eiders captured in Captain's Bay and around Amaknak Island (near Dutch Harbor) in spring 2001 reveal that eiders show site fidelity to general wintering areas (Reed and Flint 2007). The birds marked in Captain's Bay were never detected outside of the area that the flock was observed using. Birds marked around Amaknak Island remained in the general area, but appeared to use a larger home range. Satellite telemetry data indicated that two tagged Steller's eiders used an area of only a few square kilometers from November through February (Philip Martin, FWS, Pers. comm.). Although further investigation is needed, preliminary studies suggest that Steller's eiders show high site fidelity at over wintering sites, at least within one winter season. Whether Steller's eiders show fidelity to over wintering sites between years remains unknown.

We note that site fidelity has been observed in wintering harlequin ducks; they showed strong site fidelity for short stretches (5 km) of coastline (Cooke et al. 2000). Robertson et al. (1999) concluded that strong site tenacity suggests that local knowledge of an area is valuable and may help ensure high survival of individuals remaining in a familiar site. They suggest that site fidelity would be expected of long-lived species that are sensitive to adult mortality and depend, at least in part, upon habitat stability for survival.

Population Structure

Genetic analysis of vertebrate populations suggests that there are often genetic gradients or differences that correspond to the geographic distribution of the species (Lande and Barrowclough 1987). The Alaska breeding population of Steller's eiders may contain unique geographic sub-populations because of: 1) the distance between breeding populations on the Y-K Delta and the Arctic Coastal Plain [about 804 km (500 mi)], and 2) the anticipated site fidelity of nesting adult females (Anderson et al.1992). The similarly distributed North Slope and Y-K Delta populations of spectacled eiders possess distinct mitochondrial DNA markers, implying limited maternal gene flow between these two areas for that species (Scribner et al. 2001).

Food Habits

Steller's eiders employ a variety of foraging strategies that include diving to a maximum depth of at least 9 m (30 ft), bill dipping, body tipping, and gleaning from the surface of water, plants, and mud. During the fall and winter, Steller's eiders forage on a variety of invertebrates that are found in near-shore marine waters (Metzner 1993, Petersen 1981, Bustnes et al. 2000). Esophageal contents from 152 Steller's eiders collected at Izembek Lagoon, Kinzarof Lagoon, and Cold Bay, Alaska, indicate Steller's eiders forage on a wide variety of invertebrates, which made up the majority of their diet (92%, aggregate dry weight; Metzner 1993). In addition,

occurrence of shell-free prey (e.g., *Crustacea*, *Polychaeta*) predominated, compared to that of food items with shells (Metzner 1993). Metzner (1993) concluded that Steller's eiders were opportunistic generalists, foraging primarily on fauna associated with eelgrass beds in Izembek Lagoon and Kinzarof Lagoon. During molt, Steller's eiders consumed blue mussel (*Mytilus edulis*), especially while growing wing-feathers, other bivalves (e.g. *Macoma balthca*), and amphipods (a small crustacean; Petersen 1981).

In northern Norway, 31 species were identified as Steller's eider winter food items; 13 species of gastropods (68.4% of total number of items), four species of bivalves (18.5%), 12 species of crustaceans (13%), and two species of echinoderms (0.1%; Bustnes et al. 2000). Juveniles sampled in this study fed more on crustaceans (x = 61% aggregate wet weight) than did adults (x = 26% aggregate wet weight). Examination of female Steller's eiders found dead near Barrow showed they had consumed mostly Chironomid larvae, which are the predominant macrobenthic invertebrate in Arctic tundra ponds (Quakenbush et al. 1995).

Predators

Predators of Steller's eiders during nesting include snowy owls (*Nyctea scandiaca*), short-eared owls (*Asio flammeus*), peregrine falcons (*Falco peregrinus*), gyrfalcon (*Falco rusticolus*), pomarine jaegers (*Stercorarius pomarinus*), rough-legged hawks (*Buteo lagopus*), common raven (*Corvus corax*), glaucous gulls (*Larus hyperboreus*), Arctic fox (*Alopex lagopus*), and red fox (*Vulpes vulpes*). Quackenbush et al. (1995) reported five adult male and three adult female Steller's eiders taken by avian predators in 4 years near Barrow. Predators included peregrine falcons, gyrfalcons, and snowy owls. In addition, pomarine jaegers preyed on Steller's eider eggs. On the Y-K Delta, Steller's eider nests have been destroyed by gulls (Paul Flint, USGS, pers. comm.). In fall, winter, and spring predation can be attributed primarily to avian predators, such as bald eagles (*Haliaeetus leucocephalus*) and gyrfalcons (*Falco rusticolus;* Christian Dau, FWS, pers. comm.).

Population Dynamics

Population Size

Population sizes are only imprecisely known. The Pacific wintering population is estimated to be about 73,904 birds (Larned and Bollinger 20). The threatened Alaska-breeding population is thought to be about 500 on the Arctic Coastal Plain (Stehn and Platte 2009), and possibly tens on the Y-K Delta (FWS, Anchorage Fish and Wildlife Field Office, Unpublished Data).

<u>Y-K Delta</u> -- Estimating the size of the Steller's eider breeding population in Alaska has proved difficult. Due to the low counts and high variation in counts between years during systematic surveys, an accurate/precise statistical estimate is unavailable. Aerial surveys that included the Y-K Delta but did not include the Arctic Coastal Plain indicated that the population sizes of eiders had declined by 90% since 1957 (Hodges et al. 1996). For the 1950s and early 1960s, the upper limit of the population, excluding the North Slope, had been estimated to be approximately 3,500 pairs (Kertell 1991). Kertell noted, however, that the population might have been smaller due to the potential restriction of nesting Steller's eiders to specific habitats. Kertell concluded that the Steller's eider had been extirpated from the Y-K Delta prior to 1990.

Since publication of Kertell (1991), a few pairs of Steller's eiders have nested on the Y-K Delta (Table (II)1; Paul Flint, USGS, pers. comm. 1999; Brian McCaffery, FWS pers. comm., 2005). In no single year have biologists found more than three nests, despite extensive ground-based nest search efforts throughout nearly all of the Steller's eider critical habitat area. No nests have been found on the Y-K Delta since 2005.

Because extensive ground investigations occur over at least 1.4% of Steller's eider critical habitat on the Y-K Delta each year (Tim Bowman, FWS, Anchorage, 2003, Pers. comm.), with additional searching occurring by crews walking to and from study sites, and since these searches have not revealed more than two Steller's eider nest in any given year, we believe the estimate of hundreds of Steller's eiders on the Y-K Delta is optimistic.

Arctic Coastal Plain/North Slope -- Aerial surveys provide the best estimate of Steller's eider population size in northern Alaska; though caution must be used when interpreting the survey program results. Neither the surveys conducted by Mallek et al. (2005) nor Larned et al. (2005) were designed to estimate Steller's eider populations. It is a low density species in this area and surveys are not typically flown at the optimum time for observing Steller's eiders.

The Arctic Coastal Plain (ACP) Breeding Bird Survey point estimate for Steller's eiders reported by Mallek et al. (2005) from 1986 to 2005 ranged from 0 to 2,543 (Table (II)2), with a 20-year average of 774. The North Slope Eider Surveys is timed to be flown during the spectacled eider early nesting period, which is the best time to detect most breeding waterfowl populations. But it is typically flown too early to accurately estimate Steller's eiders.

The actual numbers of Steller's eider present on the North Slope during spring is probably underestimated in most years due to an unknown proportion of birds missed during aerial surveys because they have not yet arrived. Conversely, the data may over estimate population size due to the periodic presence of non-breeding birds or failed breeders from other areas. For example, the second highest count from the ACP Breeding Bird Survey from 1986-2005 (2,524) occurred in 1994 when the species failed to nest in the Barrow area and remained in terrestrial (non-marine) habitats until mid-July (Quakenbush et al. 2001).

The problem of Steller's eider population estimation results from the species dispersal across a huge landscape at very low densities. In addition, the number of Steller's eiders present on the ACP may fluctuate dramatically from year to year. Aerial surveys optimized to detect eiders have been conducted on the North Slope since 1992 (Larned et al. 2006), and indicate Steller's eiders occur at very low densities across the ACP, with a higher density in the vicinity of Barrow. Standardized ground surveys for eiders near Barrow have been conducted since 1999, and have found an average density near Barrow of 0.66 birds per km^2 (Rojek 2006). The Barrow vicinity supports the largest known concentration of nesting Steller's eiders in North America.

Table (II)1. Sightings of Steller's eiders on the Y-K Delta.

Year	General Location	Number of Pair	Nest Detected	Number of Eggs	Fate of Nest
1994	Kashunuk River near Hock Slough	1	1	7	Destroyed by Gulls
1996	Tutakoke River	1	1	6	Unknown
1997	Tutakoke River	2	0	NA	NA
1997	Kashunuk River	1	1	6	Hatched
1998	Tutakoke River; Kashunuk River	2;1	2; 1	Unk.; 7	Destroyed; Hatched
1999	Kigigak Island	2	2	unknown	unknown
2000	Kigigak Island	2	2	unknown	unknown
2004	Kigigak Island (south central)	1	1	7	Hatched
2005	Kigigak Island (south central and west coastal)	2 probable	1	6; unknown	Abandoned; 2 ducklings observed

Table (II)2. Aerial population estimates for Steller's eiders, from the North Slope.

Year	Population Estimate	Nesting Status Near Barrow
1986	0[4]	-
1987	0[4]	-
1988	0[4]	-
1989	2002[4]	-
1990	534[4]	-
1991	1118[4]	Nesting[1]
1992	954[4] /0[5]	Non-nesting[1]
1993	1313[4]/262[5]	Nesting[1]
1994	2524[4]/47[5]	Non-nesting[1]
1995	931[4]/281[5]	Nesting[1]
1996	2543[4]/0[5]	Nesting[1]
1997	1295[4]/189[5]	Nesting[1]
1998	281[4]/0[5]	Non-nesting[1]
1999	1250[4]/785[5]	Nesting[1]
2000	563[4]/0[5]	Nesting[2]
2001	176[4]/288[5]	Non-nesting[2]
2002	0[4]/0[5]	Non-nesting[2]
2003	0[4]/93[5]	Non-nesting[2]
2004	0[4]/48[5]	Non-nesting[2]
2005	110[4]/99[5]	Nesting[2]
2006	96[3]/112[5]	Nesting[2]
2007	96[6]	Nesting[2]
2008	576[7]	Nesting[2]
2009	Data unavailable	Non-nesting [3]

[1] Quakenbush et al. 2001; [2] Nora Rojek, FWS, pers. comm.; [3] Ritchie et al. 2006; [4] Mallek et al. 2005; [5] Larned et al. 2006; [6]Obritschkewitsch et al. 2008; [7]Stehn and Platte 2009

Three aerial survey efforts provide a range of estimates of the North Slope breeding population of Steller's eiders. The 1989-2006 ACP survey estimated a total average population of 866 birds (539.9-1192.7, 90% CI; Mallek et al. 2007). The 1992-2008 NSE survey averaged 161.6 birds (79.2-244.0, 90% CI; Larned et al. 2008). The 1999-2007 ABR survey averaged 99.6 birds (55.5-143.7, 90% CI; Obrischkewitsch et al. 2008).

Stehn and Platte (2009) conducted a review of the distribution, abundance, and trend of the listed population of Steller's eiders on the ACP. Utilizing information from three aerial surveys, they assessed the population status and trend of the Steller's eider population nesting on tundra wetlands of northern Alaska. The three surveys are the ACP, the North Slope eider survey (NSE) and the Barrow Triangle survey (ABR). Data reported from these three surveys provide different estimates of average population size and trend. Average population size and trend can be biased by changes in observer, detection rates and survey timing. Survey timing was considered

especially important for species with male departure early in incubation, or other marked shifts in habitat use, movements, or flocking behavior (ground breeding surveys near Barrow indicate the best time for aerial surveys of breeding Steller's is about 12-20 June, after arrival of most breeding individuals but before most males depart. Using a subset of data least confounded by changes in survey timing and observer, the appropriately-timed NSE survey observations from 1993-2008 averaged 173 indicated total Steller's eiders (88-258, 90% confidence interval) with an estimated growth rate of 1.011 (0.857 – 1.193, 90% CI). The authors assumed a detection probability of 30% (based upon reasonable estimates with similar species and habitats), yielding a total average population of Steller's eiders breeding in the ACP of about 576 (292-859, 90% CI) individuals (Stehn and Platte 2009).

Aerial surveys likely undercount Steller's eiders because an unknown number are simply missed when observers count from aircraft; this proportion varies by species and is unknown for Steller's eiders. Additionally, because observations at Barrow indicate that many Steller's eiders vacate nesting habitat early in non-nesting years, it is possible that aerial surveys fail to detect some individuals that were present early in the season, at least in some years. Further, the concentration area at Barrow, which contains a significant proportion of Steller's eiders detected on the entire ACP in most years, may be under-sampled because: 1) the scale of the concentration is too small to be adequately represented in the sampling regime; and 2) a portion of the concentration area is excluded because the area near the Barrow airport cannot be flown due to aviation safety concerns.

Population Variability

Variability in the abundance of the Alaska breeding population of Steller's eiders is not well understood. The sampling errors around our population estimates are large enough to obscure large annual population fluctuations. However, ground-based efforts in the Barrow area suggest that the local breeding populations there fluctuate dramatically (Quakenbush et al. 1995). Indeed, during some years, as in 2000 and 2002, Steller's eiders completely forego nesting in this area (Philip Martin, FWS, pers. comm.).

Population Stability

The Steller's eider is a relatively long-lived species. Such species do not typically display highly variable populations. That Steller's eiders completely forego nesting in some years near Barrow is consistent with the reproductive strategy for a long-lived species (Begon and Mortimer 1986). However, high adult mortality rates may be undermining this species' ability to maintain a stable population.

The population of Pacific wintering Steller's eiders molting and wintering along the Alaska Peninsula appears to be declining (Flint et al. 2000, Larned 2000b). In addition, comparison of banding data from 1975 -1981 to 1991-1997 indicates a reduction in Pacific wintering Steller's eider survival over time (Flint et al. 2000). Population models for other waterfowl applied to this species indicate that the observed reduction in annual survival over time would have a substantial negative effect on populations (Schmutz et al. 1997; Flint et al. 2000).

The Alaska breeding population is nested within the Pacific wintering Steller's eider population (Runge 2004). The Y-K Delta breeding population is presumed extirpated, and the population

trajectory for the North Slope breeding population is ambigious (based on aerial survey data (declining - Mallek et al. 2007, Obrischkewitsch et al. 2008; increasing (Larned et al. 2010); Stehn and Platte 2009), but appears to have undergone a range contraction compared to its pre-1970 distribution (Quakenbush et al. 2002). However, assuming that there is no permanent immigration or emigration between Asian breeding and Alaskan breeding Steller's eiders, and that the best available estimates of vital rates are accurate and precise (Appendix VII), listed Steller's eiders have a high probability of extinction in the foreseeable future (Runge 2004; Swem and Matz 2008).

Status and Distribution

Reasons for Listing

The Alaska breeding population of Steller's eiders was listed as a threatened population on June 11, 1997 (62 FR 31748; FWS 1997). It was listed due to: 1) its recognition as a distinct vertebrate population segment; 2) a substantial decrease in the species' nesting range in Alaska; 3) a reduction in the number of Steller's eiders nesting in Alaska; and 4) the vulnerability of the remaining breeding population to extirpation (FWS 1997).

Habitat Loss: Critical habitat was designated for the Steller's eider on February 6, 2001 (65 FR 13262). The direct and indirect effects of future gas/oil development within the National Petroleum Reserve-Alaska, and future village expansion (e.g., at Barrow), were cited as potential threats to the Steller's eider (FWS 1997). Within the marine distribution of Steller's eiders, perceived threats included marine transport, commercial fishing, and environmental pollutants (FWS 1997).

Until recently eider breeding habitat on the ACP was largely unaltered by humans, but limited portions of each species' breeding habitat have been impacted by fill of wetlands, presence of infrastructure that presents collision risk, and other types of human activity that may disturb birds or increase populations of nest predators. These impacts have resulted from the gradual expansion of communities, cold war era military developments such as the Distant Early Warning (DEW) Line sites at Cape Lonely and Cape Simpson (*circa* 1957), and, more recently, the initiation and expansion of oil development since construction of the Prudhoe Bay field and Trans Alaska Pipeline System (TAPS) in the 1970s.

Oil development is gradually spreading westwards across the North Slope from the original hub at Prudhoe Bay. Given industry's interest in NPR-A as expressed by lease sales, seismic surveys, drilling of exploratory wells, and the construction of the Alpine field, expansion of industrial development is likely to continue. Development in NPR-A may also facilitate development in more remote, currently undeveloped areas such as the Chukchi Sea Program Area or additional areas of the Beaufort Sea Program Area, and vice versa.

Hunting -- Although not cited as a cause in the decline of Steller's eiders, the take of this species by subsistence hunters was cited as a threat to the population of Steller's eiders near Barrow in the final rule to list (FWS 1997). Hunting for Steller's eiders was closed in 1991 by Alaska State regulations and FWS policy. In 2003, the FWS published a harvest regulation which opened spring/summer subsistence harvest of migratory birds in Alaska, as allowed for under the amended treaty protocols with Canada and the United Mexican States. Under this regulation the

harvest of Steller's eiders was prohibited. Before the regulation took effect, it was estimated that approximately 97 Steller's eiders were shot each year in Alaska (FWS 2006b). Post 2003, it was predicted that approximately 59 Steller's eiders were killed by hunters each year (FWS 2007b).

Lead Poisoning -- The presence of lead shot in the nesting environment on the Y-K Delta was cited as a continuing potential threat to the Steller's eider. A lead shot ban was adopted in the 2007-2008 Alaska Hunting Regulations for Game Management Unit 26, which covers a large portion of northern Alaska. This ban, which prohibits use of lead shot for bird hunting in the 89,000 square mile area, includes Barrow, the only known significant breeding location for threatened Steller's eiders in the United States.

Predation -- Increased predation by Arctic foxes resulting from the concurrent crash of goose populations was cited as a possible contributing factor to the decline of the Steller's eider on the Y-K Delta (FWS 1997). The potential for increased predation near villages resulting from the villages' associated gull and raven populations was also cited as a potential threat to this species (FWS 1997).

There is some evidence that predator and scavenger populations may be increasing on the North Slope near sites of human habitation, such as villages and industrial infrastructure (Eberhardt et al. 1983, Day 1998). Reduced fox trapping, anthropogenic food sources in villages and oil fields, and nesting/denning sites on human-built structures may have resulted in increased fox, gull, and raven numbers (Day 1998). These anthropogenic influences on predator populations and predation rates may have affected eider populations, but this has not been substantiated. However, increasing predator populations are a concern, and Steller's eider studies at Barrow attributed poor breeding success to high predation rates (Obritschkewitsch et al. 2001), and in years where arctic fox removal was conducted at Barrow prior to and during Steller's eider nesting, nest success appears to have increased significantly (Rojek 2008).

Ecosystem Change -- Direct and indirect changes in the marine ecosystem caused by increasing populations of Pacific walrus, gray whale (*Eschrichtius robustus*), and sea otter (*Enhydra lutris*), were cited as potential causes of the decline of Steller's eiders (62 FR 31748). Declines in the southwestern Alaska sea otter population (65 FR 67343) subsequent with the continued decline in Steller's eider populations suggest that otters were not responsible for a decline in eider numbers.

In addition, changes in the commercial fishing industry were also cited as perhaps causing a change in the marine ecosystem with possible effects upon eiders (FWS 1997). However, we are unaware of any link between changes in the marine environment and contraction of the eider's breeding range in Alaska (FWS 1997).

Threats Not Assessed At The Time Of Listing

Petroleum Spills – The acute or chronic release of petroleum hydrocarbons near large concentrations of Steller's eiders is a threat not considered at the time of listing. Because of the gregarious behavior of Steller's eiders during the non-breeding months, a spill event may result in acute and/or chronic toxicity in large numbers of birds. Indeed, Larned (2000b), expressed

concern for the survival and reproductive success of the large number of Steller's eiders observed in harbors.

A life-history strategy of long life and low annual reproductive effort would be expected to evolve under conditions of predictable and stable non-breeding environments (Stearns 1992). The life history strategy of the Steller's eider seems to fit this model. That is, the Steller's eider is long-lived, has low annual recruitment, and winters in apparently productive and reasonably stable near-shore marine environments. Because the Steller's eider is a relatively small bodied duck and winters at northern latitudes, it may do so near the limits of its energetic threshold. Therefore, environmental perturbations that reduce prey availability or increase the species energetic needs may result in harm. Fuels and oils are toxic to Steller's eiders (Holmes et al. 1978, Holmes et al. 1979, McEwan and Whitehead 1980, Leighton et al. 1983, Holmes 1984, Leighton 1993, Rocke et al. 1984, Yamato et al. 1996, Glegg et al. 1999, Trust et al. 2000b, Esler et al. 2000) and their prey (e.g., amphipods and snails; Newey and Seed 1995 as in Glegg et al. 1999, Finley et al. 1999), and exposure of Steller's eiders to oil in harbors in Alaska has been documented (Miles et al. 2007). Therefore, we believe that petroleum hydrocarbons entering the marine environment from anthropogenic sources are likely to adversely affect Steller's eiders and their habitats.

Seafood Processor Waste -- Discharge from seafood processors may affect the water column, sea floor, or shore directly or indirectly through burial and smothering, putrification and decay, eutrofication, nutrient loading and alteration of habitats, aquatic communities and food webs. Although wave action in shallow, near-shore habitat may keep particles suspended and prevent waste deposition, contaminants, parasites, viruses, and other pathogens may be present and/or concentrated in these wastes and may bioaccumulate in prey items consumed by eiders. Furthermore, fish waste directly or indirectly supplies food to scavenging seabirds (Furness et al. 1992), seaducks, and eagles that tend to congregate in the vicinity of processing facilities and outfalls (Reed and Flint 2007, Ellen Lance, FWS, pers. observation).

Increased Risk of Lead Poisoning -- Because this species continues feeding near the nesting site before and during incubation (D. Solovieva, Zoological Institute, Russian Academy of Science, pers. comm.), it may be subjected to an increased risk of exposure to lead shot over other tundra waterfowl species that largely forego feeding at this time. Even though spectacled eiders do not seem to engage in feeding activities as much as Steller's eiders once breeding has commenced, they have been observed to have higher rates of exposure to lead than any species sampled on the Y-K Delta (Flint et al. 1997). The proportion of spectacled eiders on the Y-K Delta's lower Kashunuk River drainage that contained lead shot in their gizzards was high (11.6%, n = 112) compared to other waterfowl in the lower 48 states from 1938-1954 (8.7%, n = 5,088) and from 1977-1979 (8.0%, n = 12,880). Blood analyses of spectacled eiders indicated elevated levels of lead in 13% of pre-nesting females, 25.3% of females during hatch, and 35.8% of females during brood rearing. Nine of 43 spectacled eider broods (20.9%) contained one or more ducklings exposed to lead by 30 days after hatch (Flint et al. 1997). Thus, if spectacled eiders have experienced population level effects on the Y-K Delta due to lead poisoning, then it is reasonable to conclude that Steller's eiders may have experienced similar or greater lead-induced effects, since they continue to feed during the nesting period.

Lead poisoning of Steller's eiders has been documented on the ACP (Trust et al. 1997). Female Steller's eiders nesting at Barrow in 1999 had blood lead concentrations that reflected exposure to lead (>0.2 ppm lead), and six of the seven tested had blood lead concentrations that indicated poisoning (>0.6 ppm lead; Pattee and Pain 2003). Additional lead isotope tests confirmed the lead in the Steller's eider blood was of lead shot origin, not that of the background sediments (Angela Matz, FWS, Fairbanks Fish and Wildlife Field Office, Unpublished Data).

Collisions with Manmade Structures -- Steller's eiders have been documented to collide with wires, communication towers, and other on land structures (Table (II)3). In addition, "bird storms" are a well-documented occurrence within the commercial crab fishery fleet, a result of their use of bright lights during inclement nighttime weather. The actual number of birds injured and killed through collisions is likely higher than reported; many injured and killed birds are believed to go undetected, unreported, or become scavenged before humans detect them. Preliminary data from a scavenging trial in Cold Bay, Alaska suggests that carcass removal rate from scavengers could be as high as 50% per 24 hours (Flint et al. 2010). Therefore, unless obstructions are checked every day, few carcasses would ever be documented. Searcher efficiency can also affect bird mortality estimates, for example following oil spills (Ford 2006).

Accelerated Climate Change -- This global phenomenon, defined by a drastic change in climatic parameters including air and water temperature, is believed to be caused by atmospheric carbon enrichment, otherwise known as the greenhouse effect. Some greenhouse gasses are produced naturally, but since the industrialization of the modern world, the production of these gasses may be accelerated by the burning of fossil fuels and other anthropogenic means.

Fueled by warming air and sea temperatures, glaciers and other permanent or semi-permanent ice sheets melt and cause the sea level to raise. While ocean level seemingly rose a minute amount over the past 100 years (0.1-0.2 m), it is projected to rise at double or quadruple the rate over the next 100 years (IPCC 2001b). If sea level rises at the high end of the projection, thousands of square miles of coastal wetland could be covered by water (Inkley et al. 2004). In some areas, such as those surrounding tidewater glaciers in Alaska, sea level rise will have minimal effect on coastal wildlife areas due to the subsequent glacial rebound (from the melting glaciers) offsetting the rising waters (Shaw et al. 1998). Conversely, in coastal urban areas, intertidal habitat availability may be limited to wildlife following a rising sea (Parmesan and Galbraith 2004). Already scientists are able to detect range changes in wildlife species and correlate those changes with rising temperatures (Root et al 2003). Expansions of spring waterfowl ranges have been correlated with a significant increase in the number of April and May days with temperatures above 6°C (Prop et al 1998). Milder springs can enhance reproductive success (Boyd and Diamond 1994, Alisauskas 2002, Fischer et al. 2004) with average date of egg laying growing earlier (Dunn and Winkler 1999). Milder weather leads to later migratory departure dates (Able 1973). Migration routes have shifted, apparently in response to changing sea surface temperatures (Spear and Ainley 1999). However, more plastic taxa may have the ability to change in place, rather than shift their range (Smith and Betancourt 1998).

The warming trend is more pronounced during winter than summer (Houghton et al. 1996, Inkley et al. 2004). Furthermore, increased nighttime temperatures could markedly influence range patterns of species with life histories especially influenced by ice cover (Inkley et al.

2004). Arctic sea-ice thickness decreased 1-2 meters during the past few decades (Rothrock et al. 1999). In some parts of Alaska, average annual temperatures have increased by 2-4 °C (4-7 °F) since 1900 (Oechel et al. 1993, IPCC 2001b).

It is not known how much of a role the rapidly warming environment played on the significant population declines in Steller's eiders. Changes in the marine ecosystem as a result of warming may directly affect Steller's eiders, but the pathways to those potential effects have not been fully identified. During winter, groups of Steller's eiders move in response to ice floes (Flint and Lance, USGS and FWS, Unpublished Data), but this behavior has not been modeled relative to ice-cover predictions within their wintering distribution.

Stochastic Events -- The small population size of the Steller's eiders on the Y-K Delta and the Arctic Coastal Plain may put them at risk of the deleterious effects of demographic and environmental stochasticity. Demographic stochasticity refers to random events that affect the survival and reproduction of individuals (e.g., shifts in sex ratios, striking wires, being shot, oil/fuel spills; Goodman 1987). Environmental stochasticity is due to random, or at least unpredictable, changes in factors such as weather, food supply, and populations of predators (Shaffer 1987). As discussed by Gilpin (1987), small populations will have difficulty surviving the combined effects of demographic and environmental stochasticity. The risk of local extirpation is probably highest for Steller's eiders nesting on the Y-K Delta due to the low number of birds that breed there.

The world population of Steller's eiders is probably not at high risk of extinction due to environmental stochasticity alone. But, local groups of wintering birds may be vulnerable to starvation due to stochastic events (e.g., unusually heavy ice-cover in their feeding habitats).

Table (II)3. Summary of reported Steller's eiders' collisions with structures and vessels (FWS, Anchorage Fish and Wildlife Field Office, Unpublished Data, 2007).

Season/ Year	Type	Number of Steller's eiders dead or injured	Location	Comments
December 1980	Collision with M/V Northern Endeavor	≥150	False Pass (Bering Sea side)	Crab lights illuminated, stormy night
September 1991	Collision with tower	1	Togiak NWR	as cited in Henny et al. 1995
February, 1991	Collision with P/V Wolstad	2	Unknown	Crab lights illuminated
February, 1997	Collision with vessel Elizabeth F	2	Unknown	One bird struck vessel on Feb. 14 and the second struck the vessel on Feb. 15.
April, 2003	Collision with power line	1	Bristol Bay Coast, near intersection of road to lake Camp and road to Rapids Camp	Rainy with low ceiling.
Pre 1974 and 1983	Collision with Grant Point DEW site tower	90 and 38 (respectively)	Izembek Lagoon, Alaska Peninsula	Strikes occurred during low viability events and storms, primarily in winter.
Unknown	Collision with vessel	Many	Nelson Lagoon, Alaska Peninsula	Villager reported to FWS personnel that he recalls sweeping Steller's eiders off the deck of his fishing boat.
Unknown	Collision with power line	150	Pilot Point, Alaska Peninsula	Pilot Point resident, responsible for erecting power line, recalls that shortly after he put it up about 150 Steller's eiders flew into it and died. The power line runs approximately 600 feet along the shoreline.
June 21, 2008	Wire Collision	1	Barrow	Female, broken wing

Allee Effect -- "Allee effect" refers to the destabilizing tendency associated with inverse density-dependence as it relates to population size and birth rate. One form of this occurs when the ability to find a mate is diminished (Begon and Mortimer 1986). For example, if the sex ratio of a population significantly shifts from a normal condition for a species, the ability of adults to produce young may diminish. For the Steller's eider, the higher mortality rate of males (Flint et al. 2000) may result in a lower number of pairs returning to nest (i.e., adult females unable to find a mate are effectively removed from the breeding population).

The annual survival rate for Steller's eiders molting and wintering in Alaska is estimated to be 0.899 ± 0.032 for females and 0.765 ± 0.044 for males (Flint et al. 2000). At this estimated annual survival rate, about 39% of the females of a cohort will reach 10 years of age, while only about 7% of the males will survive for 10 years.

The observed difference in annual survival between sexes may be manifested in a skewed sex ratio. Female Steller's eiders notably out-numbered male eiders on winter surveys of three areas during January, February, and March (Lanctot and King 2000a; Lanctot and King 2000b). In waters off Unalaska and False Pass, female Steller's eiders comprised 63 and 69%, respectively, of Steller's eiders observed (N = 2,053 and 114 respectively; John Burns, U.S. Army Corp of Engineers, pers. comm.; Lanctot and King 2000). At Akutan Harbor, the combined female to male sex ratio for all surveys was approximately 3 to 1 (n = 590) (Lanctot and King 2000b). Band recoveries reported by Dau et al. (2000) also suggest a shift in Steller's eider sex ratios through time (Table (II)4), however, in photographs taken of over 13,000 Steller's eiders at Izembek Lagoon in January, 2002, 61% were classified as males (Chris Dau, FWS, pers. comm.). Furthermore, females represented only 38% and 21% of Steller's eiders captured at Nelson Lagoon over a 3-year period (Flint et al. 2000). This suggests that spatial segregation among sexes, during winter, may lead to assumptions of skewed sex ratio depending on areas surveyed.

Observations of a skewed sex ratio in Steller's eiders are inconsistent across the range of the species (Table (II)5). However, if Dau's time series data from Izembek Lagoon are correct, then the skew towards females are in stark contrast to that which is typical for many other Anatinae, where an excess of males is the norm (Johnsgard 1994). If an excess of females does exists throughout the species range (as opposed to just at some locations) then the biased sex ratio may have implications regarding reproductive potential. Although our limited observations and Dau et al.'s (2000) banding data suggest that a biased sex ratio exists for this species, we do not know if this biased sex ratio exists range wide, nor do we know what may be causing it.

Table (II)4. Shifting sex ratio of Steller's eiders from Izembek Lagoon (Dau et al. 2000).

Years	Female	Male	Sample Size	Percent Male
1961-1966	271	566	837	68%
1968	60	85	145	59%
1974-1981	3576	2197	5773	38%
1991-1997	5971	708	6779	11%

Table (II)5. Observed sex ratios of Steller's eiders in their fall and winter range.

Location	n	Female	Male	Year
Unalaska	2,053	63	37	2000
False Pass	114	69	31	2000
Akutan	590	67	33	2000
Izembek	52 flocks	39	61	2002
Nelson Lagoon	11,961	38	62	1995-1997
Nelson Lagoon	14,940	21	79	1995-1997

Range-wide Population Trend

Populations of Steller's eiders molting and wintering along the Alaska Peninsula have declined since the 1960s (Kertell 1991. Annual spring aerial surveys provide an index of the Pacific Steller's eider population. These long term survey data suggests a 2.7% annual decline in migrating Steller's eiders ($R^2 = 0.43$; Larned and Bollinger 2011). A comparison of banding data from 1975 -1981 to 1991-1997, indicates a reduction in Steller's eider survival over time (Flint et al. 2000), and supports the conclusion that the Pacific Steller's eider population is declining.

Population growth rates (λ) calculated using log-linear regression of data from 3 different aerial survey efforts within the range of North Slope breeding Steller's eiders are ambigious (Stehn and Platte 2009); data from the 1989-2006 Arctic Coastal Plain aerial surveys suggest that North American breeding Steller's eiders are in decline (λ=0.778, 0.686-0.882, 90% CI; Mallek at al. 2007); data from the 1992-2008 North Slope Eider aerial surveys suggest that North American breeding Steller's eiders are in increasing (λ=1.059, 0.909-1.235, 90% CI; Larned et al. 2008); data from the 1999-2007 ABR aerial survey suggests a declining growth rate (λ=0.934, 0.686-1.272, 90% CI; Obrischkewitsch et al. 2008); and a recent analysis that uses of subset of data from the North Slope Eider aerial survey (1993-2008) estimates that population growth rate is basically flat (λ=1.011, 0.857-1.193, 90% CI; Stehn and Platte 2009).

So, while the latest estimation of population growth rate suggests that the population of the North Slope breeding Steller's eiders is stable, we note that the Pacific wintering population of Steller's eider appears to be in continued decline, the Y-K Delta breeding population has been apparently extirpated (Kertell 1991; Quakenbush 2002), and the current breeding season distribution on the North Slope has been reduced compared to the historical distribution (Quakenbush et al. 2002).

Population Status

The Steller's Eider Recovery Plan (FWS 2002b) establishes criteria for reclassifying the species from threatened to endangered when:

The population has $\geq$ 20% probability of extinction in the next 100 years for 3 consecutive years; OR

The population has $\geq$ 20% probability of extinction in the next 100 years and is decreasing in abundance."

Based on the IUCN 2001 Categories and Criteria (version 3.1), the Alaska breeding population of Steller's eiders belong in the category of Endangered (FWS, Anchorage Fish and Wildlife Field Office, Unpublished Data; Figure (II)1). A recent revision of the population viability analyses for both the Alaska breeding population and the Pacific population of Steller's eiders

(Runge 2004) concluded that without reintroduction, the listed population is at high risk of extinction (Swem and Matz 2008). Although the population viability model incorporates parameter estimates that are based on the best available information, the estimates are thought to be imprecise and likely biased in various ways. Regardless, we find the projected population trajectory informative.

Figure (II)1. IUCN justification for the EN categorization for Steller's eiders

A Reduction in population size based on any of the following:

1 An estimated population size reduction of ≥ 70% over the last three generations (for Steller's eiders, three generations equals about 25.5 years).

a An index of abundance appropriate to the taxon.

Evidence: Larned and others (2003) reported a 61% decline over 10 years in the wintering population of Steller's eiders. Extrapolating this 10 year / 61% decline back in time would imply that the population declined by at least 70% in the past 25.5 years.

A Reduction in population size based on any of the following:

2 An observed, estimated, inferred or suspected population size reduction of 50% over the last three generations.

Evidence: The Y-K Delta breeding population has likely been extirpated since before the 1990s (Kertell 1991; Quakenbush 2002). It it estimated that the Y-K Delta breeding population historically numbered 3500 breeding pairs (Kertell 1991). Historical estimates for North Slope Breeding Steller's eiders are ambiguous, but there is evidence suggesting that a range contraction for breeding Steller's eiders has occurred (Quakenbush 2002).

B Geographic range in the form of either extent of occurrence or area of occupancy.

1 Extent of occurrence estimated to be less than 5000 km^2 and at least two of a-c:

b Continuing decline, observed, inferred or projected in any of the following

i number of mature individuals

c Extreme fluctuations in any of the following:

ii. number of mature individuals

Evidence: Because of the large geographic extent over which this species breeds, it is unlikely that the North American Breeding population of Steller's eiders will satisfy this classification criterion unless their breeding range becomes or is determined to be restricted to the "Barrow Triangle". Ritchie and King (2002) reported that the area of the Barrow triangle is approximately 2757 km^2. We believe that available evidence suggests that the majority of Alaska breeding Steller's eiders do nest within the Barrow triangle. However, we also acknowledge occasional nesting records outside of this area.

C Population size estimated to number fewer than 2500 mature individuals and either:

1 Evidence: The current population estimate for Alaska breeding Steller's eiders (~500).

Appendix III. Status of the species: Spectacled eider *(Somateria fischeri)*

Spectacled eider *(Somateria fischeri)*

Species Description

Spectacled eiders are large seaducks, 52-56 cm long (20-22 in). In the winter and spring, adult males are in breeding plumage with black chest, white back, and pale green head with a long sloping forehead and white spectacle-like patches around the eyes. During the late summer and fall, males are entirely mottled brown. Females and juveniles are mottled brown year-round with pale brown patches.

Life History

Longevity

Seaducks tend to be long lived with high annual survival rates, deferred sexual maturity, and low rates of recruitment to breeding (Goudie et al. 1994). Such "K-selected" characteristics minimize the importance of annual investment in reproduction, and maximize the importance of annual survival and a few successful years of reproduction (Wilson 1980).

Energetics

Although the food habits of wintering spectacled eiders are still largely unknown, it appears they forage for benthic bivalves under the shifting pack ice of the Bering Sea (Lovvorn et al. 2000; Richman and Lovvorn 2003). This energetically expensive method of foraging requires high food densities and intake rates necessary to build up fat reserves vital for spring migration and breeding. High densities of clams are present in the overwintering area. Sampling over several decades suggests that the benthic community in the overwintering area has shifted from larger to smaller species of clams (Lovvorn et al. 2000, Richman and Lovvorn 2003). Spectacled eiders apparently do not exist so close to their energetic threshold as do Steller's eiders because they arrive on the nesting grounds fit enough to fast through egg laying and incubation (FWS 1993), but changes in the spectacled eider prey base in the overwintering area could be affecting the overwinter survival and ability of spectacled eiders to maintain the body condition necessary for spring migration and breeding.

Age to Maturity

Age at first breeding has not been determined but probably occurs most often in the third-year for females and the third or fourth year for males, coinciding with the acquisition of plumage (USDOI, FWS 1999). Wild and captive spectacled eiders are documented to breed as early as 2 years of age.

Reproductive Strategy

Spectacled eiders appear to arrive on the breeding grounds in pairs, probably pairing while still on their wintering grounds in the Bering Sea (Dau and Kistchinski 1977, Kistchinski and Flint 1974, Larned et al. 1995a), although some disparity in that observation exists. On the Y-K Delta they arrive as singles, pairs, and flocks (Moran 1994, 1996a, 1996b). In the Prudhoe Bay area, spectacled eiders arrive in a 1:1 sex ratio (TERA 1993, 1996a, 1996b), and evidence suggests that pair bonds span across years (Declan Troy, TERA pers. comm.2000). Spectacled eiders lay an average of five eggs (Strobel 2004), and their incubation period averages 23 days in Arctic Russia (Kondratev and Zadorina 1992), and 24 days on the Y-K Delta (Dau 1974).

Recruitment

Hatch success on the North Slope and in Arctic Russia is very high for nesting spectacled eiders. Spectacled eider eggs that are addled or that do not hatch are very rare in the Prudhoe Bay area (Declan Troy, TERA, pers. comm. 1997), and Esler et al. (1995) found very few addled eggs on the Indigirka River Delta in Arctic Russia. Additionally, from 1969 to 1973 at an inland site on the Yukon Delta National Wildlife Refuge, only 0.8% of spectacled eider eggs were addled or infertile (Dau 1974).

In contrast, 24% of all nests monitored in a coastal region of the Y-K Delta during the early to mid-1990s contained inviable eggs (Grand and Flint 1997). Approximately 10% of eggs in successful nests did not hatch due to either embryonic mortality or infertility, and the relatively high occurrence of inviable eggs is believed to be related to exposure to contaminants (Grand and Flint 1997).

Recruitment rate (the percentage of young eiders that leave the nest and live to sexual-maturity) of spectacled eiders is unknown (USDOI, FWS 1999). The nesting success of the spectacled eiders is variable, ranging from 20% to 95 % depending on the year and location (Bowman et al. 2002). Adult female survival can average 93%, and duckling survival can average 34 % (Flint and Grand 1997).

In a coastal region of the Y-K Delta, duckling survival to 30 days averaged 34%, with 74% of this mortality occurring in the first 10 days. Survival of adult females during the first 30 days post hatch was 93$\pm$3% (Flint and Grand 1997). This survival rate applied to spectacled eider females for the rest of the year leads to an extremely low survival of 40% compared to other eiders (Coulson 1984, Flint and Grand 1997, Reed 1975, Wakeley and Mendall 1976). This estimated annual survival based on daily survival during the breeding period may not be accurate however, because mortality rate is typically highest during brood rearing (Milne 1963). Clearly though, adult female mortality during brood rearing may be an obstacle to recovery (Flint and Grand 1997).

Seasonal Distribution Patterns

Breeding -- Historically, spectacled eiders nested in Alaska discontinuously from the Nushagak Peninsula north to Barrow, and east nearly to Canada's Yukon Territory (Phillips 1922-1926, Bent 1925, Bailey 1948, Dau and Kistchinski 1977, Derksen et al. 1981, Garner and Reynolds 1986, Johnson and Herter 1989).

On the Y-K Delta, spectacled eiders historically bred throughout the coastal zone. They currently breed primarily within about 15 km (~9 miles) of the coast from Kigigak Island north to Kokechik Bay (FWS 1996), although a number of sightings have been made on the Y-K Delta both north and south of this area during the breeding season (Bob Platte, FWS, MBM, pers. comm. 1997). Breeding density in 2004 was approximately 2.94 pairs per square kilometer (Fischer et al. 2004)

On the North Slope, spectacled eiders breed north of a line connecting the mouth of the Utukok River to a point on the Shaviovik River about 24 km (~15 miles) inland from its mouth. Spectacled eider nests are widely separated, nesting mainly from the Sagavanirktok River to the

Chukchi Sea, and only sparsely to the east (Larned et al. 2001). The highest densities determined from FWS aerial surveys for eiders in 1998-2001 on the Arctic Coastal Plain east to the Arctic National Wildlife Refuge were found south of Barrow, with smaller areas east of Teshekpuk Lake, on the Colville River Delta, and near western Simpson Lagoon. Overall density was determined as 0.24 birds per square kilometer in 2001 (Larned et al. 2001). It is unknown whether the breeding range of this species on the North Slope has changed in recent history.

In Arctic Russia, spectacled eiders nest from the northern side of the Chukotsk Peninsula west to the Lena River Delta and the Novosibirski Islands (Buturlin 1910, Dementev and Gladkov 1952, Portenko 1972). They are most abundant on the Indigirka River Delta and on the tundra west of the Kolyma River mouth (Kistchinski 1973). Aerial surveys by Hodges and Eldridge (1994, 1995, 1996, 2001) found eiders breeding at widely varying densities (0.02-8.8 birds per km^2) from the Kolyma River Delta west along the coast to the Indigirka River Delta, and from there, further west both along the coast and well inland to the west edge of the Lena River Delta. There is no data to indicate whether the breeding range in Russia has changed in recent decades.

Winter Distribution -- From late December to early April, the only known wintering area of spectacled eiders is among leads in the pack ice southwest of St. Lawrence Island in the Bering Sea (Petersen et al. 1999). Spectacled eiders from all three breeding populations appear to mingle in one common wintering area (Larned et al. 1995b). This area is typically well north of the southern extent of the sea-ice cover during winter, and flocks of spectacled eiders have been observed in exceedingly dense flocks in small ephemeral openings in the ice. Wintering in open areas among the ice floes is energetically costly, but roosting atop the ice may lower that cost (Petersen and Douglas 2004). Single wintering flocks as large as 150,966 birds have been observed (Larned and Tiplady 1997), and most wintering flocks occur within a 32 km (~20 mile) radius of each other at any given time.

Molt Distribution -- Molting and staging grounds for spectacled eiders occur near all three breeding grounds (Table (III)1), and receive use by large numbers of birds each year. Telemetry data suggests that virtually all female, spectacled eiders nesting on the Y-K Delta molt in eastern Norton Sound, and females nesting on the North Slope molt in either Ledyard or Mechigmenskiy Bays (Petersen et al. 1999).

Males departing from the Y-K Delta breeding grounds leave 3-weeks sooner than males from Russia and the North Slope (Petersen et al. 1999). On the North Slope, male spectacled eiders depart breeding areas in late June. Later in the season (late June through September), when females depart the North Slope, much more of the near-shore zone is ice free. Radio telemetry studies have shown that most female spectacled eiders that migrate west toward Barrow use the near-shore zone of the Beaufort Sea as they transit to their molting/staging areas (Troy 2003).

Table (III)1. Important staging and molting areas for each sex of each population of spectacled eiders.

Population and Sex	Known Major Staging/Molting Areas
Arctic Russia Males	Northwest of Medvezhni (Bear) Island group
	Mechigmenskay Bay
	Ledyard Bay
Arctic Russia Females	unknown
North Slope Males	Ledyard Bay
	Northwest of Medvezhni (Bear) Island group
	Mechigmenskaya Bay
North Slope Females	Ledyard Bay
	Mechigmenskaya Bay
	West of St. Lawrence Island
Y-K Delta Males	Mechigmenskaya Bay Northeastern Norton Sound
Y-K Delta Females	Northeastern Norton Sound

Site Fidelity

At least some spectacled eider females exhibit strong fidelity for nesting areas (Dau 1974). On the Y-K Delta, females nested within 1.5 km of their previous nest sites (Dau 1974, Harwood and Moran 1993, Moran and Harwood 1994, Moran 1996a, Moran 1996b). Moran (1994) reports that a female banded as a chick returned after 2 years to successfully nest only 750 m from her natal nest site.

Population Structure

It seems reasonable to assume that based on the high probability for site fidelity by nesting females and the distance between breeding populations on the Y-K Delta and the Arctic Coastal Plain, the Alaska breeding population of spectacled eider may contain unique geographic sub-populations. This assumption is supported by genetic data in which distinct mitochondrial DNA markers imply there is limited maternal gene flow between these two areas (Scribner et al. 2001).

Food Habits

During winter, spectacled eiders inhabit the leads in the Bering Sea ice and feed in near freezing water for benthic prey (Lovvorn et at. 2003). Spectacled eiders dive 40-60 m to feed on the benthic organisms that occur in high densities below the ice (Grebmeier and Cooper 1995, Lovvorn et al. 2003). This feeding depth is considerably deeper than other seaducks: oldsquaw (*Clangula hyemalis*), common eiders (*Somateria mollissima*), and king eiders (*S. spectabilis*) have been reported to forage at depths of 22 m, <10 m, and <40 m, respectively (Nilsson 1972, Bustnes and Lonne 1997, Frimer 1994, Guillemette et al. 1993).

During 2001, spectacled eiders consumed mainly *Nuculana radiata* clams while on their main wintering area south of St. Lawrence Island (Lovvorn et al. 2003). Other prey reported from spectacled eider stomachs include other clams (Pelecypoda), Crustacea (barnacle, amphipod, and

crab), and Mollusca, including gastropods (snail). Where the predominate species group eaten was *Macoma* spp. (clam) in earlier studies from the shores of St. Lawrence Island (Petersen et al. 1998), this clam is not prevalent in the diet of the birds on the wintering grounds (Lovvorn et al. 2003). Long-term studies of benthic organisms in this area suggest a shift in dominant clams from *Macoma calcarea* to *Nuculana radiata* (Sirenko and Koltun 1992) as well as a decline in benthic fauna biomass from 1988 through 1999 (Grebmeier and Dunton 2000).

On the molting grounds spectacled eiders feed on mollusks, and snails (*Trichotopis* spp.; Balogh 1997). On the nesting grounds, they feed by dabbling in shallow freshwater or brackish ponds, or on flooded tundra (Dau 1974, Kistchinski and Flint 1974). Food items include molluscs, insect larvae such as craneflies, trichopterans, and chironomids; small, freshwater crustaceans, and plants or seeds (Cottam 1939, Dau 1974, Kistchinski and Flint 1974, Kondratev and Zadorina 1992).

On the Indigirka River Delta in 1971, shortly after their arrival to the breeding grounds, spectacled eiders ate primarily Tipulidae larvae (Diptera) (Kistchinski and Flint 1974). By June, dipterans (primarily Chironomids) and Trichopterans made up most of the eider diet, with a notable presence of *Ranunculus pallasii* seeds also occurring in the birds upper digestive tracts. During brood rearing on the Indigirka River Delta, the spectacled eider diet was composed almost exclusively of Trichopteran larvae and *Ranunculus pallasii* seeds (Kistchinski and Flint 1974).

Incubating and brood-rearing females ate Trichoptera and Chironomidae larvae, and as the season progressed, fairy shrimp (*Polyartemia* and *Branchineta*) and tadpole shrimps (*Lepidurus arcticus*) (Kondratev and Zadorina 1992). Spectacled eider chicks prefer to remain near-shore, and are primarily surface feeders, but are capable of diving, gleaning insects on land, and capturing flying insects (Kondratev and Zadorina 1992). The primary food of spectacled eider chicks in Arctic Russia is thought to be *Cyzicus*, a freshwater shrimp. After the first month, spectacled eider chicks feed like adults (Kondratev and Zadorina 1992).

Predators

Predation is believed to be a principal cause for nesting failure in many waterfowl species including spectacled eiders. Substantive depredations of waterfowl eggs and young in the Arctic region are sometimes associated with predators gaining access to isolated populations. Predators of spectacled eiders include snowy owls, peregrine falcons, gyrfalcon, pomarine and long-tailed jaegers, rough-legged hawks, common raven, glaucous gulls, Arctic fox, and red fox. Owls, falcons, and hawks kill mostly ducklings and adult eiders, while gulls, ravens, and jaegers prey on eggs and ducklings. The greatest impact on waterfowl populations often occurs when Arctic fox densities are high and densities of nesting waterfowl are low. Foxes eat eggs, ducklings, and will kill nesting females if given the opportunity. Excessive predation of nesting hens by foxes and other predators can result in imbalanced sex ratios within populations.

Population Dynamics

Population Size

Although it is nearly a decade old, the most recent estimation of the world-wide population of spectacled eiders is 375,000 individuals (Larned and Tiplady 1999).

North Slope Breeding Population -- At Prudhoe Bay, within the ACP breeding area, Warnock and Troy (1992) documented an 80% decline in spectacled eider abundance from 1981 until 1991. Modern aerial surveys of the North Slope from 1992-2006 indicate a long-term average index of 6,903 spectacled eiders (Larned et al. 2006). The 2009 population index based on aerial surveys was 5,018 birds, and declined over17 years at a rate of 0.985 (90% CI 0.971- 0.999; Larned et al. 2010).

Yukon-Kuskokwim Delta Breeding Population -- In 1992, the Y-K Delta spectacled eider population was reportedly at about 4% of historic levels (Stehn et al. 1993). Evidence of the dramatic decline in spectacled eider nesting on the Y-K Delta was corroborated by Ely et al. (1994). They documented a 79% decline in eider nesting between 1969 and 1992 for areas near the Kashunuk River. Aerial and ground survey data indicated that spectacled eiders were undergoing a decline of 9-14% per year from 1985-1992 (Stehn et al. 1993). Further, from the early 1970s to the early 1990s, numbers of pairs on the Y-K Delta declined from 48,000 to 2,000, apparently stabilizing at that low level (Stehn et al. 1993). Before 1972, an estimated 47,700 to 70,000 pairs of spectacled eiders nested on the Y-K Delta in average to good years (Dau and Kistchinski 1977), but aerial surveys of the Y-K Delta in 2003 detected a total of 3,487 birds or 1,744 pairs, and a population growth rate, calculated from 1988 to 2003, of 1.073 (Platte and Stehn 2004).

Recent population growth rates paint a much rosier picture for spectacled eiders nesting on the Y-K Delta. In 2010 it is estimated that 6,750 nests were built producing 28,957 viable eggs (Fischer et al. 2010). This estimate reproduction for 2010 is the third highest since 1985 and 42% above the 1985-2009 average. Population growth rate averaged over the past 10 years is positive.

Population Variability

Variability in the abundance of the Alaska breeding population, of spectacled eiders is not well understood (FWS 1999). The sampling errors around population estimates are large enough to obscure large annual fluctuations, but ground surveys in the Barrow area suggest that the local breeding populations there fluctuate with fewer spectacled eiders nesting during some years.

Population Stability

The world population of spectacled eiders has declined substantially over the past 30 years (FWS 1999; 2002). Long-lived species like spectacled eiders do not typically have highly variable populations. Unknown mortality factors may be undermining their ability to maintain a stable population. The causes of decline could be varied and are largely unknown, but if the cause of the decline is within the marine environment, it is reasonable to conclude that the Alaska nesting population and the Russia nesting population are being affected similarly because the Russian population and the Alaska population winter together in the Bering Sea.

Status and distribution

Reasons for Listing

The spectacled eider was listed as a threatened species under the ESA in May 1993 after undergoing a population decline of about 96% (Stehn et al. 1993, FWS 2002b).

Habitat Loss -- Stehn et al. (1993) speculated that spectacled eiders at sea may be competing with certain marine mammals for food during fall and winter. From 1960 to 1980, the Pacific walrus population apparently tripled and began to show signs of overpopulation (Fay et al. 1989). It is thought that the walrus population increase was due largely to harvest regulations enacted in Russia. In addition, gray whale (*Eschrichtius robustus*) numbers in the northern Bering and Chukchi seas have been increasing at a rate of 3.29% per year over the past several decades (Rice and Wolman 1971, Buckaland et al. 1993), also likely a result of the enactment of protection measures in Russia. Both walrus and gray whales can, while feeding, disturb substantial areas of benthos which spectacled eiders depend upon while at sea.

Ecological changes in the Bering Sea may be related to complex changes in fish and invertebrate populations. Bering Sea ecosystem stocks of crab, herring, halibut and various ground fish have been the focus of huge harvests in the past 30 years. Commercial fishing-induced ecosystem changes could be affecting other bird species as well. Steller's eiders, oldsquaw, and emperor geese, (species that winter at the southern edge of the Bering Sea), all underwent population declines between 1970 and 1992 (Kertell 1991).

Additional potential causes of Bering Sea ecosystem changes include global climate change (discussed in more detail below), and contamination, including radioactive waste disposed of in Russian territorial waters (OPRF 1993), acids, metals, and toxic organic compounds (Barrie et al. 1992).

Alaska Native villages periodically undertake construction activities that may result in the loss of small portions of spectacled eider breeding range. Housing construction in Barrow along Gaswell Road is taking place within a wetland used by both spectacled and Steller's eiders, and will result in loss of some of that wetland. Y-K Delta villages may also experience growth along their outer edges which impinges on spectacled eider breeding habitat. Overall, however, the direct effect of village growth, in terms of habitat degradation, is probably minuscule.
Until recently eider breeding habitat on the ACP was largely unaltered by humans, but limited portions of each species' breeding habitat have been impacted by fill of wetlands, presence of infrastructure that presents collision risk, and other types of human activity that may disturb birds or increase populations of nest predators. These impacts have resulted from the gradual expansion of communities, cold war era military developments such as the Distant Early Warning (DEW) Line sites at Cape Lonely and Cape Simpson (*circa* 1957), and, more recently, the initiation and expansion of oil development since construction of the Prudhoe Bay field and Trans Alaska Pipeline System (TAPS) in the 1970s.

Oil development is gradually spreading westwards across the North Slope from the original hub at Prudhoe Bay. Given industry's interest in NPR-A as expressed by lease sales, seismic surveys, drilling of exploratory wells, and the construction of the Alpine field, expansion of industrial development is likely to continue. Development in NPR-A may also facilitate development in more remote, currently undeveloped areas such as the Chukchi Sea Program Area or additional areas of the Beaufort Sea Program Area, and vice versa.

Disturbance -- Prudhoe Bay area (North Slope) spectacled eiders have been observed to be disturbed by noise from a compressor plant (Anderson et al. 1992). However, Warnock and Troy (1992) found that spectacled eiders and their nests were neither closer to, nor farther from oilfield facilities than expected from random sampling, with the exception of water impoundments adjacent to facilities, which supported above average densities of birds. The effect of oil development and associated activities on spectacled eiders in Arctic Russia is unknown (FWS 1996).

Vessel traffic causing disturbance in concentration areas such as where spectacled eiders molt in Norton Sound is believed to have adverse effects (Petersen et al. 1999). These effects may be especially severe during high stress times, such as molting, when the birds are flightless. As a response to this potential disturbance, the FWS established a voluntary "no traverse zone" for the primary molting area in Norton Sound.

Hunting -- Hunting for spectacled eiders was closed in 1991 by Alaska State regulations and FWS policy. In 2003, the FWS prosecuted a harvest regulation which opened spring/summer subsistence harvest of migratory birds in Alaska, as allowed for under the amended treaty protocols with Canada and the United Mexican States. Under this regulation the harvest of spectacled eiders was prohibited. Before the regulation took effect, it was estimated that approximately 201 spectacled eiders were shot each year (FWS 2006b). Current estimates for spectacled eiders harvested from the North Slope indate that tens to hundreds of birds are killed by hunters each year (USFWS 2011).

Research: Although effects to nesting spectacled eiders from research activities have been reported (Bowman and Stehn 2003), adverse effects of researchers on nesting success is not believed to be substantial (Bety and Gauthier 2001). Protocols have been established to minimize the impact of investigators on breeding spectacled eiders. Visitation to nests in the random nest plot survey on the Y-K Delta accounted for an additive loss of 0.08% of the eider egg production for the average year from 1994-2002. Applying these loss rates to all other Y-K Delta eider studies, cumulative visitation effects on spectacled eiders amounted to a loss of 15 nests and 57 eggs per year (Bowman and Stehn 2003).

Predation -- Depressed fur prices, and the resultant decrease in trapping effort may have allowed Alaska's fox populations to increase. Moreover, the 90% decline in cackling Canada and white-fronted goose populations on the Y-K Delta may have resulted in prey switching; Arctic foxes foraging in territories of fixed size would increase their focus and impact on the remaining waterfowl nesting populations (Stehn et al. 1993). Between the 1960s and 1983, foxes may have switched to spectacled eiders.

Predators of spectacled eider eggs include gulls, jaegers, and foxes. In Arctic Russia, nest success may have been as low as < 2% in 1994 and 27% in 1995; foxes, gulls, and jaegers are suspected to have depredated most of the nests (Pearce et al. 1998). On Kigigak Island in the Yukon Delta NWR, nest success ranged from 20-95% in 1991-1995 (Harwood and Moran 1993, Moran and Harwood 1994, Moran 1994, Moran 1996a,b). This reported range of nest success may have been influenced by fox control on Kigigak Island in 1992. On the North Slope, nest

success ranged from 25-40% during the early to mid-1990s in the Kuparuk and Prudhoe Bay oil fields (Warnock and Troy 1992, Anderson et al. 1998). Kistchinski and Flint (1974) reported that gulls depredated a large number of spectacled eider clutches on the Indigirka River Delta, and Degtyarev (1993) documented five successful attacks of gulls on downy spectacled eider ducklings.

Lead Poisoning -- Ingestion of lead by spectacled eiders was first reported in 1978 (Franson et al. 1995). Since then, acute lead poisoning of spectacled eiders on the Y-K Delta has been documented, and four spectacled eiders have been confirmed dead as a result of lead pellet consumption (Franson et al. 1995). Likely, the documented deaths from lead poisoning are an underestimate of the true mortality on the Y-K Delta, since: 1) lead poisoned birds seek heavy cover when they are afflicted, 2) they are probably never found, and 3) they are probably predated or scavenged.

Poisoning from the ingestion of spent lead shot on the Y-K Delta's lower Kashunuk River area and on Kigigak Island is the cause of additive mortality in spectacled eiders, that is, mortality over and above that caused by natural circumstances (Grand et al. 1998). The proportion of spectacled eiders on the Y-K Delta's lower Kashunuk River drainage that contained lead shot in their gizzards was high (11.6%, n=112) compared to other waterfowl in the lower 48 states from 1938-1954 (8.7%, n=5088) and from 1977-1979 (8.0%, n=12,880). Further, the lead exposure rate in spectacled eiders (based on X-rays) is likely biased low (Flint et al. 1997), because lead is retained in the gizzard for only about 3-weeks (Elder 1954, Dieter and Finley 1978, Anderson and Havera 1986, Franson 1986, Anderson et al. 1987). Blood analyses of spectacled eiders indicate elevated levels of lead in 13% of pre-nesting females, 25.3% of females during hatch, and 35.8% of females during brood rearing. Nine of 43 spectacled eider broods (20.9%) contained one or more ducklings exposed to lead by 30 days after hatch (Flint et al. 1997).

Lead shot deposited in pond sediment on the Y-K Delta is persistent in the organic layer of sediment; its settlement rate is slow but measurable at approximately 1 cm per year (Flint 1998). However, most ponds have an active organic layer, underlain by a firm in-organic mud at 6 to 8 cm below the surface. Pellets apparently settle to the interface between these layers where they may remain indefinitely (Paul Flint, USGS, pers. comm. 2002). Use of lead shot for waterfowl hunting has been banned, nationwide since September 1, 1991 however enforcement of the ban did not begin in Alaska until March 1, 1998 (FWS 1997).

The State adopted lead shot restrictions in the 2008-2009 Alaska Hunting Regulations on Game Management Unit 18 (GMU 18), which covers a large portion of southwestern Alaska including the entire Yukon-Kuskokwim Delta. These regulations prohibit the taking of any game using lead shot smaller than 0.2 inches (the sizes commonly used for bird and small game hunting) in GMU 18. This 29 million acre area includes the primary United States breeding location for threatened spectacled eiders, and also provides nesting habitat for threatened Steller's eider.

New Threats

Collisions -- Spectacled eiders have been documented colliding with wires, communication towers, boats, and other structures (Table (III)2). The incidence of bird strikes appears to rise when objects are illuminated with constant diffuse light, and the tendency for birds to be drawn

to diffuse light appears to increase during rainy or foggy weather. Fog or low cloud cover makes the attraction problem worse, because the moisture droplets associated with overcast conditions increase the area illuminated by refraction (Rojek 2001).

The incidence of species-specific bird strikes certainly relates to life histories. Eiders likely migrate at night and are known to fly below an altitude of 10 meters (Johnson and Richardson 1982, Day et al. 2003b), which makes them susceptible to flying into structures, particularly during periods of low visibility. Except during breeding season, spectacled eiders tend not to spend much time on land. But during late June, when the Beaufort Sea has little open water, male spectacled eiders traveling from the breeding grounds to Ledyard Bay to molt fly directly overland (Troy 2003). Moreover, although spectacled eiders tend to fly off shore during migration, they may stray inland during periods of low visibility or "cut a corner" of the landscape while migrating.

Avian literature is replete with reports of birds attracted to the artificial lights of communication towers and other tall lighted structures. Further, these reports suggest that extinguishing lights stops or prevents birds' responses (Cochran and Graber 1958, Aldrich et al. 1966, Herbert 1970, Avery et al. 1976, Avise and Crawford 1981, Crawford 1981a, Crawford 1981b, Verheijen 1981, Larkin and Frase 1988, Fedun 1995, Bower 2000). Bird attraction to artificial lights is so strong, the scientific community utilizes artificial lights as a technique for capturing birds for research purposes. This technique, used on several species of waterfowl (Cummings and Hewitt 1964, Bishop and Barratt 1969) and common eiders (Snow et al. 1990), disorients birds, allowing easy capture. Shielding lights, a technique commonly recommended by regulatory agencies and utilized by industry, can reduce attraction more than 40%, but does not eliminate the problem (Reed et al. 1985, Rojek 2001). Good shielding reduces the amount of light escaping into space and reflects more light into a discrete pool on the ground and reduces confusion in navigating birds (Wong 2002).

The attraction of seabirds to lights of commercial fishing vessels has been noted by observers involved with long-line fisheries (Cherel et al.1996, Ryan and Watkins 1999, Weimerskirch et al. 2000). Furthermore, large seabird wrecks (otherwise known as bird storms) have been noted in the literature and are well documented within the commercial crab fishery fleet as a result of their use of bright lights during inclement nighttime weather. Dick and Donaldson (1978) documented over 6,000 crested auklets (*Aethia cristatella*) landing aboard a crab-fishing vessel near Kodiak Island, Alaska. The boat had bright fishing lights on and the crew feared they might capsize because they were being overloaded by the auklets. After the crew finally realized that their outside lights attracted the birds and turned them off, the number landing on board decreased. Several hundred birds were still on the boat the following day.

The issue of birds striking man-made objects is not unique to Alaska. Drawn to lights atop towers, particularly at night and during low cloud cover, birds circle in confusion, dying by the thousands in collisions with towers, its guy wires and related structures, each other, or even the ground (Ornithological Societies of North America 2002).

Avian mortality associated with power line strikes has also been well documented (Crowder and Rhodes 2002). Factors that may influence a bird's prevalence to strike power lines include

normal flight altitude, flock size, size of bird, and wing morphology (Crowder and Rhodes 2002). Ducks are considered good flyers with high wing loading (ratio of wing span^2 to wing area), and are twice as likely to react to power lines as birds with low wing loading (Crowder and Rhodes 2002). Further, flocks of over ten birds reacted to power lines at a significantly greater mean distance than did solitary birds (Crowder and Rhodes 2002). Some believe that waterfowl almost never strike power lines, but others report contrary results (Crowder and Rhodes 2002). During an avian mortality study along a 9.6 km power line in North Dakota, waterfowl collisions accounted for 26% of all bird mortalities documented, although the majority of those waterfowl were dabbling ducks (Faanes 1987). In this 2-year study, 81% of all bird mortality was found during fall migration. As opposed to electrocution from striking the conductor, collision with the overhead ground wire was responsible for most of the bird deaths (93%). Typical injuries from striking the wires included broken wings, broken legs, lacerations, puncture wounds, and abrasions (Faanes 1987). Likewise, in a study of 5.9 km of power line in Oregon and Washington, green-winged teal (*Anas carolinensis*) collided with overhead ground wires of the power lines more frequently than other bird species (>35%; Meyer 1978).

In Alaska, spectacled eiders are known or suspected to have collided with power lines on at least three separate occasions. Two of those accounts were from power lines near Barrow on the North Slope and one account was from the Village of Savoonga on St. Lawrence Island.

Table (III)2. Reported Spectacled Eider Collisions in Alaska or in Alaskan Waters.

Season/ Year	Type	Number of SPEI Dead or Injured	Location	Comments
October, Year unknown	Collision with guy wires of tower	≥ 1	Gambel, St. Lawrence Island	Tower is reportedly a favorite place among villagers to collect dead ducks after a fog event.
April, 1998	Collision with power line	1 to 6	Savoonga, St. Lawrence Island	6 spectacled eiders captured and shipped to Bird TLC in Anchorage for rehabilitation. All birds were emaciated upon arrival. One observed striking power line, others found unable to fly
June, 1998	Collision with unknown structure	1	Barrow	Picked up by villager, broken wing
March, 2001	Collision with vessel Coast Guard Cutter	3	Bering Sea	Predawn collision
October, 2002	Collision with vessel F/V *Sea Storm*	≥ 2	Eastern Bering Sea: 62 59.741N 172 30.366W	Stormy weather conditions, blowing snow and whiteout conditions. Necropsy report noted massive internal injuries throughout neck and torso. Leg and wing broken.
June 22, 2003	Collision with vehicle or power line	1	North Slope	Broken right wing. Wing amputated and is currently (2004) housed at Alaska Sea Life Center. Adult male
June 29, 2004	Possible collision with vehicle or overhead wires	1	Barrow	Found under a tall power line. Broken neck and possibly broken back. Fog not noted that day.
July 12, 2004	Possible collision with radio tower	1	Barrow	Found in pond in close proximity to a 122 m tall radio tower. Laceration of right wing. Unable to fly.
June 28, 2008	Collision with overhead wire	1	Barrow	Male
June 5, 2009	Collision with overhead wire	1	Barrow	Female; Law Enforcement found under electrical wires
June 7, 2010	Collision with overhead wire	1	Barrow	Female; Found injured in pond. Powerlines along road with no diverters. Bird had what appeared to be a powerline strike injury to the left wing on the patagium. Did not appear that tendon was cut. Bird appeared normal otherwise. No broken bones on initial exam. Bird captured and sent to ASLC, then transferred to Central Park Zoo, NY in November 2010.

Accelerated Climate Change – As with Steller's eiders, exceptional climate change in the Arctic, associated changes in marine communities and ice dynamics in spring, may have had important impacts on spectacled eiders whose declines of ~90% are not fully understood. Spectacled eiders in the marine environment feed predominately on clams and lesser quantities of snails, amphipods, and other bivalves. In March-April 1999 and 2001, studies within the spectacled eider wintering areas showed that the esophagi of collected eiders contained only clams, almost entirely *Nuculana radiata* with no trace of the once-dominant *Macoma calcarea* (Lovvorn et al. 2003). Changes in the density of *M. calcarea* in the Bering Sea are coincident with an oceanic regime shift to warmer conditions in 1976-77 (Lovvorn et al. 2003). Declines in biomass and mean sizes of clams since the mid 1980s reflect widespread alterations in the Bering Sea food web that seem to be related to climate change (Grebmeier and Dunton 2000, Lovvorn et al. 2003). The Russian breeding population of spectacled eider, however, did not undergo a similar decline as the Y-K Delta population, even though they apparently all winter together. Due to this fact and because the timing of prey switching was not concordant with the timing of the eider decline, it is believed that the change in prey availability may have little to do with the eider's population decline (Petersen and Douglas 2004).

A rapidly warming climate is predicted to have significant effects on spectacled eider breeding habitat. On the Y-K Delta, alteration of nesting habitat through sea level rise (erosion, inundation, salinization), melting permafrost, and increased river discharge (accelerated sedimentation rates) may change the value of current nesting areas (Fischer et al. 2010). On the ACP, where permafrost is continuous, the unique hydrological system is dependent on cold temperatures for stability. If temperatures warm, the hydrological patterns could change and alter spectacled eider breeding habitat. But, such changes are difficult to predict at this time (FWS 2010a).

Petroleum Spills -- Eiders, scoters and long-tailed ducks are among the most frequent avian victims of oil pollution in the world's seas due to several factors, including: the large amount of time spent on water; their foraging behavior; and their presence in heavily navigated sea lanes (Day and Pritchard 2000). Their tendency to clump into discrete areas during molting and winter makes them vulnerable to large impacts from petroleum spills (Petersen et al. 1999). Significant risk to spectacled eiders from an acute oil spill is most likely to occur on their molting grounds due to the bird's tendency to concentrate and their extreme vulnerability when they are flightless (Stout 1998). Considering the nature and extent of vessel traffic, spills are unlikely scenarios in Norton Sound, an important molting area for spectacled eiders (Stout 1998, Peterson et al. 1999). But the recent proposal for oil and gas development in Ledyard Bay may result in risk of oil contamination for the North Slope breeding birds (Peterson et al. 1999).

The recent and unexpected grounding of the freighter M/V *Selandang Ayu*, in which hundreds of thousands of gallons of bunker fuel were released into the near-shore environments of Unalaska Island in the Aleutians killing at least 1,600 wintering water birds, reminds us that these devastating events are unpredictable. The rapidly warming climate has brought about the opening of the Canadian Northwest Passage and the Northern Sea Route in Russia, creating the possibility of new shipping routes in the future (NASA 2008). With those new routes comes the potential for sudden, accidental but catastrophic spills within the range and habitat of spectacled eiders.

Other Toxins -- In addition to lead concentrations above toxic thresholds, selenium and mercury were measured at levels above detection limits in spectacled eider adults and ducklings on their breeding grounds on the North Slope (Wilson et al. 2004), but the concentrations were not considered harmful. Interestingly, mercury concentrations increased while breeding females were on the nesting grounds, albeit at low levels, so it is presumed that this metal is available where spectacled eiders breed on the North Slope (Wilson et al. 2004).

Range-Wide Population Trend

North Slope -- The North Slope population growth rate is estimated at 0.985 (90% CI 0.971-0.999; Larned et al. 2010).

Yukon-Kuskokwim Delta -- The average long-term growth rate (1985-2010) suggests this population has stabilized (Fischer et al. 2010), and the current 10-year positive growth rates of nests and eggs suggest the population is increasing (Figure (III)1).

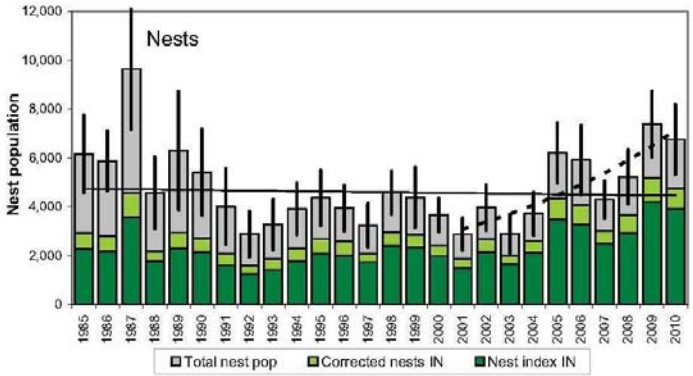

Figure (III)1. Nest population estimates from the Y-K Delta, 1985 to present (Fischer et al. 2010).

Arctic Russia -- Aerial surveys on the eastern Arctic coast of Russia from 1993 to 1995 produced an index of 146,245 (coefficient of variation (CV) = 0.08, unadjusted for detection rate) spectacled eiders (Hodges and Eldridge 2001). No surveys have occurred since 1995, and range-wide population numbers and trends are unknown, other than what can be inferred from winter population estimates.

Appendix IV. Status of the species: Northern sea otter (*Enhydra lutris kenyoni*)

Northern sea otter (*Enhydra lutris kenyoni*)

Species Description

The sea otter is a mammal in the family Mustelidae and it is the only species in the genus *Enhydra.* It is the smallest marine mammal in the world, except for the South American marine otter (*Lontra* (= *Lutra*) *felina*) (Reidman and Estes 1990). Adult males average 130 cm (4.3 ft) in length and 30 kg (66 lb) in weight; adult females average 120 cm (3.9 ft) in length and 20 kg (44 lb) in weight (Kenyon 1969). The northern sea otter in Russian waters (*E. l. lutris*) is the largest of the three subspecies, characterized as having a wide skull with short nasal bones (Wilson et al. 1991). The southern sea otter (*E. l. nereis*) is smaller and has a narrower skull with a long rostrum and small teeth. The northern sea otter in Alaska (*E. l. kenyoni*) is intermediate in size and has a longer mandible than either of the other two subspecies. Sea otters lack the blubber layer found in most marine mammals and depend entirely upon their fur for insulation (Riedman and Estes 1990). Their pelage consists of a sparse outer layer of guard hairs and an underfur that is the densest mammalian fur in the world, averaging more than 100,000 hairs per square centimeter (645,000 hairs per inch^2) (Kenyon 1969). As compared to pinnipeds (seals and sea lions) that have a distinct molting season, sea otters molt gradually throughout the year (Kenyon 1969).

Life History

Longevity

The maximum life span of a wild sea otter is believed to be 23 years (Nowak 1999).

Energetics

Sea otters have a relatively high metabolic rate as compared to land mammals of similar size (Costa 1978; Costa and Kooyman 1982, 1984). To maintain the level of heat production required to sustain them, sea otters eat large amounts of food; estimated at 23– 33% of their body weight per day (Riedman and Estes 1990).

Age to Maturity

Male sea otters appear to reach sexual maturity at 5–6 years of age (Schneider 1978, Garshelis 1983). The average age of sexual maturity for female northern sea otters is 3–4 years (von Biela et al. 2007), but there is variation in age of first reproduction even within the southwest DPS (von Biela et al. 2008). The average age of reproduction for female sea otters from the Aleutian Islands is 4.29 years, which is significantly different from those from Kodiak Island (3.19 years).

Reproductive Strategy

The presence of pups and fetuses at different stages of development throughout the year suggests that reproduction occurs at all times of the year. Most areas that have been studied show evidence of one or more seasonal peaks in pupping (Rotterman and Simon-Jackson 1988). Similar to other mustelids, sea otters can have delayed implantation of the blastocyst (developing embryo) (Sinha et al. 1966). As a result, pregnancy can have two phases: from fertilization to implantation, and from implantation to birth (Rotterman and Simon-Jackson 1988). The average time between copulation and birth is 6–7 months. Female sea otters typically will not mate while

accompanied by a pup (Lensink 1962; Kenyon 1969; Schneider 1978; Garshelis et al. 1984). The interval between pups is typically 1 year.

Recruitment
Estimating recruitment of sea otters into a population is difficult primarily because of 1) asynchronous pupping; and 2) an inability to reliably distinguish males from females and juveniles from adults externally.

For long lived species, we expect that survivorship of offspring is related to maternal age and experience, and that recruitment rate is more sensitive than survival rate to environmental fluctuations (Eberhardt 1977).

Distribution
E. l. kenyoni, also known as the northern sea otter, has a range that extends from the Aleutian Islands in southwestern Alaska to the coast of the State of Washington. Three stocks of sea otters are recognized in Alaska: southwestern, south-central and southeastern (Figure (IV)1). The southwest Alaska stock ranges from Attu Island at the western end of the Near Islands in the Aleutians, east to Kamishak Bay on the western side of lower Cook Inlet, and includes waters adjacent to the Aleutian Islands, the Alaska Peninsula, the Kodiak archipelago, and the Barren Islands (FWS 2005a).

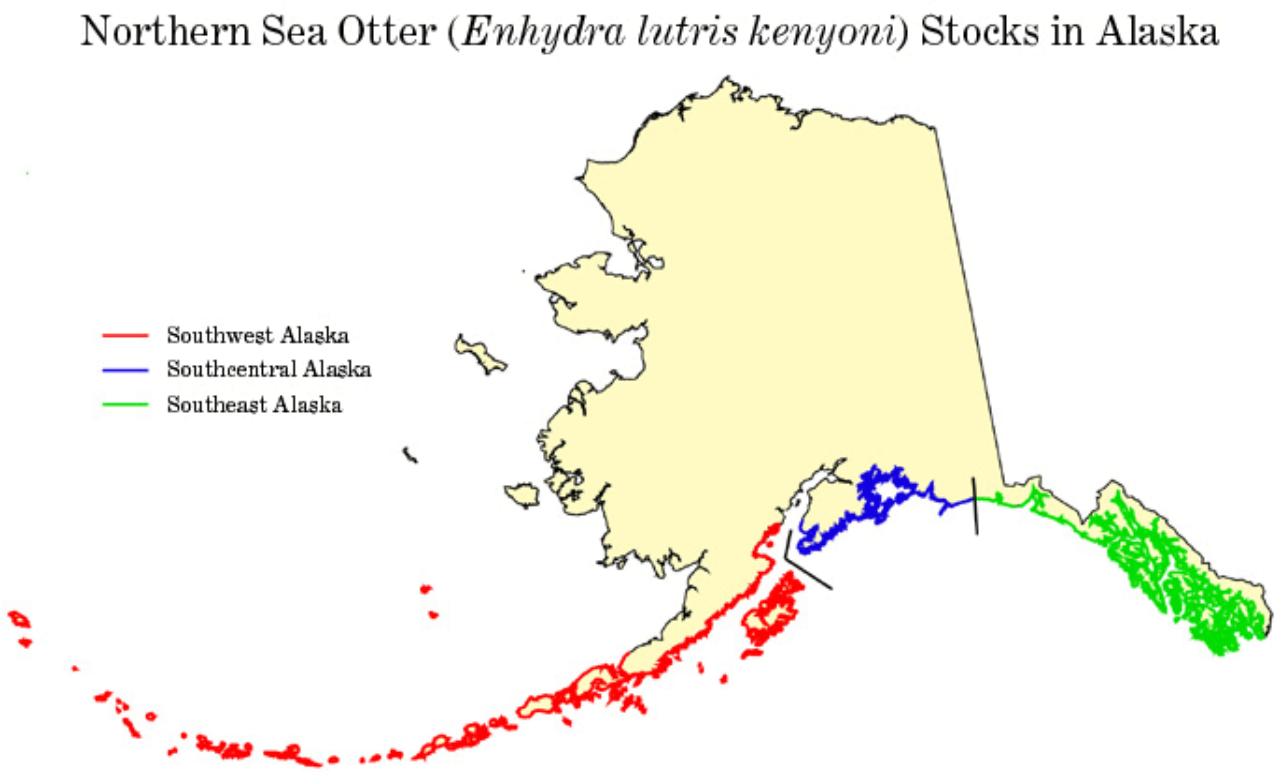

Figure (IV)1. Northern sea otter stocks in Alaska.

Movement Patterns
Movement patterns of sea otters have been influenced by the processes of natural population recolonization and the translocation of sea otters into former habitat after they had been extirpated by the fur trade. While sea otters have been known to make long distance movements up to 350 km (217 mi) over a relatively short period of time when translocated to new or vacant habitat (Ralls et al. 1992), the home ranges of sea otters in established populations are relatively small.

Once a population has become established and has reached equilibrium density within the habitat, movement of individual sea otters appears to be largely dictated by: environmental and social factors including gender, breeding status, age, climatic variables (e.g., weather, tidal state, season), and human disturbance. Home range and movement patterns of sea otters vary depending on the gender and breeding status of the otter. In the Aleutian Islands, breeding males remain for all or part of the year within the bounds of their breeding territory, which constitutes a length of coastline anywhere from 100 m (328 ft) to approximately 1 km (0.62 mi). Sexually mature females have home ranges of approximately 8–16 km (5–10 mi), which may include one or more male territories. Male sea otters that do not hold territories may move greater distances between resting and foraging areas than territorial males (Lensink 1962, Kenyon 1969, Riedman and Estes 1990, Estes and Tinker 1996). Juvenile males (1–2 years of age) are known to disperse later and for greater distances, up to 120 km (75 mi), from their natal (birth) area than 1-year-old females, for which the greatest distance traveled was 38 km (23.6 mi) (Garshelis and Garshelis 1984, Monnett and Rotterman 1988, Riedman and Estes 1990).

Sea otter movements are also influenced by local climatic conditions such as storm events, prevailing winds, and in some areas, tidal states. Sea otters tend to move to protected or sheltered waters (bays, inlets, or lees) during storm events or high winds. In calm weather conditions, sea otters may be encountered further from shore (Lensink 1962, Kenyon 1969). In the Commander Islands, Russia, weather, season, time of day, and human disturbance have been cited as factors that induce sea otter movement (Barabash-Nikiforov 1947, Barabash-Nikiforov et al. 1968).

Site Fidelity
Sea otters in Alaska are non-migratory and generally do not disperse over long distances (FWS 2008c). They usually remain within a few kilometers of their established feeding grounds (Kenyon, 1981), however, translocated populations are known to shift and expand their distribution in favorable habitats (Jameson 2002).

Population Structure
There are three subspecies of sea otter recognized worldwide: 1) the southern sea otter that occurs off the coast of California and Oregon; 2) the Asian sea otter that occurs west of the Aleutian Islands; and 3) the northern sea otter that occurs from the west end of the Aleutian Islands in Alaska, to the coast of the State of Washington (Wilson et al. 1991). Within northern sea otters (*E. l. kenyon*i), there are physical barriers to movement across the upper and the lower portions of Cook Inlet, and there are morphological and some genetic differences between sea otters that correspond to the southwest and south-central Alaska stocks (FWS 2005a).

Genetic analyses show some similarities between sea otters in the Commander Islands and Alaska (Cronin et al. 1996), which indicates that movements between these areas has occurred, at least over evolutionary/geologic time scales. All existing sea otter populations have experienced at least one genetic bottleneck caused by the commercial fur harvests from 1741 to 1911. As part of efforts to re-establish sea otters in portions of their historical range, otters from Amchitka Island (part of the Aleutian Islands) and Prince William Sound were translocated to other areas outside the range of what we now recognize as the southwest Alaska distinct population segment, but within the range of *E. l. kenyoni* (Jameson et al.1982).

Habitat

Sea otters generally occur in shallow water areas near the shoreline. They are most commonly observed within the 40 m (131 ft) depth contour (FWS 2008c), although they can be found in waters up to 100 m (328 ft) in depth. The majority of all foraging dives take place in waters less than 30 m (98 ft) in depth (Bodkin et al. 2004). As water depth is generally correlated with distance to shore, sea otters typically inhabit waters within 1–2 km (0.62–1.24 mi) of shore (Riedman and Estes 1990).

Much of the marine habitat of the sea otter in southwest Alaska is characterized by a rocky substrate. In these areas, sea otters typically are concentrated between the shoreline and the outer limit of the kelp canopy (Riedman and Estes 1990), but they also occur further seaward. Sea otters also inhabit marine environments that have soft sediment substrates, such as Bristol Bay and the Kodiak archipelago. As communities of benthic invertebrates differ between rocky and soft sediment substrate areas, so do sea otter diets.

Food Habits

Sea otters are carnivores that eat a wide variety of benthic (living in or on the sea floor) invertebrates, including sea urchins, clams, mussels, crabs, and octopus. In some parts of Alaska, sea otters also eat epibenthic (living upon the sea floor) fishes (Estes et al. 1982; Estes 1990).

Sea otters are considered a keystone species that strongly influence the species composition and diversity of the near-shore marine environment they inhabit (Estes et al. 1978). For example, studies of subtidal communities in Alaska have demonstrated that when sea otters are abundant, epibenthic herbivores such as sea urchins will be present at low densities whereas kelp, which is consumed by sea urchins, will flourish. Conversely, when sea otters are absent, grazing by abundant sea urchin populations creates areas of low kelp abundance, known as urchin barrens (Estes and Harrold 1988).

Predators

Sea otter predators include white sharks in the southern range and north to southeastern Alaska, and killer whales (*Orcinus orca*) in all areas. Killer whales may have been a key factor in the decline of the southwestern Alaska stock of sea otters (Estes et al. 1998), but the extent of predation and its potential impact on the population as a whole has not been determined. Sea otter pups may occasionally be taken by bald eagles or sea lions (Rotterman and Simon-Jackson 1988).

Population Dynamics

Population Size

Aleutian Islands -- The first systematic, large-scale population surveys of sea otters in the Aleutian Islands were conducted from 1957 to 1965 by Kenyon (1969). The total unadjusted count for the entire Aleutian archipelago during the 1965 survey was 9,700 sea otters (Table (IV)1). In 1965, sea otters were believed to have reached equilibrium densities throughout roughly one-third of the Aleutian archipelago, ranging from Adak Island in the east to Buldir Island in the west (Estes 1990). Islands in the other two-thirds of the archipelago had few sea otters, and researchers expected additional population growth in the Aleutians to occur through range expansion.

From the mid-1960's to the mid- 1980's, otters expanded their range, and presumably their numbers as well, until they had recolonized all the major island groups in the Aleutians. Although the maximum size reached by the sea otter population is unknown, a habitat-based computer model estimates that the population in the late-1980s may have numbered approximately 74,000 individuals in the Aleutians (Burn et al. 2003). But in a 1992 aerial survey of the entire Aleutian archipelago, only 8,048 otters were counted (Evans et al. 1997); approximately 19% fewer than the total reported for the 1965 survey. Sea otter surveys conducted during the mid-1990s also indicated substantial declines at several islands in the western and central Aleutians (Estes et al. 1998).

In April 2000, 2,442 sea otters were counted; a 70% decline from the count 8 years previous (Doroff et al. 2003). Along the more than 5,000 km (3,107 miles) of shoreline surveyed, sea otter density was at a uniformly low level, which clearly indicated that sea otter abundance had declined throughout the archipelago. Doroff et al. (2003) calculated that the decline proceeded at an average rate of 17.5% per year in the Aleutians.

Alaska Peninsula -- Three remnant colonies (at False Pass, Sandman Reefs, and Shumagin Islands) were believed to have existed near the western end of the Alaska Peninsula after commercial fur harvests ended in 1911 (Kenyon 1969). During surveys in the late 1950s and early 1960s, substantial numbers of sea otters were observed between Unimak Island and Amak Island (2,892 in 1965) on the north side of the Peninsula, and around Sanak Island and the Sandman reefs (1,186 in 1962), and the Shumagin Islands on the south side (1,352 in 1962) (Kenyon 1969). Schneider (1976) estimated 17,000 sea otters on the north side of the Alaska Peninsula in 1976 (Burn and Doroff 2005) , which he believed to have been within the carrying capacity for that area. In 1986, it was estimated that 6,474–9,215 sea otters occurred in this area (Burn and Doroff 2005). In May 2000, an estimated 4,728 sea otters were counted on the north side of the Alaska Peninsula; a 27–49% decline from 1986 (Burn and Doroff 2005).

Estimates of sea otters occupying offshore areas on the south side of the Alaska Peninsula in 1986 (Brueggeman et al. 1988) are 13,900–17,500 (Burn and Doroff 2005). A replication of this 1986 survey route during April of 2001, suggested a 93% decline in abundance (Burn and Doroff 2005).

Table (IV)1. Summary of Northern sea otter population surveys in southwest Alaska (FWS 2005a)

Survey area	Year	Count or Estimate	Source
Aleutian Islands	1965	9,700	Kenyon (1969)
	1992	8,048	Evans et al. (1997)
	2000	2,442	Doroff et al. (2003)
North Alaska Peninsula Offshore Areas	1976	11,681	Schneider (1976)
	* 1986	6,474 ± 2,003 (JUN) 9,215 ± 3,709 (AUG) 7,539 ± 2,103 (OCT)	Brueggeman et al. (1988) Burn and Doroff (2005)
	2000	4,728 ± 3,023 (MAY)	Burn and Doroff (2005)
South Alaska Peninsula Offshore Areas	* 1986	13,900 ± 6,456 (MAR) 14,042 ± 5,178 (JUN) 17,500 ± 5,768 (OCT)	Brueggeman et al. (1988), Burn and Doroff (2005).
	2001	1,005 ± 1,597 (APR)	Burn and Doroff (2005)
South Alaska Peninsula Islands	1962	2,195	Kenyon (1969)
	1986	2,122	Brueggeman et al. (1988)
	1989	1,589	DeGange et al. (1995)
	2001	405	Burn and Doroff (2005)
South Alaska Peninsula Shoreline	1989	2,632	DeGange et al. (195)
	2001	2,651	Burn and Doroff (2005)
Kodiak Archipelago	1989	13,526 ± 2,350	DeGange et al. (1995)
	1994	9,817 ± 5,169	Doroff et al. (in prep.)
	2001	5,893 ± 2,630	Doroff et al. (in prep.)
	2004	11,005 ± 2,135	Doroff et al. (in prep.)
Kamishak Bay	2002	6,918 ± 4,271	USGS in litt. (2002).

*Estimates recalculated by the FWS (Burn and Doroff 2005) from original data of Brueggeman et al. (1988).

Several island groups along the south side of the Alaska Peninsula; Pavlof and Shumagin Islands, as well as Sanak, Caton, and Deer Islands were surveyed in 1962 (Kenyon 1969; 1,900 otters), in 1986, (Brueggeman et al. 1988; 2,122 otters) in 1989 (DeGange et al. 1995; 1,589 otters). There were approximately 16–28% fewer sea otters in 1995 than were reported in the earlier counts. This decrease was the first indication of a sea otter population decline in the area of the Alaska Peninsula. Sea otter counts were again conducted in these island groups in 2001, and only 405 individuals were counted (Burn and Doroff 2005); an 81% decline from the 1986 count (Brueggeman et al. 1988).

In 1989, DeGange et al. (1995) counted 2,632 sea otters along the southern shoreline of the Alaska Peninsula from False Pass to Castle Cape. In a repeated survey of this route in 2001, 2,651 sea otters were counted (Burn and Doroff 2005), nearly the same as the 1989 count.

The results from the different survey areas along the Alaska Peninsula indicate various rates of change. Overall, the combined counts for the Peninsula have declined by 65–72% since the mid-1980s (Table (III)2). The estimate of sea otters along the Alaska Peninsula was 19,821 as of 2001.

Kodiak Archipelago -- One of the remnant sea otter colonies in southwest Alaska is thought to have occurred at the northern end of the Kodiak archipelago, near Shuyak Island. In 1959, Kenyon (1969) counted 395 sea otters in the Shuyak Island area. Over the next 30 years, the sea otter population in the Kodiak archipelago grew in numbers, and its range expanded southward around Afognak and Kodiak Islands (Schneider 1976, Simon-Jackson et al. 1984, Simon-Jackson et al. 1985). DeGange et al. (1995) surveyed the Kodiak archipelago in 1989 and calculated an adjusted population estimate of 13,526 sea otters. In 1994, there was an estimated 9,817 otters in the Kodiak archipelago (approximately 27% lower than in 1989 (Doroff et al. in prep.). A repeated survey conducted in 2001 suggested a 40% decline from 1994 (5,893 sea otters; Doroff et al. prep.).

Kamishak Bay -- Kamishak Bay is located on the west side of lower Cook Inlet, north of Cape Douglas. In the summer of 2002, the USGS, Biological Resources Division conducted an aerial survey of lower Cook Inlet and the Kenai Fiords area, in part to estimate sea otter abundance in Kamishak Bay. Sea otters were relatively abundant within Kamishak Bay during the 2002 survey (6,918 otters; USGS in litt. 2002), with numerous large rafts of sea otters observed.

Our current estimate of the size of the southwest Alaska population of the northern sea otter, which includes the 2004 estimate for the Kodiak archipelago, is 46,586 animals (Table (IV)2). This estimate is based on range-wide survey information collected from 2000–2004, and is adjusted for animals not detected. As recent site-specific surveys indicate the decline has not abated in the Aleutian archipelago and south Alaska Peninsula study areas, it is possible that the current population size is actually lower.

Survey methods vary in different locations. Like survey efforts of most species, detection of all the individuals present is not always possible. Sea otters spend considerable time under water, and it is not possible to detect individuals that are below the surface at the time a survey is conducted. Also, observers do not always detect every individual present on the surface.

Population Variability
Difference in sampling and estimation techniques may be responsible for variabilty in some population estimates (FWS 2005a). Even with variabilty in population estimates, the magnitude of the decline is so great that the likelihood that the population has not declined is exceedingly small.

Population Stability
Estes (1990) estimated population growth rates ranging from 17–20 % per year for four northern sea otter populations expanding into unoccupied habitat. While Bodkin et al. (1999) also reported similar population growth rates, they noted that population growth rates in translocated populations were significantly greater than for remnant populations. After the initial period of growth, populations typically reach an equilibrium density that can be supported by the habitat (Estes 1990).

Table(IV)2. Recent population estimates for the Northern sea otter in southwest Alaska (FWS 2005a, 2008b)

Survey area	Year	Unadjusted count or estimate	Adjusted count or estimate	Reference
North Alaska Peninsula Offshore Areas	2000	4,728	11,253	Burn and Doroff (2005)
Aleutian Islands	2000	2,442	8,742	Doroff et al. (2003)
South Alaska Peninsula Offshore Areas	2001	1,005	2,392	Burn and Doroff (2005)
South Alaska Peninsula Shoreline	2001 a	2,190	5,212	Burn and Doroff (2005)
South Alaska Peninsula Islands	2001	405	964	Burn and Doroff (2005)
Unimak Island	2001	42	100	Burn and Doroff (2005)
Kodiak Archipelago	2004	-	11,005	Doroff et al. (in prep.).
Kamishak Bay	2002	-	6,918	USGS Unpublished Data
Total			46,586	

Status and Distribution

Reasons for Listing

The southwestern DPS of the Northern sea otter was listed as threatened on August 9, 2005 (70 FR 46366). The definition of a threatened species is one that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. Recent surveys conducted in 2003 and 2004 indicate that the population decline has not abated in several areas within southwest Alaska. If the decline continues at the observed rates, the population may become extirpated throughout portions of its range within the next decade (Estes et al. 2005), at which point the DPS may be in danger of extinction.

The southwest DPS of northern sea otter is currently distributed throughout their former range, but at extremely low densities in most areas. Otters are now absent, or nearly so at some of the smaller islands in the Aleutian archipelago to the point where it is possible that Allee effects (reduced productivity at low population densities) may occur (Estes et al. 2005).

Predation -- The weight of evidence of available information suggests that predation by killer whales may be the most likely cause of the sea otter decline in the Aleutian Islands (Estes et al. 1998). Data that support this hypothesis include: 1) a significant increase in the number of killer whale attacks on sea otters during the 1990s, (Hatfield et al. 1998); 2) the number of observed attacks fits expectations from computer models of killer whale energetics; 3) the scarcity of beach cast otter carcasses that would be expected if disease or starvation were occurring; and 4) markedly lower mortality rates between sea otters in a sheltered lagoon (where killer whales cannot go) as compared to an adjacent exposed bay; and 5) the decline was driven by elevated mortality rate, not reduced fertility or redistribution (Laidre et al. 2006).

The hypothesis that killer whales may be the principal cause of the sea otter decline suggests that there may have been significant changes in predator-prey relationships in the Bering Sea ecosystem (Estes et al. 1998; Springer et al. 2003). For the past several decades, harbor seals (*Phoca vitulina*) and Steller sea lions (*Eumetopias jubatus*), the preferred prey species of transient, marine mammal eating killer whales, have been in decline throughout the western North Pacific. In 1990, Steller sea lions were listed as threatened under the Act (55 FR 49204). Estes et al. (1998) hypothesized that killer whales may have responded to declines in their preferred prey species, harbor seals and Steller sea lions, by broadening their prey base to include sea otters. Springer et al. (2003) suggest that modern industrial whaling led to declines in great whale populations in the North Pacific, which in turn resulted in killer whales "fishing down" the marine food web; first harbor seals, then fur seals, sea lions and finally sea otters in succession as preferred prey were depleted.

Subsistence Harvest -- The best available scientific information does not indicate that the subsistence harvest by Alaska natives has had a major impact on the southwest Alaska DPS of the northern sea otter. Some of the largest observed sea otter declines have occurred in areas where subsistence harvest is either nonexistent or extremely low. The majority of the subsistence harvest in southwest Alaska occurs in the Kodiak archipelago. Given the estimated population growth rate of 10% per year estimated for the Kodiak archipelago by Bodkin et al. (1999), we would expect that these harvest levels by themselves would not cause a population decline. Subsistence harvest has reportedly removed fewer than 1,400 sea otters from the southwest

Alaska DPS since 1989 (average = 85 per year; range = 24 to 180 per year; FWS, Marine Mammals Management, Anchorage, Alaska, Unpublished Data).

Interaction with Commercial Fisheries -- While there are some fisheries for benthic invertebrates in southwest Alaska, there is little competition for prey resources due to the limited overlap between the geographic distribution of sea otters and fishing effort. In addition, the total commercial catch of prey species used by sea otters is relatively small (Funk 2003). Sea otters are sometimes taken incidentally in commercial fishing operations. Information from the NMFS list of fisheries indicates that entanglement leading to injury or death occurs infrequently in set net, trawl, and finfish pot fisheries within the range of the southwest Alaska DPS of the northern sea otter (67 FR 2410, January 17, 2002). During the summers of 1999 and 2000, NMFS conducted a marine mammal observer program in Cook Inlet for salmon drift and set net fisheries. No mortality or serious injury of sea otters was observed in either of these fisheries in Cook Inlet (Fadely and Merklein 2001). Similarly, preliminary results from an ongoing observer program for the Kodiak salmon set net fishery also report only four incidents of entanglement of sea otters, with no mortality or serious injury (Manly et al. 2003). Based on Kodiak fisheries data coupled with self-reporting records from the Bering Sea and Aleutian Island ground fish trawl fishery, it is estimated that fewer than 10 sea otters per year might be killed or seriously injured as a result of entanglement with fishing gear (FWS 2008c)

Commercial Over-utilization -- Sea otters have rebounded from the estimated 1,000–2,000 individuals that were left after the cessation of commercial hunting (FWS 2005a). Following 170 years of commercial exploitation, sea otters were protected in 1911 under the International Fur Seal Treaty, which prohibited further hunting. There is no commercial use of sea otters in the United States. Recreational, scientific, and educational use have been regulated under the Marine Mammal Protection Act (MMPA) of 1972.

Habitat -- Critical habitat for the southwest DPS of northern sea otter was designated in 2009. The Primary Consituent Elements (PCEs) which contain the physical and biological features that are essential to the conservation of the species and may require special management considerations include, but are not limited to:
1. Space for individual and population growth and for normal behavior;
2. Food, water, air, light, minerals, or other nutritional or physiological requirements;
3. Cover or shelter;
4. Sites for breeding, reproduction, or rearing (or development) of offspring; and
5. Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

Research -- Scientific research on sea otters occurs primarily as aerial and skiff surveys, and such surveys are conducted annually. When they occur, they last for very short durations of time. During the 1990s, 198 otters were captured and released as part of health monitoring and radio telemetry studies at Adak and Amchitka (T. Tinker, University of California at Santa Cruz, in litt. 2003). In the past 5 years, 98 sea otters from the southwest Alaska DPS were live-captured and released as part of a multi-agency health monitoring study (USFWS 2005a, 2008b). Accidental capture-related deaths have been rare, with research activities carefully monitored by the FWS Division of Management Authority.

Disease -- Parasitic infection was identified as a cause of increased mortality of sea otters at Amchitka Island in 1951 (Rausch 1953). These highly pathogenic infestations were apparently the result of sea otters foraging on fish, combined with a weakened body condition brought about by nutritional stress. More recently, sea otters have been impacted by parasitic infections resulting from the consumption of fish waste. Necropsies of carcasses recovered in Orca Inlet, Prince William Sound, revealed that some otters in these areas had developed parasitic infections and fish bone impactions that contributed to their deaths (Ballachey et al. 2002, King et al. 2000).

Valvular endocarditis and septicemia have recently been isolated as a major, proximate cause of sea otter deaths in Alaska (Gill et al. *In Prep*). The majority of these deaths are ultimately related to exposure to and infection from *Streptococcus* bacteria.

Chronic Oiling -- The conventional wisdom that oil effects on sea otters are limited to short-term acute exposure to fur, resulting in death from hypothermia, smothering, drowning, or ingestion of toxics during preening, is being challenged. While these acute effects are not disputed, a growing body of evidence suggests that oil also affects sea otters over the long term, with interactions between natural environmental stressors and the compromised health of animals exposed to oil lingering well beyond the acute mortality phase (Peterson et al. 2003). The myriad of studies that have been undertaken since the 1989 *Exxon-Valdez* Oil Spill (EVOS) provide the most comprehensive data, by which to evaluate the effects to wild populations of sea otters to long-term, low-level exposure to hydrocarbons (Bodkin et al. 2002, Stephensen et al. 2001). But, documenting chronic effects of EVOS on sea otters has been difficult due to lack of appropriate controls combined with the natural variability among affected resources. However, until rigorous experimental control becomes feasible in assessing the impacts of unpredictable environmental perturbations, correlates will remain our best inferential tool.

Oil persisting in the habitat and uptake by prey continues to affect sea otter recovery in Prince William Sound (PWS) as sublethal exposure compromises health, reproduction and survival across generations (Bodkin et al. 2002, Ballachey et al. 2003). Sea otters consuming prey in habitats contaminated by residual oil have a high likelihood of encountering subsurface oil while excavating prey from sediments (Bodkin et al. 2002). Unlike vertebrates, invertebrates do not metabolize hydrocarbons, thus they accumulate hydrocarbon burdens in their tissues (Short and Harris 1996). As such, sea otters are potentially exposed to residual oil through two pathways: physical contact with oil while digging for prey, and ingestion of contaminated prey.

Persistent exposure to residual oil by sea otters in western PWS has been confirmed. Several authors reported higher levels of a biomarker (P450 1A), which indicates exposure to aromatic hydrocarbons in sea otters sampled from oiled areas of PWS compared to animals sampled from un-oiled areas (Ballachey et al. 2000a; Ballachey et al. 2000b; Bodkin et al. 2002). Chronic, persistent exposure to oil appears to cause reduced productivity and reduce survival of young (Mazet et al. 2001, Ballachey et al. 2003). A comparison of body lengths of sea otters that attained adulthood prior to the spill, relative to post-spill measurements, suggests that food resources were approximately equivalent before and after the spill occurred. These results imply

that factors other than body condition are affecting pup survival in western PWS (Ballachey et al. 2003).

Trans-generational effects may arise from direct exposure to a mutagen such as petroleum hydrocarbons, and therefore may be realized long after the contaminant exposure has ceased (Bickham and Smolen 1994). Sea otters are long-lived with relatively low annual reproductive rates and high annual adult survival; factors that result in either reduced reproduction, increased mortality, or increased emigration, will eventually lead to depressed population growth rates (Riedman and Estes 1990). Finally, exposure to pollutants such as crude oil may affect sea otters at a variety of levels of organization, beginning with somatic or germinal cell mutations and leading to a cascade of alterations that go beyond the individual or community to threaten the long-term survival of the population (Bickham et al. 2000, Clements 2000).

Range-Wide Trend

Historically, sea otters occurred throughout the coastal waters of the North Pacific Ocean from the northern Japanese archipelago around the North Pacific Rim to central Baja California, Mexico. Commercial hunting of sea otters began shortly after the Bering/Chirikof expedition to Alaska in 1741. Over the next 170 years, sea otters were hunted to the brink of extinction first by Russian, and later American, fur hunters. Prior to commercial exploitation, the worldwide population of sea otters was estimated at 150,000-300,000 animals (Kenyon 1969, Johnson 1982).

Sea otters were protected from further commercial harvests under the International Fur Seal Treaty of 1911. At that time, only 13 small remnant populations are believed to have persisted. The total worldwide population at that time may have been only 1,000-2,000 animals. Two of these remnant populations (Queen Charlotte Island and San Benito islands) declined to extinction (Kenyon 1969, Estes 1980). The remaining 11 populations began to grow in number, and expanded to recolonize much of the former range. Six of these remnant populations (Rat Islands, Delarof Islands, False Pass, Sandman Reefs, Shumagin Islands, and Kodiak Island) were located within the bounds of the southwest Alaska DPS. Because of the remote, pristine nature of southwest Alaska, these remnant populations grew rapidly during the first 50 years following protection from further commercial hunting.

The available survey data indicates that the sea otter population in southwest Alaska had grown in numbers and re-colonized much of its former range by the mid- to late-1980s. At that time, the sea otter population was believed to have numbered between 92,800 - 126,900 animals in southwest Alaska. Recent survey data indicates that sea otters have suffered drastic population declines throughout much of southwest Alaska during the past 10-15 years. The current population appears to have declined by 60-70%.

Appendix V. Status of the species: Polar Bear *(Ursus maritimus)*

Polar bear (*Ursus maritimus*)

Species Description

Polar bears are the largest of the living bear species (DeMaster and Stirling 1981). They are characterized by a large stocky body, with a longer neck and proportionately smaller head than other members of the bear family, and they lack the distinct shoulder hump common to brown bears (*U. arctos*). Polar bears exhibit sexual dimorphism, with female body length, skull size, and body mass considerably less than males (Derocher et al. 2005). Adult males have been recorded weighing 654 kilograms (1,440 pounds; Kolenosky et al. 1992), with some individuals estimated at 800 kg (1,760 pounds; DeMaster and Stirling 1981). Adult females weigh 181 to 317 kg (400 to 700 pounds). Polar bear fur color varies between white, yellow, gray, and brown, and is affected by oxidation or exposure to air, light conditions, and staining due to contact with fats from prey items. The nose, lips, and skin of polar bears is black (DeMaster and Stirling 1981, Amstrup 2003).

Genetic analyses indicate that polar bears branched off from brown bears and occupied an open niche on the surface of the sea-ice during maximal extent of the continental ice sheets during the late Pleistocene. Molecular genetic techniques indicate this could have occurred as long as 250,000 years ago (Amstrup 2003). Subsequent behavioral and physical adaptations have allowed polar bears to increasingly specialize at hunting seals from the surface of the ice (Stirling 1974, Smith 1980, Stirling and Øritsland 1995).

Physical adaptations to life on sea-ice include the whitish pelage with water repellent guard hairs and dense underfur, a short furred snout, and small ears. Polar bear teeth have become very specialized for a carnivorous diet, rather than the omnivorous diet of the brown bear (Amstrup 2003). Their teeth are well suited to grab prey and eat fat from the meat and hide, and less well suited for grinding grasses or other vegetation (Amstrup 2003). Polar bear feet have hair on the bottoms and are large and paddle-like (Stirling 1988). This adaptation probably assists in swimming and also helps disperse weight and avoid breaking through when walking on thin ice (Stirling 1988). Polar bear claws are shorter and more strongly curved than those of brown bears, and are larger and heavier than those of black bears (*U. americanus*), and appear to be well adapted to traveling over blocks of ice and snow and to securely gripping prey animals (Amstrup 2003).

Life History

Longevity/Survival

Polar bears are long-lived animals; the oldest known female polar bear in the wild was 32 years of age and the oldest known male was 28. However, few bears in the wild live beyond 20 years (Stirling 1990). Survival rates increase up to a certain age, with cubs-of–the-year having the lowest rates and prime age adults (between 5 and 20 years of age) having survival rates that can exceed 90% (Schliebe et al. 2006a). Cub survivorship depends on their weight when they exit maternity dens (Derocher and Stirling 1992). Most cub mortality occurs soon after they emerge from the den (Amstrup and Durner 1995, Derocher and Stirling 1996), and it is generally associated with starvation (Derocher and Stirling 1996). Survival of cubs to weaning stage (generally 27-28 months) is estimated to range from 15 to 56% of births (Schliebe et al. 2006a).

Energetics
Polar bears depend upon sea-ice for access to their prey and for other aspects of their life history (Stirling and Øritsland 1995; Stirling and Lunn 1997; Amstrup 2003). They are well adapted for the thermoregulatory challenges of the extreme cold conditions in the Arctic (Schliebe et al 2006). Normal body temperature of a resting polar bear is 37.0º Celsius (98.6º Fahrenheit), similar to other mammals (Best 1982, Stirling 1988). A combination of fur and hide properties, and up to 11 centimeters (4.5 inches) of blubber serve as excellent insulators and maintain body temperatures and metabolic rates at near normal levels at environmental temperatures of -37º C (-34.6º F) (Stirling 1988). However, polar bears are susceptible to overheating (Best 1982, Stirling 1988). Polar bears radiate heat from their muzzle, nose, ears, footpads, insides of the thighs, and blood vessels in the shoulder region near the skin (Stirling 1988). Polar bears can cool by swimming, because water conducts heat approximately 20 to 24 times more efficiently than air (Stirling 1988). Young cubs, however, can become chilled by swimming if it cools the body too much (Blix and Lentfer 1979, Stirling 1988). Polar bears also conserve energy by curling into a ball when exposed to extreme cold, windy weather, or sprawl out to keep cool on warm days (Stirling 1988). Bears in warm areas like Hudson Bay also move very little in summer in order to stay cool and conserve energy (Knudsen 1978, Derocher and Stirling 1990).

Unlike other species of bears where both sexes may hibernate, only pregnant female polar bears have a period of dormancy during the winter (Stirling 1988, Amstrup 2000). This is specialized winter dormancy, and not true hibernation. It is typified by a slightly depressed heart rate and temperature, during which time the bear does not feed and lives off accumulated fat stores (Stirling 1988, Amstrup 2003). Polar bears can also enter a hibernation-like state as needed (Derocher et al. 2004). This necessitates the adaptation for polar bears to feed perphagically (dramatically increase food intake to be stored as fat), both seasonally and when an unpredictable opportunity presents itself, and then slow down their metabolism to make stored fat reserves last longer during periods of food shortage (Derocher et al. 1990, Ramsay et al. 1991, Stirling and Øritsland 1995). Metabolic flexibility and the ability to digest fat with 98% efficiency are important adaptations that allow them to survive in Arctic (Schliebe et al. 2006a).

Age to Maturity
Age of maturation of mammals is often associated with a threshold body mass (Sadleir 1969), and in polar bears it appears to be largely dependent on numbers and productivity of ringed seals. In the Beaufort Sea, ringed seal densities are lower than in some areas of the Canadian High Arctic and Hudson Bay. As a possible consequence, female polar bears in the Beaufort Sea usually do not breed for the first time until they are 5 years of age (Stirling et al. 1976, Lentfer and Hensel 1980); giving birth for the first time at 6 years of age. In contrast, many of the Canadian females reach maturity at age 4 and produce their first young at age 5 (Stirling et al. 1977, 1980, 1984; Ramsay and Stirling 1982, 1988; Furnell and Schweinsburg 1984).

Reproductive Strategy
Polar bears have an intrinsically low reproductive rate characterized by late age of sexual maturity, small litter sizes, and extended parental investment in raising young. Female polar bears enter a prolonged estrus between March and June, when breeding occurs. Ovulation is thought to be induced by mating (Wimsatt 1963, Ramsay and Dunbrack 1986, Derocher and

Stirling 1992). Implantation is delayed until autumn, and gestation is 195 to 265 days (Uspenski 1977), with active development of the fetus suspended for most of that time. The timing of implantation, and therefore the timing of birth, is likely dependent upon body condition of the female, which in turn is dependent upon a variety of environmental factors (Schliebe et al. 2006a). Derocher et al. (1992) documented Hudson Bay polar bear births occurred from mid-November through mid-December. In the Beaufort Sea many pregnant females did not enter dens until late November or early December (Amstrup and Gardner 1994), and a later date of birth is assumed.

Throughout their range, most pregnant female polar bears excavate dens in snow drifts on land during September through November (Ramsay and Stirling 1990, Amstrup and Gardner 1994). The only known exceptions are in Western and southern Hudson Bay where polar bears excavate earthen dens and later reposition into adjacent snow drifts (Jonkel et al. 1972, Richardson et al. 2005) and in the southern Beaufort Sea where a portion of the population dens in snow caves located on pack and shorefast ice. Successful denning by polar bears requires an accumulation of sufficient snow combined with winds to cause snow accumulation leeward of topographic features that create denning habitat (Harington 1968). The common characteristic of all denning habitat is topographic features that catch snow in the autumn and early winter (Durner et al. 2003). Polar bear denning habitat in Alaska includes areas of low relief topography characterized by tundra with riverine banks within approximately 50 km (31 mi) of the coast (Amstrup 1993, Amstrup and Gardner 1994, Durner et al. 2001, 2003), and offshore pack ice-pressure ridge habitat. The northern Alaskan coast receives minimal snow fall, but because the landscape is flat, snow is blown throughout winter creating drifts in areas of relief. Insufficient data exist to accurately quantify polar bear denning along the Alaskan Chukchi Sea coast, however dens in the area are less concentrated than other areas in the Arctic. The majority of denning of Chukchi Sea polar bears occurs on Wrangel Island, Herald Island, and certain locations on the northern Chukotka coast of Russia.

Chronology of denning varies between polar bear populations. Satellite telemetry studies determined mean dates of den entry in the Beaufort Sea were 11 and 22 November for land (n = 20) and pack ice (n = 16), respectively (Amstrup and Gardner 1994). The mean date of emergence was 26 March for pack ice dens (n = 10) and 5 April for land dens (n = 18). For bears denning on sea-ice or moving from sea-ice to land denning habitat, time of sea-ice consolidation can alter the onset of denning. Sea-ice dens must be in ice stable enough to stay intact for up to 164 days while possibly moving hundreds of kilometers by currents (Amstrup 2003, Wiig 1998).

Polar bears are largely food deprived while on land in the ice-free period and survive by mobilizing fat during that time. Pregnant females that spend the late summer on land then go into dens and may not feed for eight months (Watts and Hansen 1987, Ramsay and Stirling 1988). This may be the longest period of food deprivation of any mammal, and it occurs when the female could be gestating and lactating. Polar bears give birth in the dens during mid-winter (Kostyan 1954, Harington 1968, Ramsay and Dunbrack 1986). Survival and growth of the cubs depends on the warmth and stable environment within the maternal den (Blix and Lentfer 1979). Family groups emerge from dens in March and April when cubs are about three months old and able to survive in the outside weather conditions (Blix and Lentfer 1979, Amstrup 1995). Newborn polar bears are very small, weighing only approximately 0.6 kg (1.3 pounds) (Blix and

Lentfer 1979). Cubs grow very quickly and may weigh 10 to 12 kg (22 to 26.4 pounds) by the time they emerge from the den about three months later. Young bears stay with their mothers until they wean at 2.3 years of age. Female polar bears are available to breed again after the cubs are weaned. Therefore, in most areas, the minimum successful reproductive interval for polar bears is 3 years (Schliebe et al. 2006a).

Polar bear reproduction lends itself to early termination without extensive energetic investment on the female (Ramsay and Dunbrack 1986, Derocher and Stirling 1992). Female polar bears may defer reproduction in favor of survival when foraging conditions are difficult (Derocher et al. 1992). Persistent deferral of reproduction could cause a declining population trend in populations with an intrinsically low rate of growth (Schliebe et al. 2006a).

Recruitment

Litter size and production rates vary by geographic area and may change in response to hunting pressure, environmental factors, and other population perturbations. Litters of two cubs are common (Schliebe et al. 2006a), with litters of three cubs occurring sporadically across the Arctic and most commonly reported in the Hudson Bay region (Stirling et al. 1977, Ramsay and Stirling 1988, Derocher and Stirling 1992). Average litter size across the species range varied from 1.4 to 1.8 cubs (Schliebe et al. 2006a), and several studies have linked reproduction to availability of seal prey, especially in the northern portion of their range. Body weights of mother polar bears and their cubs decreased markedly in the mid-1970s in the Beaufort Sea following a decline in ringed and bearded seal pup production (Stirling et al. 1976, 1977, Kingsley 1979, DeMaster et al. 1980, Stirling et al. 1982, Amstrup et al. 1986). Declines in reproductive parameters varied by region and year with the severity of ice conditions and corresponding reduction in numbers and productivity of seals (Amstrup et al. 1986). In the Beaufort Sea, females produce a litter of cubs at an annual rate of 0.25 litters per adult female (Amstrup 1995).

Seasonal Distribution Patterns

Polar bears occur throughout portions of the Northern Hemisphere where the sea is ice-covered for all or much of the year (Amstrup 2003). Information from telemetry studies indicate polar bear movements are not random, nor do they passively follow ocean currents on the ice as previously thought (Pedersen 1945, Mauritzen et al. 2003). Males and females had similar activity areas on a monthly basis, but males traveled farther each month (Amstrup et al. 2000b, Amstrup et al. 2001). Movement data gathered prior to the recent changes of retreating ice conditions indicate that in the Beaufort Sea, annual activity areas for individually monitored female bears averaged 149,000 km^2 (57,529 mi^2), ranging from 13,000 km^2 to 597,000 km^2 (5,019 mi^2 to 230,503 mi^2; Amstrup et al. 2000b). Total annual movements by female bears in the Beaufort Sea averaged 3,415 km (2,122 mi) and ranged up to 6,200 km (3,853 mi), with movement rate of >4.0 km per hr (2.5 mi per hr) sometimes sustained for long periods, and movements of >50 km per day (31 mi per day) observed (Amstrup et al. 2000b). The mean activity area in the Chukchi Sea, characterized by highly dynamic ice conditions, was 244,463 km^2 (94,388 mi^2; Garner et al. 1990). The average annual distance moved by Chukchi Sea female bears was 5,542 km (3,444 mi).

Some individual polar bears occupy home ranges which they seldom leave (Amstrup 2003). The size of a polar bear's home range is determined, in part, by the annual pattern of freeze-up and break-up of sea-ice, and therefore by the distance a bear must travel to obtain access to prey (Stirling 1988, Durner et al. 2004). A bear that has consistent access to ice, leads (narrow, linear cracks in the ice that form when ice floes diverge or shear as they move parallel to each other), and seals may have a relatively small home range, while bears in areas such as the Barents, Greenland, Chukchi, Bering or Baffin seas may have to move many hundreds of kilometers each year to remain in contact with sea-ice from which they can hunt (Born et al. 1997, Mauritzen et al. 2001, Ferguson et al. 2001, Amstrup 2003, Wiig et al. 2003).

Site Fidelity

Fidelity to denning locales has been investigated (Amstrup and Gardner 1994). Bears that denned once on pack ice were more likely to den on pack ice than on land in subsequent years. Similarly, bears were faithful to general geographic areas – those that denned once in the eastern half of the Alaska coast were more likely to den there than to the west in subsequent years. Annual variations in weather, ice conditions, prey availability, and the long-distance movements of polar bears (Amstrup et al. 1986, Amstrup et al. 2000b, Garner et al. 1990) make recurrence of exact denning locations unlikely.

Population Structure

Population age structure data indicate subadults 2 to 5 years survive at lower rates than adults (Amstrup 1995), probably because their hunting and survival skills are not fully developed (Stirling and Latour 1978). High adult survival rates (greater than 90%) are essential to sustain polar bear populations (Eberhardt 1985, Amstrup and Durner 1995), and adult female survival has been estimated to exceed 96%.

Causes of mortality include injury, starvation, and old age. Polar bears that avoid serious injury may become too old and feeble to hunt efficiently and most are generally believed to die of old age. Local and widespread climatic phenomena, which have the potential to make seals less abundant or less available, can significantly affect polar bear populations through survival or production (Kingsley 1979, DeMaster et al 1980, Amstrup et al. 1986, Stirling 2002).

Food Habits

High fat intake achieved by specializing on marine mammal prey allows polar bears to thrive in the harsh Arctic environment (Stirling and Derocher 1990, Amstrup 2003). Polar bears derive essentially all their sustenance from marine mammal prey and have evolved a strategy that utilizes the high fat content of marine mammals (Best 1985, Amstrup et al. 2007). Over half the caloric content of a seal carcass is located in the layer of fat between the skin and underying muscle (Stirling and McEwan 1975). Polar bears show their preference for fat by quickly removing the fat layer from beneath the skin after they catch a seal.

Over much of their range, polar bears are dependent on one species of seal, the ringed seal (*Phoca hispida*; Smith and Stirling 1975, Smith 1980), and the relationship between ringed seals and polar bears is so close that the abundance of ringed seals in some areas appears to regulate the density of polar bears. In turn, polar bear predation regulates density and reproductive success of ringed seals (Hammill and Smith 1991, Stirling and Øritsland 1995). Polar bears can

rarely catch seals on land or in open water (Furnell and Oolooyuk 1980); rather they consistently catch seals and other marine mammals at the air-ice-water interface, where aquatic mammals come to breathe (Amstrup et al. 2007).

Polar bears occasionally catch belugas (*Delphinapterus leucas*), narwhals (*Monodon monocerus*), walrus (*Odobenus rosmarus*), and harbor seals (*P. vitulina*) (Smith 1985, Calvert and Stirling 1990, Smith and Sjare 1990, Stirling and Øritsland 1995, Derocher et al. 2002). Where common, bearded seals (*Erignathus barbatus*) can be a large part of polar bear diets, and are probably the second most common prey item (Derocher et al. 2002). Walruses can be seasonally important in some parts of the polar bear range (Parovshchikov 1965, Ovsyanikov 1996).

Population Dynamics

Population Size

The total number of polar bears worldwide is estimated to be 20,000 to 25,000 (Aars et al. 2006). Polar bears are distributed throughout regions of the Arctic and subarctic waters where the sea is ice-covered for large portions of the year. Patterns in spatial segregation suggested by telemetry data, along with information from surveys, marking studies, and traditional knowledge, resulted in recognition of 19 partially discrete polar bear groups by the International Union for the Conservation of Nature (IUCN) Polar Bear Specialist Group (PBSG) for the purposes of management [the distribution of the subgroups is illustrated in the final rule listing for the polar bear (73 FR 28212, May 15, 2008; page 28216)]. There is considerable overlap in areas occupied by members of these groups (Amstrup et al. 2005) and the boundaries have been adjusted as new data are collected. Two of these populations (Southern Beaufort Sea and Chukchi Sea) occur in Alaska.

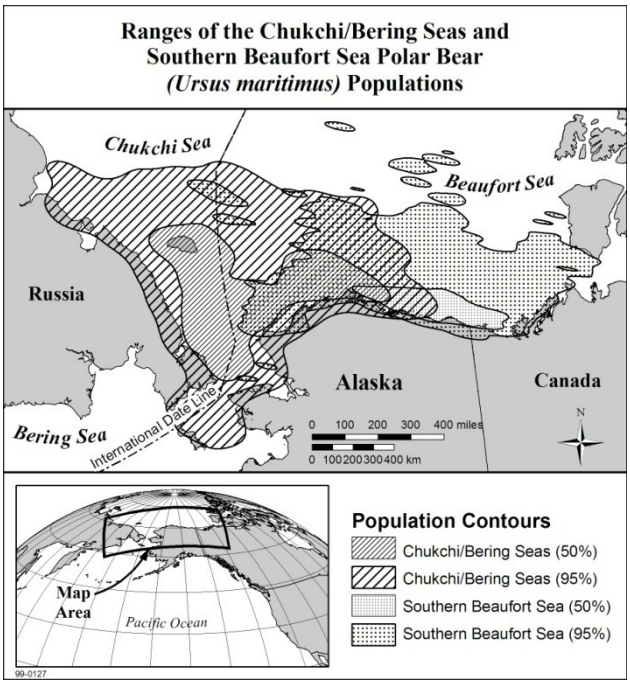

Figure (V)1. Ranges of Alaska polar bear stocks (USFWS 2009)

Population Stability/Variability

Chukchi Sea -- The Chukchi Sea (CS) population is widely distributed on the pack ice of the northern Bering, Chukchi, and eastern portions of the Eastern Siberian seas (Garner et al. 1990, Garner et al. 1994, Garner et al. 1995). Polar bears are seasonably abundant in the Chukchi Sea and their distribution is influenced by the movement of the seasonal pack ice. Polar bears in the Chukchi and Bering Seas move south with the advancing ice during fall and winter and move north in advance of the receding ice in late spring and early summer (Garner et al. 1990).

Polar bears are dependent upon the sea-ice for foraging and the most productive areas seem to be near the ice edge, leads, or polynyas (irregularly shaped areas of persistent open water that are sustained by winds or ocean heat) where the ocean depth is minimal (Durner et al. 2004). In addition polar bears could be present along the shoreline in this area as they opportunistically scavenge on marine mammal carcasses (Kalxdorff and Fischbach 1998). The current CS population size is not precisely known (Aars et al. 2006, Schliebe et al. 2006a). Reliable estimates of population size based upon mark and recapture studies are not available for this region, and measuring the population size is a research challenge. It is believed the status of the CS population increased after the harvest was reduced in 1972, but the status and trend cannot yet be determined for this population (73 FR 28212, May 15, 2008; page 28217).

The CS population is subject to subsistence hunting in Alaska where average annual harvest levels declined about 50% between the 1980s and 1990s (Schliebe et al. 1998) and have remained at low levels in recent years. No hunting quota has been set; in 2004/2005, 32 bears were harvested in Alaska. There is believed to be a substantial harvest in Russia where a minimum of 100 bears are thought to be harvested annually, and in some years the estimates have exceeded 200 animals killed (Schliebe et al. 2006a). Currently the combined Alaska-Chukotka polar bear harvest is believed to exceed sustainable levels, and the CS polar bear population is considered uncertain or declining (Aars et al. 2006).

Southern Beaufort Sea -- The Southern Beaufort Sea (SB) population occurs between Icy Cape, Alaska on the western boundary and Pearce Point, Northwest Territory (NWT), Canada (Amstrup et al. 1986, Amstrup and DeMaster 1988, Stirling et al. 1988). The estimated size of the SB population is 1,526 (95% CI = 1,211 - 1,841) polar bears in the region in 2006 (Regehr et al. 2006). The harvest of polar bears in the SB region is shared between Canada and the United States and since 1988 has been managed under the "Polar Bear Management Agreement for the Southern Beaufort Sea" by the Inuvialuit Game Council of Canada, and the North Slope Borough of Alaska. The harvest quota for the SB is 80 animals (40 for Alaska and 40 for NWT). In 2004/2005 the joint harvest was 46 bears (Schliebe et al. 2006a, Branigan et al. 2006). The status of the SB population is designated as reduced (73 FR 28212, May 15, 2008; page 28217) and the predicted trend is declining (Aars et al. 2006).

Status and Distribution

Reasons for Listing

Due to threats to its sea ice habitat, on May 15, 2008 the Service published a Final Rule in the Federal Register listing the world-wide population of the polar bear (*Ursus maritimus*) as threatened (73 FR 28212) under the ESA. In the U.S., the polar bear is also afforded protection under the MMPA and is managed by MMM.

Loss of sea-ice habitat due to climate change was identified as the primary threat to polar bears range-wide. Polar bears are widely distributed throughout the Arctic where the sea is ice-covered for large portions of the year. Sea ice provides a platform for hunting and feeding, for seeking mates and breeding, for denning, for resting, and for long-distance movement. Polar bears primarily hunt ringed seals, which also depend on sea ice for their survival, but they also consume other marine mammals (73 FR 28212).

Climate change will significantly impact polar bears in the marine environment in many ways, including decreasing access to their principle food source and increasing energetic demands required to seek out available prey (Derocher et al. 2004). Polar bears are completely dependent upon Arctic sea-ice habitat for survival. They need sea-ice as a platform from which to hunt their primary prey, ringed seals, to make seasonal migrations between the sea-ice and their terrestrial denning areas, and for resting and mating (Schleibe et al. 2006). As sea-ice melts, the summer season becomes a fasting time for polar bears as they are forced over deeper less productive Arctic waters or onto land where their food supply is extremely limited or non-existent. While this summer fasting cycle is a component of polar bear life history, as the ice melts earlier in the summer and re-freezes later in the fall, the bears must fast for progressively longer periods. The decline of sea-ice decreases access to their principle food supply and increases the amount of energy that the bears must expend to reach the seals they do consume (Derocher et al. 2004). Long distance swims to reach pack ice or land can place polar bears in potentially hazardous conditions. The result can reduce individual survival and consequently reduce populations (Monnett and Gleason 2006).

Climate change may also lead to changes in habitat use and increase population vulnerability. A warming climate may affect the availability and quality of denning habitat on land. An estimated 50% of females from the Beaufort Sea stock den on land, while the remaining 50% den on drifting pack ice. Reproduction by ice-denning females must occur on relatively stable ice (Durner et al. 2006). As climate changes continue, the quality of sea-ice may decrease, forcing more females to den on land (Durner et al. 2006). However, if large areas of open water persist until late winter due to a decrease in the extent of pack ice, females may be unable to access land to den (Stirling and Andriashek 1992).

Sixty five percent of confirmed terrestrial dens on Alaska's North Slope have been noted as occurring on coastal or island bluffs (Durner et al. 2006). These bluffs are suffering rapid erosion and slope failure as permafrost melts and wave action increases in both duration and magnitude. In all areas, dens are constructed in autumn snowdrifts (Durner et al. 2003). Changes in autumn and winter precipitation or wind patterns predicted by climate change models (Hinzman et al. 2005) may significantly alter the quality and availability of denning habitat.

Polar bears use of coastal habitats in fall during open-water and freeze-up conditions has increased since 1992 (FWS 2006a), and if it continues, this trend may result in the increase in number of human – polar bear interactions if bears occur close to human settlements or development. Direct interactions between people and polar bears in Alaska appear to have increased markedly in recent years (Amstrup 2000). The number of bears taken for safety reasons, based on 3-year running averages, increased steadily from about three in 1993, to about

12 in 1998, and has averaged about 10 in recent years. This apparent increase in human-polar bear interactions could be an artifact of increased reporting by the hunters, or of an increased polar bear population and corresponding increased probability of interactions with humans. An alternative or combined explanation is that polar bears from the SBS and CS populations typically move from pack ice to the near-shore environment in fall to take advantage of higher productivity of ice seals over the continental shelf. In the 1980s and early 1990s, the nearshore environment froze by early-or mid-October, allowing polar bears to effectively access seals in the area. Since the late 1990s, the timing of ice formation in the fall has occurred later in November or early December, resulting in an increasing amount of time the bears spend on land near humans, and an increased probability of bear-human interactions occurring in coastal villages (Schliebe et al. 2006a). Some experts predict the number of human-polar bear interactions will increase as climate change continues (Derocher et al. 2004).

Northern shipping routes become more realistic with the shrinking Arctic sea-ice. As shipping along the Canadian Northwest Passage and the Russian Northern Sea Route becomes a reality, the likelihood of accidental oil spills in polar bear habitat will become greater (Derocher et al. 2004).

Other threats evaluated included hunting, oil and gas development, human-bear interactions, environmental contaminants, disease, and predation. Whereas loss of sea-ice habitat is considered the principle threat to polar bears, each of the other threats could become more significant in the future in combination with effects of climate change (Schliebe et al. 2006a).

Habitat – The Service designated polar bear critical habitat on November 24, 2010 (75 FR 76086). The PCEs of critical habitat for the polar bear are:

Sea-ice habitat used for feeding, breeding, denning, and movements, which is sea ice over waters 300 m (984.2 ft) or less in depth that occurs over the continental shelf with adequate prey resources (primarily ringed and bearded seals) to support polar bears.
Terrestrial denning habitat, which includes topographic features, such as coastal bluffs and river banks, with the following suitable macrohabitat characteristics:
Steep, stable slopes (range 15.5–50.0), with heights ranging from 1.3 to 34 m (4.3 to 111.6 ft), and with water or relatively level ground below the slope and relatively flat terrain above the slope;
Unobstructed, undisturbed access between den sites and the coast;
Sea ice in proximity to terrestrial denning habitat prior to the onset of denning during the fall to provide access to terrestrial den sites; and
The absence of disturbance from humans and human activities that might attract other polar bears.
Barrier island habitat used for denning, refuge from human disturbance, and movements along the coast to access maternal den and optimal feeding habitat, which includes all barrier islands along the Alaska coast and their associated spits, within the range of the polar bear in the United States, and the water, ice, and terrestrial habitat within 1.6 km (1 mi) of these islands (no-disturbance zone).

Critical habitat does not include manmade structures (e.g., houses, gravel roads, generator plants, sewage treatment plants, hotels, docks, seawalls, pipelines) and the land on which they are located existing within the boundaries of designated critical habitat on the effective date of this rule.

Range-Wide Population Trend

Long-term data to establish trends is not existent for some of the 19 polar bear populations. Of the populations for which long-term data is available, two are increasing (FWS 2007c). But the populations for which we have the most extensive time series data, Western Hudson Bay and SB, the populations are declining. Further, based on environmental factors and observed patters of population trends as a whole, it is likely that most populations will exhibit declines in the future (FWS 2007c).

Appendix VI. Status of the species: Kittlitz's murrelet *(Brachyramphus brevirostris)*

Kittlitz's murrelet *(Brachyramphus brevirostris)*

Species Description

The Kittlitz's murrelet is a small seabird, about 25 cm long, with no distinct sexual differences in size or coloration, however breeding and winter plumage is distinct. Juvenile plumage is similar to the basic plumage with exception of faint barring visible in the throat and breast areas. Basic coloration in adults is white on the underside with speckled gray and brown plumage topside. Upper wing plumage is dark gray or brown. Kittlitz's murrelet is easily confused with the similar appearing marbled murrelet *(B. marmoratus)*.

Life History

Longevity

The longevity of Kittlitz's murrelet is unknown, but may be similar to the closely related marbled murrelet. Cooke (1999) reported that two adult marbled murrelets tagged in 1991 were at least 8 years old when recaptured in 1997. Based on predicted survivorship curves, marbled murrelets could live about 30 or 40 years (Burger 2002).

Energetics

Similar to other small seabirds, Kittlitz's murrelets may be living close to their bioenergetic threshold most of the year and must forage with regularity to survive.

Age to Maturity

Age to maturity in Kittlitz's murrelets is unknown, but is likely similar to that estimated for marbled murrelets. The average age of first breeding for marbled murrelets is also not known, but based on other alcids of similar size, it is assumed to be between 2 and 5 years, with 3 years as a likely average (DeSanto and Nelson 1995; Beissinger and Nur 1997; Boulanger et al. 1999).

Reproductive Strategy

Little is known about the reproductive strategy of Kittlitz's murrelet because nesting sites are difficult to find (Day et al. 1999). Birds appear to be paired upon arrival to the breeding grounds. Egg-laying ranges from mid-May to mid-June depending on the population and range. One egg per clutch with one clutch per year is speculated. Large-scale non-breeding may be common to Kittlitz's murrelet. Both parents incubate and feed their young. Fledging in northern populations is generally believed to occur during August.

Recruitment

Little is known about Kittlitz's murrelet recruitment and, as in some long-lived species, recruitment may be dependant on periodic nesting success after an extended period of non-breeding (Day et al. 1999).

Seasonal Distribution Patterns

Summer Distribution -- The marine habitat associations of the Kittlitz's murrelet are characterized by congregations of birds near tidewater glaciers, and to a lesser extent offshore of remnant high-elevation glaciers and deglaciated coastal mountains (Day and Nigro 1999; Day et

al. 1999). They prefer shallow, turbid waters near stable or advancing tidewater glaciers (Day et al. 1999; Day et al. 2003a). During the breeding-season, Kittlitz's murrelets appear to favor waters <200 m from shore (Day et al. 2000), although a recent study suggests oceanic topography, rather than distance to shoreline, may be a more biologically meaningful parameter (Kissling et al. 2005). Information on Kittlitz's murrelets from the Russian Far East is sparse. In the summer they range from the coastal waters of Wrangel Island in the East Siberian Sea, along the coast of the Chukotka Peninsula, to the southern tip of Kamchatka, and around to the Sea of Okhotsk (Kondratyev et al. 2000).

During nesting season, the distribution of Kittlitz's murrelets is highly clumped within its geographic range (Isleib and Kessel 1973). Kittlitz's murrelets can be found along coasts where waters are influenced by glacial outwash, such as the Malaspina Forelands, where glacial runoff seeps across miles of exposed coast before entering the ocean (Kozie 1993). Kittlitz's murrelets are also found around Kodiak Island, the Aleutian Islands, Bristol Bay, Seward Peninsula, Cape Lisburne, and Chukotka and Kamchatka peninsulas in Russia; areas not currently influenced by glaciers. Along the Aleutians, Kittlitz's murrelets are associated with larger islands containing deep bays and inlets. This distribution outside of current glacial influence may represent remnant populations of previously glaciated habitat (AKNHP 2004).

Nesting Distribution-- Nesting habitat in Alaska is believed to be unvegetated scree-fields, coastal cliffs, barren ground, rock ledges, and talus above timberline in coastal mountains, generally in the vicinity of glaciers, cirques near glaciers, or recently glaciated areas, primarily from the Alaska Peninsula to Glacier Bay (Day et al. 1983; Day 1995; Day et al. 1999; Piatt et al. 1999). New information suggests that nesting habitat is not always associated with glaciers (FWS 2010b).

Russian-breeding Kittlitz's murrelets are commonly found along a 3km-wide strip of coastal Kamchatka waters (Vyatkin 1999). Breeding habitat is reportedly treeless, mountainous tundra habitat (Vyatkin 1999).

Post-breeding Distribution, Fall Migration, and Molting – In general, the post-breeding distribution of this species is largely unknown, but the shift between summer and winter distribution appears to be rapid and asynchronous (Day et al. 1999). During the non-breeding season, the marine distribution of Kittlitz's murrelets is farther offshore. In the northern Gulf of Alaska during winter and spring, it is believed that Kittlitz's murrelets prefer the Alaska Coastal Current and mid-shelf regions, and avoid the shelf-break front and Alaska Stream (Day and Prichard 2001). In winter, few Kittlitz's murrelets occur in the protected waters of PWS, Kenai Fjords, Kachemak Bay, Kodiak Island and Sitka Sound (Kendall and Agler 1998; Day et al. 1999; Stenhouse et al. 2007). A few birds have been observed during late winter in the Sireniki polyna of southern Chukotka in Russia (Konyukhov et al. 1998).

Food Habits

During the breeding season, Kittlitz's murrelets feed on schooling fishes such as Pacific capelin, Pacific sand lance, Pacific herring (*Clupea pallasi*), and walleye pollock (Piatt et al. 1994; Day and Nigro 2000; Agness 2006; Kissling et al. 2007). Although they are considered a piscivorous species, Kittlitz's murrelets also feed on invertebrates (Sanger 1987; Hobson et al. 1994).

Because the energy content of available forage fishes is seasonally influenced (Montevecchi and Piatt 1987; Litzow et al. 2004), Kittlitz's murrelets may switch prey at various times of the year (Ostrand et al. 2004).

Predators
In the Gulf of Alaska and Aleutian Islands, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) commonly take marbled murrelets, which are similar in size and appearance to Kittlitz's murrelets (R. J. Ritchie, ABR Inc., Fairbanks, Alaska, pers. comm.; Hughes JH, in litt.; Schempf PF, in litt.; White CM, in litt. as cited in Day et al. 1999). During summer of 2007, approximately 35 Kittlitz's murrelet remains were found in the territories (e.g., eyries and plucking posts) of 3 peregrine falcon pairs in Icy Bay (M. Kissling, FWS, Juneau, Alaska, Unpublished Data, 2007). Nest predation by Glaucous-winged gulls (*Larus glaucenscens*) has been documented on Agattu Island in the Near Island group of the Aleutians. The rate of predation by glaucous-winged gulls on Kittlitz's murrelet eggs was high and accounted for the failure of 40% of nests observed (Kaler et al. 2009.). Mammals typically are not considered to be significant predators of nesting Kittlitz's murrelets (Piatt et al. 1994, 1999). That said, a Kittlitz's murrelet nest being monitored on Kodiak Island in 2008 was predated by a red fox (*Vulpes vulpes*).

Population Size
The current world-wide abundance estimate of Kittlitz's murrelets is believed to range from 30,900 and 56,800 individuals, with appromately 11,000 birds occupying Russian waters (FWS 2010b).

Status and Distribution
The Kittlitz's murrelet is a small diving seabird whose entire North American population and most of the world's population inhabits Alaskan coastal waters. It was proposed as a candidate for listing under the ESA on May 11, 2005 (FWS 2005b).

The Kittlitz's murrelet appears to have undergone significant population declines in three of its core population centers -- Prince William Sound, Malaspina Forelands, and Glacier Bay. Based on a long-term data set from PWS, Kittlitz's murrelets in Alaska have declined at a rate of up to 18% per year from 1989 to 2000 (Kuletz et al. 2003b; FWS 2004). These data from PWS in South-central Alaska indicate that the Kittlitz's murrelet population has declined 84% over the 11 survey years. Analysis of this estimated decline reveals a significantly negative slope ($p = 0.038$). If this decline is linear and remains constant, extirpation of Kittlitz's murrelets in PWS is predicted to occur in approximately 30 years (Kuletz et al. 2005).

Threats
<u>Glacial retreat</u> -- Loss of glacial volume is a phenomenon occurring on a global scale (Dyurgerov and Meier 2000; IPCC 2007). Glacial retreat has been occurring since the end of the Little Ice Age (around 1850), but during recent decades, glaciers are melting at rates that cannot be explained by historical trends (Brown et al. 1982; Dyurgerov and Meier 2000). It is highly likely that the increase in average yearly temperatures over the past 50 years is primarily due to the global rise in anthropogenic greenhouse gasses (Crowley 2000; IPCC 2001; Karl and Trenberth 2003; Stott 2003; IPCC 2007).

Glaciers respond to change in climate almost immediately (Dyurgerov and Meier 2000). Correlations between warm mean surface temperatures and concomitant glacial melting events (Dickey et al. 2002) suggest that glaciers, particularly the maritime glaciers of Alaska, are sensitive to warming trends (Calkin 1994). There is an association between glacial ice thickness and rate of retreat whereby retreat is accelerated when ice thickness decreases (van der Veen 1996). The retreat rate of tidewater glaciers is related to water depth, such that the deeper the water, the more rapidly the glaciers retreat (Adalgeirsdottir et al. 1998). The widespread decrease in glaciers and ice caps has contributed to sea level rise, creating a feedback mechanism, which increases the rate of retreat for tidewater glaciers in particular (IPCC 2007). There is high confidence that the rate of observed sea level rise increased from the 19th to the 20th century, and the rate of global average sea level rise has increased over the past decade (IPCC 2007). Projected climate change over the next century will further affect the rates at which glaciers melt. Best estimates for average surface air warming ranges from 1.1° C (the lowest estimate under the B1 or low emission scenario) to 6.4° C (the highest estimate under the A1F1 or highest emission scenario). Even with an average temperature rise of 1° C, glaciers will continue to retreat in the next century (Oerlemans et al. 1998).

The especially rapid retreat of Alaska's glaciers represents about half the loss in mass of glacial ice worldwide (Hassol 2004). Most glaciers in Alaska have been receding since the turn of the 20th century (Lethcoe 1987; Molnia 2001). The Harding Icefield, on the Kenai Peninsula, is the largest ice field in North America. Seven of its 38 glaciers are currently tidewater, and on average the icefield has undergone a total volume change of -34 km^3 over the past 43 years (Adalgeirsdottir et al. 1998). This volume change corresponds to an average elevation change of -21 m (±5 m). From 1961 to 2003, the thickness of "small" glaciers reportedly decreased approximately 8 meters (NSIDC 2006); however Adalgeirsdottir et al. (1998) found no significant correlation between volume loss and type or characteristics of glaciers. Bering Glacier has shrunk up to 7.4 miles in length during the past century (Barretta 1997; Wiles et al. 1999). The retreat of Muir Glacier in Glacier Bay has been documented since the turn of the 20th century (Powell 1991), and is retreating at a rate of 3m/year (Hunter 1994). In PWS, there has been a near continuous ice retreat with minor advances since the Little Ice Age; one glacier reportedly has retreated 62 m/year for the past 75 years (Wiles et al. 1999).

Kittlitz's murrelets exhibit a strong association to glacially-influenced marine habitat in PWS, Kenai Fjords, Glacier Bay, Icy Bay, and the south side of the Alaska Peninsula (Kendall and Agler 1998; Kuletz et al. 2003a; Robards et al. 2003; van Pelt and Piatt 2003; van Pelt and Piatt 2005; Agness 2006). Their preference for areas near stable or advancing tidewater glaciers may be related to the diversity and abundance of high energy forage fishes such as Pacific capelin and Pacific sand lance (Piatt et al. 1994; Day and Nigro 2000; Agness 2006; Kissling et al. 2007). The distribution and availability of these high-energy forage fishes may change as glaciers recede, and the physical parameters of marine habitats are modified. Reduced diversity and abundance of high-energy forage fishes may reduce the Kittlitz's murrelet's ability to feed young during nesting season.

The accelerated melting and calving of tidewater glaciers is conducive to high rates of sedimentation (Koppes and Hallet 2002). Fjords are efficient traps for sediment produced by

tidewater glaciers, leaving little opportunity for removal. Sedimentation can change the suitability of marine habitats for forage fish that Kittlitz's murrelets feed upon. In extreme cases, sedimentation, glacial retreat and glacial rebound may combine to transform marine feeding habitat into glacial rivers draining onshore cirque and valley glaciers (Plassen and Vorren 2003).

Climate warming may be causing glaciers to release increasingly contaminated melt water to receiving water bodies. A substantial percentage of current glacial melt originated from ice that was deposited in 1950 through 1970, when organochlorines were more concentrated in the atmosphere than they are now, or were before 1950 (Blais et al. 2001). In addition, organochlorines that were deposited during that time were deposited more heavily in colder locations, such as ice fields. Contaminants in the melt-water from glaciers may contribute high concentrations of pesticides for decades or centuries to come (Donald et al. 1999). Although there is currently no direct evidence to support this hypothesis, exposure to environmental contaminants in forage fish could increase mortality and decrease productivity in Kittlitz's murrelets that are associated with the receiving waters of the melting glaciers.

The interrelated effects of a rapidly warming climate on the glacially influenced marine environment may result in reduced availability of high quality food for Kittlitz's murrelet adults and young. If forage quality and quantity are reduced, productivity will be negatively affected and mortality of Kittlitz's murrelets will increase. Increased mortality of breeding adults generally has greater population level effects in long-lived species with delayed maturity and low rates of reproduction (k-selected species such as seabirds), than it does for more r-selected species (e.g., geese and ducks; MacArthur and Wilson 1967; Beissinger 1995).

Climate Regime Shift -- Long-term changes in food supply may be part of a natural ecosystem response to a change in the ocean's climate (Kitaysky et al. 2007). Climate changes in the marine environment play a significant role in the population regulation of phytoplankton, zooplankton, and fish, and can disturb the balance in predator-prey relationships (Hunt and Stabeno 2002). As ocean temperatures change, forage fish abundance changes (Hunt et al. 2002). The marine climate regime shift that occurred in 1976-1977 is hypothesized as being partially responsible for the decline in Kittlitz's murrelets (van Vleit 1993; Day et al. 1999). Other piscivorous marine bird species in the Gulf of Alaska have declined over the past few decades (Piatt and Anderson 1996; Agler et al. 1999), apparently influenced by wide-spread changes in ocean climate and forage fish abundance (Piatt and Anderson 1996; Anderson and Piatt 1999; Hare and Mantua 2000; Hollowed et al. 2001). Marbled murrelets, which may have a high degree of dietary overlap with Kittlitz's murrelets (Day et al. 2003a), have also declined in some areas (Stephensen et al. 2001; Robards et al. 2003) lending support to the hypothesis that broader ecological changes have affected Kittlitz's murrelets. Ocean climate related declines in forage abundance and quality can cause food-related stress in sea birds, and those stressors may be further exacerbated by anthropogenically-caused mortalities such as pollution and commercial fishing (Piatt and Anderson 1996; Kitaysky et al. 2005).

Hydrocarbon contamination -- Petroleum hydrocarbons in marine waters are considered among the most potentially harmful contaminants to organisms (Martin and Richardson 1991). In other taxa, chronic exposure to hydrocarbons is associated with risks of cancer, reproductive anomalies, and endocrine dysfunction (Irwin et al. 1997; Springman et al. 2005). Petroleum

products released into the marine environment can remain for years (Hayes and Michel 1999), with documented adverse effects on marine birds (Custer et al. 2000; Esler et al. 2000; Trust et al. 2000b; Yamato et al. 1996) and their prey (Glegg et al. 1999). The pathway to exposure is either direct or indirect via ingestion of contaminated prey.

Small oil spills frequently occur in marine habitat within the range of Kittlitz's murrelets. From 1995 through August 2005, at least 1,923 small fuel spills from vessels resulted in the release of more than 271,700 gallons of petroleum hydrocarbons in Alaska waters (Alaska Department of Environmental Conservation, Anchorage, Alaska, unpublished data, 2005). Ninety percent of those spills occurred within the range of Kittlitz's murrelets. Additionally, cruise ships and recreational boating activity is increasing in glaciated fjords within Glacier Bay and PWS, in the very habitats that are most important to Kittlitz's murrelets (Day et al. 1999; Murphy et al. 2004).

Petroleum hydrocarbons are frequently introduced into the marine environment within the range of Kittlitz's murrelets. Spills are expected to increase in frequency as vessel traffic increases. Therefore, the probability that Kittlitz's murrelets will be exposed to low levels of hydrocarbons (directly or through prey ingestion) will increase. This increased probability of exposure may result in reduced reproductive capacity and/or longevity.

Based on the species' body size, diving behavior, tendency to cluster in nearshore waters, restricted distribution, and low productivity, the Kittlitz's murrelet is vulnerable to direct mortality from oil pollution (King and Sanger 1979). In 1989, the commercial oil tanker *Exxon-Valdez* spilled nearly 11 million gallons of heavy Alaska crude oil into PWS, eventually contaminating approximately 30,000 km^2 of coastal and offshore waters that served as habitat for approximately one million marine birds (Piatt et al. 1990). Estimates of direct mortality of Kittlitz's murrelets from the spill ranges from approximately 500 (Kuletz 1996) to over 1,000 birds (van Vleit and McAllister 1994). In either case, a notable portion of the PWS population (perhaps 7-15%) was lost. The proportion of resident Kittlitz's murrelets lost in this oil spill exceeds that of all other species impacted by this spill.

In December 2004, the *Selandang Ayu* spilled approximately one-half million gallons of heavy bunker C and diesel fuel oils into the nearshore waters off Unalaska, Aleutian Islands, leaving approximately 35 km of shoreline oiled (Alaska Department of Environmental Conservation, Anchorage, Alaska, unpublished data, 2005; Unified Command 2005). Few *Brachyramphus* murrelet carcasses were recovered after this oil spill (Byrd and Daniel 2007). However, about one-third of all the Kittlitz's murrelet observations made around Unalaska were from Makushin Bay (Romano et al. 2005), an area heavily oiled from this spill, and murrelets were observed in oiled waters (Stehn, US Geological Survey, Anchorage, Alaska, unpublished data, 2005). Kittlitz's murrelet mortality that may occur from fuel spills and petroleum contamination may go largely unobserved in Alaska's vast and remote waters (Kuletz 2001). Consequently, lack of observed mortality from oil pollution does not confirm its absence.

Alaska Maritime National Wildlife Refuge manages much of the Aleutian Island's coastal habitat. Approximately 2,900 ships on US/Asia routes annually traverse a Great Circle Route that takes them in close proximity to these islands. Based on the certainty that oil spills will

continue to occur in this region where high volumes of ships traverse dangerous waters, the Alaska Maritime National Wildlife Refuge is considered among the most vulnerable refuges in the country (NWRA 2005). Eighteen percent of Alaska's Kittlitz's murrelets cluster in this high risk region. Most of these individuals are clustered at just a few islands (e.g. Attu, Agattu, Adak, Atka, and Unalaska).

Recreational Boating -- This small, cryptic-colored seabird is rarely sought out by tour boat operators; however, the scenic tidewater glacier habitat with which it is associated (Day et al. 1999) is the ultimate destination for many recreational and commercial tour boats throughout the region (Murphy et al. 2004). Recreational and commercial tourism has increased substantially in many of its breeding areas, especially Glacier Bay, PWS, Kenai Fjords, and lower Cook Inlet/Kachemak Bay (Glacier Bay National Park, Alaska, unpublished data; Murphy et al. 2004; Hoover-Miller et al. 2006). The number of cruise ships allowed into Glacier Bay has increased 30% since 1985, while smaller charter boats and private boats have increased 8% and 15%, respectively. Mid-sized tour boat traffic has remained stable (Glacier Bay National Park, Alaska, unpublished data). Agness (2006) found that Kittlitz's murrelets were temporarily disturbed by vessel activity, near-shore, but concluded that vessel activity at currently observed levels does not constitute a loss of suitable habitat in Glacier Bay.

Excessive boat disturbance has been implicated in the decline of Kittlitz's murrelets in PWS (Day et al. 2003a). Most human use in PWS is concentrated in the northwestern part of the Sound, and in central mainland fjords with tidewater glaciers, the same areas favored by murrelets (Murphy et al. 2004). In PWS and Kenai Fjords, peak vessel activity occurs in June and July (B. Conner, National Park Service, Seward, Alaska, pers. comm.; Murphy et al. 2004), a time when Kittlitz's murrelets face intense energetic requirements to complete chick-rearing, and when new fledglings first enter marine waters and must quickly learn to forage on their own. Disturbance can disrupt feeding birds and cause them to swallow fish meant for their nestling (Speckman et al. 2004), and persistent boat traffic may prevent murrelets from using high quality foraging areas (Piatt and Naslund 1995). Disturbance causing reduced access to high energy food and increased stress could negatively affect longevity and reproduction in Kittlitz's murrelets (Day et al. 2003a); however, we lack data to confirm this.

Among all Kittlitz's murrelet population strongholds, Southeast Alaska's Icy Bay is the only fjord that remains relatively free of tourist traffic and commercial fishing. Interestingly, this is the only location where Kittlitz's murrelets still outnumber all other alcids. The importance of Icy Bay to the survival of the species may increase as anthropogenic disturbances increase throughout other portions of the species' range. Previously, it was believed that the logging operations near the entrance to Icy Bay did not overlap with Kittlitz's murrelet distribution in the Bay. However, new telemetry data indicates that Kittlitz's murrelets utilize the entrance of the Bay as well as the upper portions (Kissling et al. 2007). The extent to which logging operations such as low flights and boat activities affect Kittlitz's murrelet in Icy Bay is unknown.

Commercial Fisheries--Commercial gillnet fisheries take an unknown number of Kittlitz's murrelets. In PWS, salmon gillnet fisheries occur each summer in or near Kittlitz's murrelets' habitat. Kittlitz's murrelets represented 5% and 30% of murrelet bycatch in gillnets during 1990 and 1991, respectively (Wynne et al. 1991, 1992). Thus, based on population size of the two

species, they appear to be caught in fisheries at a disproportionately higher rate than marbled murrelets (Wynne et al. 1992; Agler et al. 1998; Day et al. 1999). Impact from gillnet fisheries may be localized, possibly as a result of the patchy distribution of this species. In 1999 and 2000, a similar study by the National Marine Fisheries Service in lower Cook Inlet recorded no take of Kittlitz's murrelets, although marbled murrelets were taken (Manley et al. 2003). In July 2005, a juvenile Kittlitz's murrelet was killed in a gillnet fishery off Kodiak Island (National Oceanic and Atmospheric Administration, Anchorage, Alaska unpublished data). Furthermore, there are anecdotal reports and opportunistic observations of both *Brachyramphus* species being taken in gillnet fisheries in other areas of Southcentral and Southeast Alaska (K. Kuletz, US Fish and Wildlife Service, Anchorage, Alaska, pers. comm.). Studies on the effects of gillnet fisheries on murrelet species (Carter et al. 1995) strongly suggest that gillnet fishery bycatch is a conservation concern for Kittlitz's murrelets. However, we have insufficient data to determine whether bycatch contributes substantially to the observed decline in Kittlitz's murrelets in recent years.

Because little is known about the winter distribution of Kittlitz's murrelets, significant mortality from high-seas fisheries cannot be discounted. A significant proportion of the entire population of Japanese murrelet (*Synthliboramphus wumizusume*) were reportedly killed in high-seas drift net fisheries in the North Pacific (Piatt and Gould 1994).

Predation-- In the Gulf of Alaska and Aleutian Islands, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) commonly take marbled murrelets, which are similar in size and appearance to Kittlitz's murrelets (R. J. Ritchie, ABR Inc., Fairbanks, Alaska, pers. comm.; Hughes JH, in litt.; Schempf PF, in litt.; White CM, in litt. as cited in Day et al. 1999). Predation is believed to be a significant factor affecting nesting success of marbled murrelets (McShane et al. 2004). Marbled murrelet eggs and chicks are depredated by corvids (Nelson 1997), raptors, and small mammals (McShane et al. 2004). This may also be the case with Kittlitz's murrelets (Day et al. 1999). Circumstantial evidence suggests that predation from corvids may be increasing with glacial retreat (M. Romano, US Geological Survey, Anchorage, Alaska, pers. comm.). However, Kittlitz's murrelet use of high-elevation nesting habitat probably results in a lower rate of nest depredation compared to forest-nesting marbled murrelets (Day et al. 1999; Piatt et al. 1999). Mammals are not considered to be significant predators of nesting Kittlitz's murrelets (Piatt et al. 1994, 1999).

Peregrine falcons perch on vessel flagpoles and take murrelets on the water (K. Kuletz, FWS, Anchorage, Alaska, pers. comm.). In Icy Bay during summers of 2006 and 2007, both peregrine falcons and bald eagles predated 28% and 13% (respectively) of radio-tagged Kittlitz's murrelets (M. Kissling, US Fish and Wildlife Service, Juneau, Alaska, pers. comm.; Kissling et al. 2007). During summer of 2007, approximately 35 Kittlitz's murrelet remains were found in eyries and plucking posts of three peregrine falcon pairs in Icy Bay (M. Kissling, FWS, Juneau, Alaska, Unpublished data, 2007). Nesting peregrine falcons were not observed during a bird survey in 1993 (Kozie 1993). The current number of nesting peregrine falcons in Icy Bay may represent a recent increase in the peregrine falcon population (M. Kissling, US Fish and Wildlife Service, Juneau, Alaska, pers. comm.). This new information suggests that peregrine falcons may play a significant role in the population decline of Kittlitz's murrelets in Icy Bay.

Appendix VII. Simple deterministic model of survival when Steller's eiders are chronically exposed to petroleum hydrocarbons at five locations where mixing zones are authorized for seafood and sewage discharges. Reduction of survivorship is estimated at 5.7% per year (Esler et al. 2000). Assumes that: 1) reduction in survivorship affects both sexes and all age classes equally, 2) that there is no reproductive input, 3) there is no immigration or emigration, and 4) this is the only source of mortality (i.e., does not account for the population-wide decline which is estimated at 2.7% per year or any other threat that may affect population growth).

South Unalaska Bay

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# birds @ *t*	1334.0	1258.0	1186.3	1118.6	1054.9	994.8	938.0	884.6	834.2	786.6	741.8	699.5	659.6	622.0	586.6
Survivorship Reduction	76.0	71.7	67.6	63.8	60.1	56.7	53.5	50.4	47.5	44.8	42.3	39.9	37.6	35.5	33.4
#birds @ *t*+1	1258.0	1186.3	1118.6	1054.9	994.8	938.0	884.6	834.2	786.6	741.8	699.5	659.6	622.0	586.6	553.1

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
# birds @ *t*	553.1	521.6	491.9	463.8	437.4	412.5	389.0	366.8	345.9	326.2	307.6	290.0	273.5	257.9	243.2
Survivorship Reduction	31.5	29.7	28.0	26.4	24.9	23.5	22.2	20.9	19.7	18.6	17.5	16.5	15.6	14.7	13.9
#birds @ *t*+1	521.6	491.9	463.8	437.4	412.5	389.0	366.8	345.9	326.2	307.6	290.0	273.5	257.9	243.2	229.4

After 30 years, the population of wintering Steller's eiders at Unalaska will be reduced by 1104.6 birds (= # birds @ *t=1* minus # birds @ *t=30* or 1334.0-229.4) or 8.8 listed Steller's eider (=1104.6*.008) as a result of chronic oil contamination. Note: as the numbers of individuals decrease, the probability that chronic exposure to an individual decreases (i.e., sampling error).

Sand Point

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# birds @ *t*	1028.0	969.4	914.1	862.0	812.9	766.6	722.9	681.7	642.8	606.2	571.6	539.0	508.3	479.3	452.0
Survivorship Reduction	58.6	55.3	52.1	49.1	46.3	43.7	41.2	38.9	36.6	34.6	32.6	30.7	29.0	27.3	25.8
#birds @ *t*+1	969.4	914.1	862.0	812.9	766.6	722.9	681.7	642.8	606.2	571.6	539.0	508.3	479.3	452.0	426.3

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
# birds @ *t*	426.3	402.0	379.0	357.4	337.1	317.9	299.7	282.7	266.5	251.3	237.0	223.5	210.8	198.8	187.4
Survivorship Reduction	24.3	22.9	21.6	20.4	19.2	18.1	17.1	16.1	15.2	14.3	13.5	12.7	12.0	11.3	10.7
#birds @ *t*+1	402.0	379.0	357.4	337.1	317.9	299.7	282.7	266.5	251.3	237.0	223.5	210.8	198.8	187.4	176.7

After 30 years, the population of wintering Steller's eiders at Sand Point will be reduced by 851.3 birds (= # birds @ *t=1* minus # birds @ *t=30* or 1028.0-176.7) or 6.8 listed Steller's eiders (=851.3*.008) as a result of chronic oil contamination. Note: as the numbers of individuals decrease, the probability that chronic exposure to an individual decreases (i.e., sampling error).

Akutan Harbor

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# birds @ *t*	727.0	685.6	646.5	609.6	574.9	542.1	511.2	482.1	454.6	428.7	404.3	381.2	359.5	339.0	319.7
Survivorship Reduction	41.4	39.1	36.8	34.7	32.8	30.9	29.1	27.5	25.9	24.4	23.0	21.7	20.5	19.3	18.2
#birds @ *t*+1	685.6	646.5	609.6	574.9	542.1	511.2	482.1	454.6	428.7	404.3	381.2	359.5	339.0	319.7	301.4

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
# birds @ *t*	301.4	284.3	268.1	252.8	238.4	224.8	212.0	199.9	188.5	177.8	167.6	158.1	149.1	140.6	132.5
Survivorship Reduction	17.2	16.2	15.3	14.4	13.6	12.8	12.1	11.4	10.7	10.1	9.6	9.0	8.5	8.0	7.6
#birds @ *t*+1	284.3	268.1	252.8	238.4	224.8	212.0	199.9	188.5	177.8	167.6	158.1	149.1	140.6	132.5	125.0

After 30 years, the population of wintering Steller's eiders at Akutan Harbor will be reduced by 602.0 birds (= # birds @ *t=1* minus # birds @ *t=30* or 727.0-125.0) or 4.8 listed Steller's eiders (=602.0*.008) as a result of chronic oil contamination. Note: as the numbers of individuals decrease, the probability that chronic exposure to an individual decreases (i.e., sampling error).

Kodiak-Chiniak Bay

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# birds @ *t*	1318.0	1242.9	1172.0	1105.2	1042.2	982.8	926.8	874.0	824.2	777.2	732.9	691.1	651.7	614.6	579.5
Survivorship Reduction	75.1	70.8	66.8	63.0	59.4	56.0	52.8	49.8	47.0	44.3	41.8	39.4	37.1	35.0	33.0
#birds @ *t*+1	1242.9	1172.0	1105.2	1042.2	982.8	926.8	874.0	824.2	777.2	732.9	691.1	651.7	614.6	579.5	546.5

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
# birds @ *t*	546.5	515.4	486.0	458.3	432.2	407.5	384.3	362.4	341.7	322.3	303.9	286.6	270.2	254.8	240.3
Survivorship Reduction	31.2	29.4	27.7	26.1	24.6	23.2	21.9	20.7	19.5	18.4	17.3	16.3	15.4	14.5	13.7
#birds @ *t*+1	515.4	486.0	458.3	432.2	407.5	384.3	362.4	341.7	322.3	303.9	286.6	270.2	254.8	240.3	226.6

After 30 years, the population of wintering Steller's eiders at Kodiak-Chiniak Bay will be reduced by 1091.4 birds (= # birds @ *t=1* minus # birds @ *t=30* or 1318.0-226.6) or 8.7 listed Steller's eider (=1091*.008) or 8.7 listed Steller's eiders as a result of chronic oil contamination. Note: as the numbers of individuals decrease, the probability that chronic exposure to an individual decreases (i.e., sampling error).

Chignik Bay

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
# birds @ *t*	976.0	920.4	867.9	818.4	771.8	727.8	686.3	647.2	610.3	575.5	542.7	511.8	482.6	455.1	429.2
Survivorship Reduction	55.6	52.5	49.5	46.7	44.0	41.5	39.1	36.9	34.8	32.8	30.9	29.2	27.5	25.9	24.5
#birds @ *t*+1	920.4	867.9	818.4	771.8	727.8	686.3	647.2	610.3	575.5	542.7	511.8	482.6	455.1	429.2	404.7

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
# birds @ *t*	404.7	381.6	359.9	339.4	320.0	301.8	284.6	268.4	253.1	238.6	225.0	212.2	200.1	188.7	177.9
Survivorship Reduction	23.1	21.8	20.5	19.3	18.2	17.2	16.2	15.3	14.4	13.6	12.8	12.1	11.4	10.8	10.1
#birds @ *t*+1	381.6	359.9	339.4	320.0	301.8	284.6	268.4	253.1	238.6	225.0	212.2	200.1	188.7	177.9	167.8

After 30 years, the population of wintering Steller's eiders at Chignik Bay will be reduced by 808.2 birds (= # birds @ *t=1* minus # birds @ *t=30* or 976.0-167.8) or 6.5 listed Steller's eider (=808.2*.008) or 6.5 listed Steller's eiders as a result of chronic oil contamination. Note: as the numbers of individuals decrease, the probability that chronic exposure to an individual decreases (i.e., sampling error).

Appendix VIII. Steller's eider vital rates used in Swem and Matz (2008).

Vital Rate	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
BP	0.5455	0	0.6061	0	0.5685	0.4302	0.4371	0	0.313	0.4894	0	0	0
Egg	2.71	0	2.65	0	2.4	2.8	2.75	0	2.95	2.71	0	0	0
NS	0.71	0	0.18	0	0.14	0.35	0	0	0.09	0.12	0	0	0
DS	0.0714	0	0.0714	0	0.0714	0.0714	0	0	0.0714	0.0714	0	0	0
WS	0.35	0	0.35	0	0.35	0.35	0	0	0.35	0.35	0	0	0
JS1	0.8678	0.8576	0.7779	0.8985	0.8158	0.8733	0.8244	0.8129	0.8728	0.8632	0.8447	0.8335	0.7854
JS2	0.8678	0.8576	0.7779	0.8985	0.8158	0.8733	0.8244	0.8129	0.8728	0.8632	0.8447	0.8335	0.7854
AS	0.76	0.8576	0.76	0.8985	0.76	0.76	0.76	0.8129	0.76	0.76	0.8447	0.8335	0.7854

Where:
BP is the proportion of females age 3 and older that attempt to breed;
Egg is the mean clutch size ; NS is mean nest success ;
DS is mean duckling survival;
WS is survival of offspring to their first birthday in year j of the ith stochastic projection;
JS is juvenile survival; and
AS is adult survival.

Appendix IX. Predictive population growth model for Steller's eiders used in jeopardy analysis.

VORTEX version 9.50 (Lacy et al. 2005) was used to model the population growth rate (λ) of Alaska breeding Steller's eiders and to compare λ when that population is subjected a 5.7% reduction in survivorship that results from attraction to mixing zones and subsequent exposure to petroleum hydrocarbons. VORTEX is an individual-based, age-structured population simulation model that can include carrying capacity, demographic stochasticity (in mortality and breeding structure), environmental stochasticity, catastrophes, density-(in)dependent reproductive rates, inbreeding depression, and allows a range of user defined functions to replace fixed parameter terms (Miller and Lacy 2005).

Using vital rates reported by Runge (2004) and Rojek (2008), we built a deterministic model to calculate the baseline λ of the Alaska breeding population with a starting population of 576 birds (Stehn and Platte 2009). We assume a polygynous mating system, an even age distribution, a 50/50 sex ratio, and that males are not limiting. We then programmed the model to simulate a catastrophe, where the baseline model was subjected to a 6% reduction in survivorship due to exposure to petroleum hydrocarbons across 8% of the population. We estimated that 8% of the Alaska breeding population winters in one of the five harbors, in which discharges permitted through the MZR attract Steller's eiders, and where they are subsequently exposed to petroleum hydrocarbons. There are no data to support or refute the 8% estimation, which is a simple proportion. That is, we calculated the percentage of Pacific wintering Steller's eiders that occur in the five harbors (i.e., 5,353/70,480; best estimate in 2008). We therefore assume that a proportional distribution applies to Alaska breeding Steller's eiders. Because we lack the ability to identify Alaska breeding Steller's eiders on the wintering grounds, we are unable to validate or refute this assumption. The result of the simulation was the recalculation of λ. The population growth rate of the baseline population was 0.861 and the λ of the population when subjected to a 6% reduction in survivorship across 8% of the population was 0.857 (Table (IX)1). Thus, the realized population level effect on Alaska breeding Steller's eiders is a reduction in the population growth rate of 0.004. The net result of this reduction in population growth rate is a reduction the probability that the population will persist. While the reduction of 0.004 is small, it is graphically noticeable (Figure (IX)1) and potentially measurable.

We tested the sensitivity of the population growth rate to incremental changes in juvenile survivorship (i.e., recruitment) and in adult survivorship (Table (IX)1) and we found that the difference (Δ) between baseline λ and petroleum hydrocarbon contamination λ does not vary much. Simply put, petroleum hydrocarbon contamination will affect population growth rate (λ) at a fairly constant level, even if our vital rate estimates are wrong. Thus, we conclude that the estimate of the realized effect of exposure to petroleum hydrocarbons on the population growth rate is robust to imprecise estimates of vital rates. Furthermore, we note that even when juvenile recruitment is high enough to facilitate a positive λ (i.e., the population increases through time), attraction to harbors where petroleum hydrocarbon contamination exists results in a depression of λ.

Thus, reintroduction and/or augmentation efforts may recruit more young into the population, but the direct and indirect effects of the mixing zone regulation causes a reduction in the ability of the population to recover. In other words, regardless of any efforts to recruit more youngsters into the population, adverse effects of mixing zones will hinder population recovery.

Table (IX)1. Comparison of the sensitivity of baseline λ and λ when the baseline population is exposed to petroleum hydrocarbons (PAH's) at five harbors. Delta (Δ) is the difference between the two population growth rates given varying estimates of 1) percent mortality of juveniles recruited into the population and 2) percent mortality of adult breeding birds. The gray shaded rows indicate the model output using vital rates from Runge 2004 and Swem and Matz 2008). Population trajectories indicated in the gray shaded rows are plotted in Figure (IX)1.

	Baseline λ	PAH contamination λ	Δ
Recruitment = 1%	0.722	0.719	0.003
Recruitment= 7%	0.861	0.857	0.004
Recruitment = 17%	0.964	0.959	0.005
Recruitment = 27%	1.035	1.030	0.005
Recruitment = 37%	1.093	1.088	0.005
Recruitment = 47%	1.143	1.137	0.006
Mortality after 3yrs = 1%	1.007	1.002	0.005
Mortality after 3yrs =11%	0.934	0.930	0.004
Mortality after 3yrs = 21%	0.861	0.857	0.004
Mortality after 3yrs = 31%	0.789	0.785	0.004
Mortality after 3yrs = 41%	0.719	0.715	0.004
Mortality after 3yrs = 51%	0.651	0.648	0.003

As a population becomes small, the estimates for such deterministic variables become more uncertain. This VORTEX model is in general agreement with models by Runge (2004) and Swem and Matz (2008), which is logical because most of the same parameter estimates were used in each of the three models. Based on empirical vital rate data, all three models conclude that the Alaska breeding population is rapidly headed for extinction, yet the realized population decline is not noticeably severe.

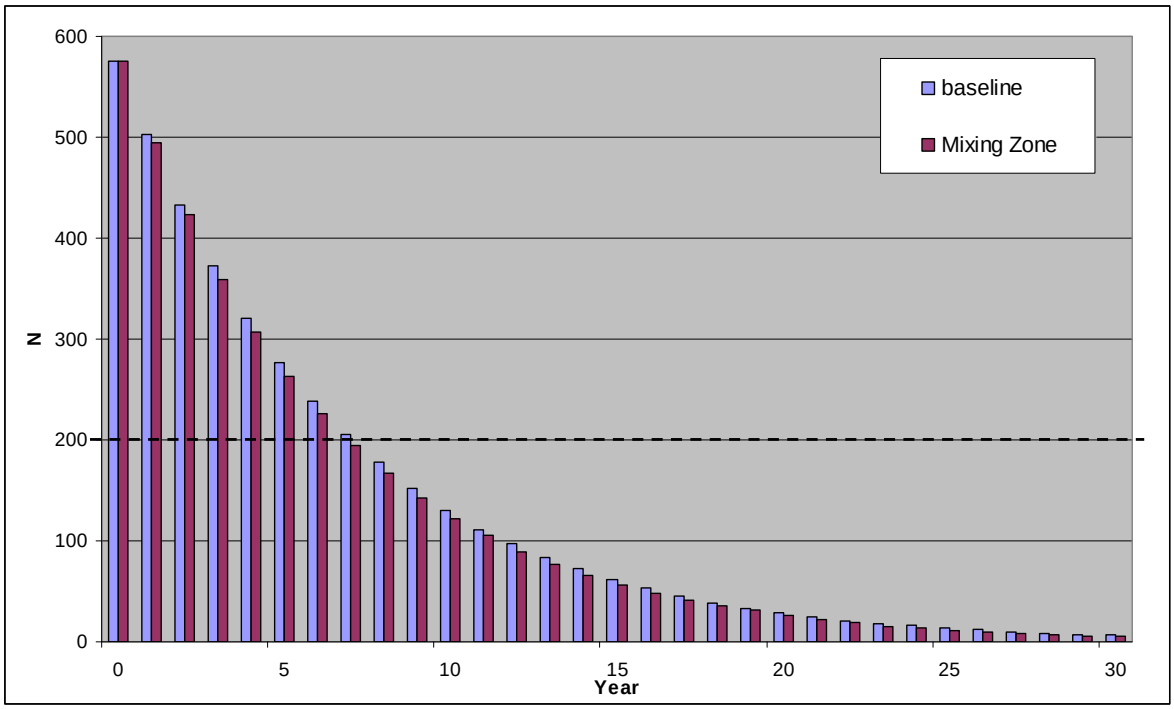

Figure (IX)1. Using the program VORTEX (see discussion below), the predicted population growth for Alaska breeding Steller's eiders is compared, with (red columns) and without (blue columns) exposure to petroleum hydrocarbons at five harbors. We assume that 8% (5,383/70,480) of all Alaska breeding Steller's eiders are exposed to petroleum hydrocarbons during winter as a result of attraction to mixing zones in the vicinity of fishing ports. The dashed line represents the quasi-extinction threshold.

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