

DRAFT

**Guidelines for the Protection of Marine
Animals During the Use of Explosives
In the Waters of the State of Florida**

May 2006 DRAFT

PURPOSE

This document is intended to provide guidance for mitigation planning and consultation purposes with state and federal agencies for new projects in the southeast U.S. using explosives. Although there are many other direct and indirect affects associated with the use of activities using explosives that may affect protected species, this guidance focuses on the determination of effects and avoidance of blast effects to protected species and their habitats from underwater explosions.

Killing or harassing threatened and endangered species and destruction or adverse modification of critical habitat is prohibited under the Endangered Species Act (ESA). Similar protection from harm and harassment are offered to all marine mammals under the Marine Mammal Protection Act (MMPA). Although marine plants are listed (i.e., Johnson's seagrass) and marine invertebrates are being considered for listing under the ESA, this guidance document applies to protected species of fishes, sea turtles, marine mammals, and their habitats.

INTRODUCTION

The Endangered Species Act provides Federal protection for the West Indian manatee (*Trichechus manatus*) and six species of sea turtles (green, *Chelonia mydas*; hawksbill, *Eretmochelys imbricata*; Kemp's ridley, *Lepidochelys kempii*; leatherback, *Dermochelys coriacea*; loggerhead, *Caretta caretta*; olive ridley, *Lepidochelys olivacea*). The Marine Mammal Protection Act provides Federal protection for manatees, dolphins and whales. Under State of Florida statutes, the Florida Manatee Sanctuary Act provides protection for the manatee and the Marine Turtle Protection Act provides protection for sea turtles. These Federal and State statutes provide the regulatory authority for required compliance with these guidelines by the blasting proponent (e.g., the person(s) who is(are) proposing works or undertakings that involve the use of explosives). The guidelines provided herein should be for the protection of manatees, whales, mammalian dolphins and sea turtles. These guidelines are intended for in-shore or near-shore projects, and do not specifically address the blasting affects associated with the decommissioning of offshore oil and gas structures in federal waters.

Federally-listed species of fish and critical habitats under the jurisdiction of NOAA Fisheries Service that occur in Florida should also be covered under these guidelines. When blasting is used as a construction/demolition method, the protective measures for marine mammals and sea turtles should also pertain to the following ESA-listed species:

- Gulf sturgeon (*Acipenser oxyrinchus desotoi*)
- Shortnose sturgeon (*Acipenser brevirostrum*)
- Smalltooth sawfish (*Pristis pectinata*)
- Johnson's seagrass

The detonation of explosives in the marine environment has in some instances caused injury and/or death to both marine mammals and sea turtles as reviewed by Ketten (1995), Lewis (1996), and Keevin and Hemen (1997). Individual scientific publications also document the potential for marine mammal (Fitch and Young 1948; Hanson 1954; Reiter 1981; Wright 1971;

Wright 1982) and sea turtle (O’Keeffe and Young 1984; Duronslet et al. 1986; Klima et al. 1988; Gitschlag and Renaud 1989; Gitschlag 1990; Gitschlag and Herczeg 1994) injury and/or death. Based on the best available scientific information describing the potential for marine mammal and sea turtle injury/death, the Florida Fish and Wildlife Conservation Commission (FWC), in cooperation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), has prepared these guidelines to provide information to project proponents on the conservation and protection of marine mammals and sea turtles from adverse impacts resulting from the use of confined or open-water explosives in Florida’s waters. Within the context of these guidelines, an explosive is defined as a chemical compound which, when detonated, creates a compressional wave having an almost instantaneous rise time to a very high peak pressure followed by a decay to below ambient pressure by either rapid oxidation or the breaking of high-energy chemical bonds.

APPLICABLE FEDERAL AND STATE LEGISLATION

These guidelines for the protection of marine mammals and sea turtles, the application and review procedures and processes, and reporting requirements that are outlined in this document apply in the context of the State and Federal legislative authorities briefly summarized below.

The Endangered Species Act

Section 9 (16 U.S.C. 1538) - Prohibited Acts

(a) General

- (1)...it is unlawful for any person subject to the jurisdiction of the United States to-
 - (B) take any such species within the United States or the territorial sea of the United States;
 - (C) take any such species upon the high seas;

Section 3 (16 U.S.C. 1532) - Definitions

(18) The term “take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.

The Marine Mammal Protection Act

Section 102 (16 U.S.C. 1372) - Prohibitions

(a)...it is unlawful-

(1)(A) for any person or vessel or other conveyance to take any marine mammal in waters or on lands under the jurisdiction of the United States;

Section 3 (16 U.S.C. 1362) - Definitions

(13) The term “take” means to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.

(18)(A) The term “harassment” means any act of pursuit, torment, or annoyance which-

- (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or
- (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

The Florida Manatee Sanctuary Act

Title XXVII, Section 370.12 – Marine animals; regulation

(2) Protection of Manatees or Sea Cows

(d)...it is unlawful for any person at any time, by any means, or in any manner intentionally or negligently to annoy, molest, harass, or disturb or attempt to molest, harass, or disturb any manatee; injure or harm or attempt to injure or harm any manatee; capture or collect or attempt to capture or collect any manatee; pursue, hunt, wound, or kill or attempt to pursue, hunt, wound, or kill any manatee, or possess, literally or constructively, any manatee or any part of any manatee.

The Marine Turtle Protection Act

Title XXVII, Section 370.12 – Marine animals; regulation

(1) Protection of Marine Turtles

(d)(5) Any person, firm, or corporation that illegally takes, disturbs, mutilates, destroys, causes to be destroyed, transfers, sells, offers to sell, molests, or harasses any marine turtle species, or the eggs or nest of any marine turtle species as described in this subsection, commits a third degree felony.

GUIDELINES

In seeking authorization to conduct underwater blasting in the State of Florida, the project proponent is responsible for providing a Blasting Plan. These guidelines are to be used to develop a site-specific Blasting Plan to be submitted to the appropriate State and Federal regulatory agencies (i.e., U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Coast Guard, and U.S. Army Corps of Engineers) as well as the FWC. This site-specific plan is to be submitted during the permitting process and approved before permit issuance. The permit will then reference the plan and the conservation measures within the plan will become permit conditions. Revision of the plan would require a permit modification.

THE BLASTING PLAN

The Blasting Plan must include the following components: (1) Blasting Design, (2) Impact Assessment, (3) Mitigation Plan, and (4) Endangered Species Watch Plan. Each of these components is described in detail below.

1. *Blasting Design*

The project proponent shall provide a “detailed” written description of the project blasting design, which must include a diagram(s) of the blasting design. At a minimum, the following information must be included:

- a. Type of initiation system to be employed. [Is the system fully electric or completely non-electric? Are there parts of both? Is any detonation cord used?]
- b. Timing and duration of underwater blasting, the limitation to daylight shooting, and any tidal and/or seasonal restrictions.

- c. Expected type and weight of explosives to be used per shot for production shots and the maximum charge weight per interval of 25 milliseconds (preferred). Sequentially list every charges' total delay time in increasing time order. Any charge weights with less than 9-milliseconds interval are summed to find the maximum charge weight per delay.
- d. Blast pattern and geometry of the individual shots for a small project or of a general blast production for a large blasting program. Test program to develop from small charges to the maximum charge weight per delay interval necessary for production. The expected production charge weight per delay, spacing and burden between borings, placement of explosives within borings, stemming type and minimum length of stemming placement within the structure (note 3.e. below), and the location of the initiator within the boring. [A small project (e.g., bridge demolition) will have a limited blasting plan, perhaps completely prepared. A large program (e.g., harbor rock removal) will have a general blasting program that varies through the project. A program may be needed to scale the first charge weight per delay to the maximum charge weight per delay for the project.]
- e. Description of millisecond-delays that will be used if multiple charges are required.
- f. Detailed description of the material to be blasted (i.e., substrata characteristics, description of concrete and reinforcement, etc.) and surrounding geology (water depth, water width, sediment thickness, rock or structure being removed, etc.).
- g. Detailed description of control measures that will be employed to assure that hole spacing, burden, hole depth, charge placement, delay interval, the stemming minimum, and recording of the shot have met the conditions of the permit and submitted plan.

2. Impact Assessment

The project proponent shall provide a “detailed” Environmental Impact Assessment of the proposed blasting project. At a minimum, the following information must be included:

- a. The likelihood of sea turtles and marine mammals being in the blasting area. The proponent shall consult existing scientific literature and the FWC and/or other resource agencies. Pre-blast marine mammal/sea turtle surveys may be required, at the discretion of the FWC, USFWS, NMFS, or other reviewing/permitting agencies.
- b. A description of the marine mammal/sea turtle “exclusion zone” that will be developed and used for underwater blasting programs to provide species’ protection. The preferred minimum exclusion zone radius or range from which to protect marine mammal/sea turtles is 500 linear feet beyond the perimeter of placed blasting agents for a shot. The preferred maximum exclusion zone is a 2,000-foot radius beyond the blast perimeter for a submerged shot. An additional 500 feet should be added to the calculated radius or exclusion zone in order to adequately control animals being precluded from this area. When underwater blasting will be conducted in a very controlled manner for a protracted period of months and has acceptable project monitoring, the project proponent may apply to the FWC and other appropriate

permitting agencies for a special review of exclusion zone criteria.

Underwater explosions can be broadly categorized as either “confined” or “open-water.” Confined shots produce much less environmental damage for the same charge weight when compared to open-water shots (Nedwell and Thandavamoorthy 1992; Hempen et al. 2005). For confined shots, the pressure waves are dominantly radiated into a stiff medium (such as rock or a massive structure founded on rock) and remain in that medium. Confined shots have vertical heights of the stiff medium exposed to water (or loose sediment below water) of less than half the smaller areal (horizontal) dimension of removal. [For example, removal of a stiff medium (rock or concrete) exposed to 8 feet of the water and sand vertically for the smaller horizontal removal dimension of 20 linear feet would safely radiate most of its energy into the stiff medium. Alternatively, removal of a concrete column with 8 feet vertically surrounded by water and mud, and a horizontal diameter of less than 16 feet, would be presumed to adversely transmit most of its energy to the water. The former example is a low-impact confined blast, while the latter is an open-water blast that may have high organism impact.] Blasting in the water column, not connected to a structure, has a high transmission of pressure waves through the water column. Blast removal of some stiff-medium structures below the water surface (e.g., columns, piers, or pilings) releases its energy directly to the surrounding water column or loose sediment, which has a high transmission of pressure waves through the water column. Underwater blasting with high transmission to the water column and, thus potentially high organism impact, shall be termed open-water blasting.

The “exclusion zone”, also referred to as the “watch zone” shall be calculated using the following methods, appropriate to the type of blasting:

Open Water Blasting

The exclusion zone for open-water blasting shall be determined from the open-water shot’s maximum charge weight per delay, with an additional buffer of 500 feet. For an open-water shot’s maximum charge weight per delay of less than 0.19 pound, the exclusion-zone radius of 300 linear feet applies. The maximum charge weight per delay of a confined shot shall not exceed 57 pounds for the exclusion-zone criterion beneath the waters of the State of Florida, because the exclusion-zone radius would be greater than 2,000 linear feet. The equation for the open-water blasting exclusion-zone radius, EZ_{OW} , for maximum charge weights per delay between 0.19 to 57 pounds is:

$$EZ_{OW} \text{ (feet)} = (520 w^{1/3})(2) + 500 \text{ feet}$$

Where w is the maximum charge weight (in pounds) per delay of an individual open-water shot.

Confined Blasting

The exclusion zone for confined blasting shall be determined from the confined shot’s maximum charge weight per delay, with an additional buffer of 500 feet. For a confined shot’s maximum charge weight per delay of less than 1.5 pound, the “exclusion zone” radius of 500

linear feet applies. The maximum charge weight per delay of an open-water shot shall not exceed 450 pounds for the exclusion-zone criterion beneath the waters of the State of Florida, because the exclusion zone radius would be greater than 2,000 linear feet. The equation for the confined blasting exclusion zone radius, EZ_C , for maximum charge weights per delay between 1.5 to 450 pounds is:

$$EZ_{OW} \text{ (feet)} = (520 w^{1/3}) + 500 \text{ feet}$$

Where w is the maximum charge weight (in pounds) per delay of an individual confined shot.

c. A record of the type of underwater blasting (open-water or confined), procedures to reduce impacts, calculations of blast parameters, actual placement of explosive agents, organism exclusion zone distance calculations, and plans for observation shall be filed on-site before every shot is fired. Records for each shot of the blasting program shall be retained by the project proponent for the duration of project and made available to the FWC, USFWS, and NMFS immediately onsite or within two business days to the specified mailing address, as requested.

The following records shall be kept for each placement position or boring: (1) - the upper and lower bounds of cemented or consolidated material to be removed or blasted; (2) - the weight of blasting agents and explosives, and their upper and lower bounds; (3) - stemming material appropriate for the size of the borehole; and (4) - upper and lower bounds of the stemming placement within the cemented or consolidated material (usually rock or concrete). The record shall include the sequence of delays from the shortest to longest individual delay time with the total weight of blasting agent at that delay time. The record keeping shall provide enough detail to allow interpretation of the quality of shooting and level of compliance with the Blasting Plan.

d. A description of the monitoring program shall be implemented to record particle velocities when a blasting position is within 1,000 feet of a land-based location. Particle velocity monitoring independently confirms proper shot performance without the cost and difficulty of either pressure-wave recording or organism testing. Reports of particle velocity monitoring should be available to the FWC, USFWS, and NMFS, if requested, on the third business day following the shot.

e. Quantitative evaluation of potential marine mammal/sea turtle (i.e., manatee feeding areas, etc.) habitat that will be destroyed by the blasting project.

3. Mitigation Plan

The project proponent shall prepare a Mitigation Plan that shall include a detailed discussion of the measures employed to avoid or minimize the adverse impacts of blasting. Keevin (1998) provides a general description of mitigation techniques that may be useful to explosives engineers. The following measures shall be included in the Mitigation Plan:

- a. Blasting shall be conducted during the time when manatees, other marine mammals, and sea turtles are least likely to be in the blasting area. Proponents should consult with the FWC, USFWS, and NMFS to determine the appropriate timing.
- b. In tidal areas, the blasting proponent shall conduct blasting during the recommended tidal phase deemed appropriate for the area (i.e., slack or low-tide conditions).
- c. The volume and length of all blasting agents, detonation cord, and explosives will be limited to the minimum necessary to conduct the work in a manner that is efficient, safe for workers, and protective of aquatic and marine organisms. Initiation of explosive charges should be conducted with the minimum length of detonation cord possible or should utilize alternative initiation systems. Detonation cord has its own impact radius (injury/kill zone) along the entire length of submerged detonation cord.
- d. All shock-tubes and detonation cord or electric wires will be recovered and removed after each blast.
- e. After loading a charge in a hole, the hole will be back-filled (stemmed) with angular stemming material. The stemming material shall be uniform, crushed, angular stone. The stemming material shall be within the range of 1/20 to 1/8 of the borehole diameter being confined. The stemming shall not be acceptable if it contains more than 10% fines (smaller than 1/20 of the hole diameter). Stemming material shall be placed a minimum vertical length of three borehole diameters above the placed charge within sound rock or concrete. A standard procedure of logging the hole and placing the explosives shall be established to resolve and verify the proper placement of stemming material.
- f. If multiple charges are required, time-delays should be used to reduce the overall detonation pressures to a series of smaller explosions. Delays shall be used to effectively develop the removal while lowering the maximum charge weight per delay to as low as reasonably achievable. Delays of less than a 9-millisecond interval shall not be counted as delays. All charges within any 9-millisecond interval shall be summed to resolve the maximum charge weight per delay for a given shot.
- g. In addition to these measures, the proponent should consider additional mitigation measures including, but not limited to the following: Deployment of barriers or coffer dams in shallow water.

4. *Endangered Species Watch Plan (WP)*

The project proponent shall prepare a WP using the guidance below to ensure that marine mammals and sea turtles are not in the exclusion zone during blasting events.

- a. A formal WP Coordination Meeting shall be held at least one (1) week prior to the first blasting event to review the WP, to discuss the responsibilities of all parties, and to review and approve the schedule of events. Personnel invited to the WP Coordination Meeting shall be contacted at least two (2) weeks prior to the first detonation event. Contacted invitees shall

include the Explosives Engineer, the observation team, FWC, USFWS, NMFS, U.S. Coast Guard, U.S. Army Corps of Engineers, and other interested parties. The agenda shall be coordinated with the FWC, USFWS, and NMFS prior to the meeting. The meeting shall include the latest information concerning the possible presence of manatee, other marine mammals, and sea turtles during blasting, the logistics of the detonation schedule, details of the aerial survey, the communications plan, and the responsibilities of all parties involved.

b. The WP shall include time tables for the endangered species observation periods (e.g., start times for aerial surveys, boat surveys, and land-based surveys), observer positions, and a copy of the WP log sheet and map to record manatee and/or sea turtle sightings.

c. The WP shall include a list of names and qualifications of the observers. Approval of the observers is at the discretion of the FWC, USFWS, and NMFS and will be made prior to the blasting event.

d. The watch crew shall consist of a minimum of a WP Coordinator, four land or boat-based observers, and one aerial observer. All observers shall have had previous experiences in observing/spotting marine mammals and sea turtles or be approved by the FWC, USFWS, and NMFS. The aerial observer shall have a minimum of 30 aerial hours of experience observing sea turtles and marine mammals, a large number of which was flying aerial surveys as a secondary observer during blasting events.

e. Observers shall follow the protocol established for the WP and shall conduct the watch in good faith and to the best of their ability.

f. Each observer shall be equipped with a two-way radio that will be dedicated exclusively to the watch. Observers will be equipped with a cell phone as a backup verbal communications system. Observers shall also be equipped with polarized sunglasses, binoculars, a red flag for backup visual communication, and a sighting log with a map to record sightings.

g. All blasting events shall be weather dependent. Climatic conditions must be suitable for optimal viewing. Slack water, low tide provides optimal viewing conditions. Blasting is prohibited if wind speeds are in excess of 10 knots, during periods of fog and heavy rain. The WP Coordinator shall determine if optimal observation conditions occur prior to initiation of the survey for each blast event.

h. All blasting events shall occur during daylight hours to ensure that optimal observation conditions occur.

i. A continuous aerial survey shall be conducted by helicopter or airplane, beginning one hour prior to the start of blasting. The survey route shall be designed in conjunction with the FWC, USFWS, and NMFS. After detonation, the aerial survey crew will make a complete survey of the blast area. The aerial survey crew shall continue surveillance of the survey areas for 30 minutes post-blast in case there is a need of aerial tracking of an injured sea turtle or marine mammal.

- j. The additional observers shall be located at predetermined positions around the blast site. These positions will be situated to provide maximum visibility of the exclusion zone and will be approved by the FWC, USFWS, and NMFS. The observers shall begin surveying the area one hour prior to the blast event and continue observing for one half hour after the blasting event.
- k. The perimeter of the exclusion zone shall be marked with brightly colored buoys and an added 300-foot radius perimeter around the exclusion zone shall be marked with white buoys for aerial reference.
- l. All of the observers shall be in close communication with the blaster in order to halt the blast event, if the need arises. The event shall be halted (delayed), if a marine mammal or sea turtle is spotted within 300 feet of the perimeter of the exclusion zone. If a marine mammal or sea turtle is observed swimming in the direction of the blast zone and their arrival time is projected to coincide with the blast, the blasting event shall be halted. The blasting event shall be halted immediately upon the request of any observer. The blast shall not take place until the animal(s) move out of the area under its own volition. Animals shall not be herded away or harassed into leaving. If the animal(s) is not sighted a second time, the blasting shall not resume until 30 minutes after the initial sighting.
- m. If an injured or dead marine mammal or sea turtle is sighted after the blasting event, the WP Coordinator shall contact the FWC through their Hotline at 1-888-404-FWCC, the NOAA Fisheries Service's Southeast Regional Hotline at 305-862-2850. Notification shall also be given to the FWC Imperiled Species Management Section at 850-922-4330, and the USFWS at the Jacksonville Ecological Services Office at 904-232-2580 (if the project is located in north Florida), or the Vero Beach Field Office at 772-562-3909 (if in south Florida).
- n. If there are any problems encountered during blasting, the problems shall be evaluated by the observers and explosives engineer. Logistical solutions will be presented to the FWC, USFWS, and NMFS for their approval. Corrections to the WP shall be made prior to the next blasting event.
- o. Within two (2) weeks after completion of all the blasting events, the WP Coordinator will submit a summary report to the FWC, USFWS, and NMFS. The report shall include the observer logs, provide the names of the observers and their positions during the event, the number and location of manatee, other marine mammals, and sea turtles sighted and the actions that were taken when the animals were observed. The report shall reference the appropriate permit or other authorization numbers.

REFERENCES

- Duronslet, M. J., C. W. Caillouet, S. Manzella, K. W. Indelicato, C. T. Fontaine, D. B. Revera, T. Williams, and D. Boss. 1986. The effects of an underwater explosion on the sea turtles *Lepidochelys kempi* and *Caretta caretta* with observations of effects on other marine organisms. Unpublished report submitted to National Marine Fisheries Service Biological Laboratory, Galveston, Texas.
- Fitch, J. E., and P. H. Young. 1948. Use and effect of explosives in California waters. *California Fish and Game* 34:53-70.
- Gitschlag, G. R. 1990. Sea turtle monitoring at offshore oil and gas platforms. Pp. 223-246. *In: Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation*, T. H. Richardson, J. I. Richardson, and M. Donnelly (compiles). NOAA Technical Memorandum NMFS-SEFC-278.
- Gitschlag, G. R., and B. A. Herczeg. 1994. Sea turtle observations at explosive removals of energy structures. *Marine Fisheries Review* 56:1-8.
- Gitschlag, G. R., and M. Renaud. 1989. Sea turtles and the explosive removal of offshore oil and gas structures. Pp. 67-68 in *Proceedings of the 9th Annual Workshop on Sea Turtle Conservation and Biology*, S. A. Eckert, K.L. Eckert, and T. H. Richardson (compilers). NOAA Technical Memorandum NMFS-SEFC-232.
- Hanson, H. F. 1954. Hair seal control program: Copper River and Bering Sea areas. 1954 Annual Report to Alaska Department of Fisheries (Mimeo). [Cited in Wright 1982]
- Hempen, G. L., T. M. Keevin, and H. J. Ruben. 2005. Underwater blast pressures from confined rock removal shots: The Kill Van Kull Deepening Project. *In: Proceedings of the Thirty-first Annual Conference on Explosives and Blasting Technique*, Orlando, Florida. International Society of Explosive Engineers, Cleveland, OH. 11 pp.
- Keevin, T. M. 1998. A review of natural resource agency recommendations for mitigating the impacts of underwater blasting. *Reviews in Fisheries Science* 6:281-313.
- Keevin, T. M., and G. L. Hempen. 1997. The environmental effects of underwater explosions with methods to mitigate impacts. U.S. Department of Defense Legacy Report, U. S. Army Corps of Engineers, St. Louis District. 145 pp. <http://www.denix.osd.mil/denix/Public/ES-Programs/Conservation/WaterX/water1.html>
- Ketten, D. R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Pp. 391-407. *In: Sensory Systems of Aquatic Mammals*, R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall (editors). De Spil Publishers, Woerden, The Netherlands.

Klima, E. F., G. R. Gitschlag, and M. L. Renaud. 1988. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. *Marine Fisheries Review* 50:33-42.

Lewis, J. A. 1996. Effects of underwater explosions on life in the sea. DSTO-GD-0080. Melbourne, Australia.

Nedwell, J. R., and T. S. Thandavamoorthy. 1992. The waterborne pressure wave from buried explosive charges: An experimental investigation. *Applied Acoustics* 37:1-14.

O'Keeffe, D. J., and G. A. Young. 1984. Handbook on the environmental effects of underwater explosions. NSWC TR 83-240. Naval Surface Weapons Center, Dahlgren, VA.

Reiter, G. A. 1981. Cold weather response F/V Ryuyo Maru No. 2 St. Paul, Pribiloff Islands, Alaska. Pp. 227-231. *In: Proceeding of the 1981 Oil Spill Conference*. American Petroleum Institute Publication 4334, Washington, D. C.

Wright, R. A. 1971. Effects of underwater overpressures on sea otters and other aquatic animals. Amchitka Bioenvironmental Program. U.S. Atomic Energy Commission Final Report Contract No. AT (26-1).

Wright, D. G. 1982. A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Science 1052:v + 16 pp.