FINAL ENVIRONMENTAL IMPACT STATEMENT

SHOCK TESTING THE SEAWOLF SUBMARINE

MAY 1998

DEPARTMENT OF THE NAVY

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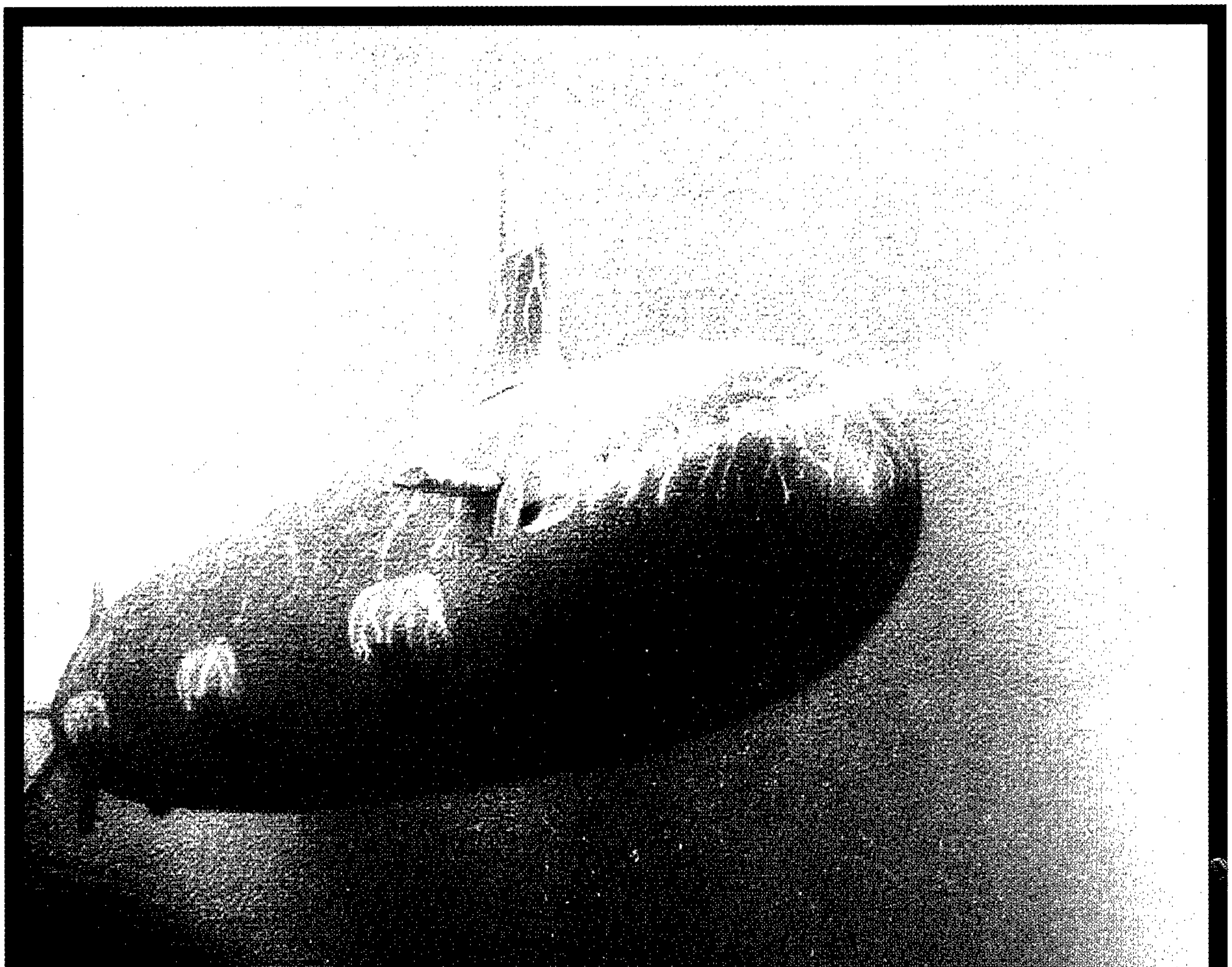

DTIC QUALITY INSPECTED 3

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SHOCK TESTING THE SEAWOLF SUBMARINE

Department of the Navy
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DTIC QUALITY INSPECTED 3

RESPONSIBLE AGENCIES:

Department of the Navy (lead agency)
National Marine Fisheries Service (cooperating agency)

PROPOSED ACTION AND GEOGRAPHIC LOCATION:

Shock Testing the SEAWOLF Submarine
Offshore Mayport, Florida or Norfolk, Virginia

CONTACT FOR FURTHER INFORMATION:

Attn: Mr. Will Sloger (Code 064WS)
Department of the Navy
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406
Telephone: (803) 820-5797

TYPE OF REPORT:

Final Environmental Impact Statement (FEIS)

ABSTRACT:

This FEIS evaluates the environmental consequences of shock testing the SEAWOLF submarine at an offshore location. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity sometime between 1 April and 30 September 2000. The FEIS evaluates a "no action" alternative and analyzes in detail two alternative areas offshore of Mayport, Florida and Norfolk, Virginia. Alternatives are compared with respect to project purpose and need, operational criteria, and environmental impacts. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the area. Using 1995 survey data from both areas as the most appropriate basis for comparison, the risk of mortality and injury of marine mammals is about 5 to 7 times lower at Mayport than at Norfolk, whereas the risk to sea turtles is about the same at the two areas. Thus, the preferred alternative is to shock test the SEAWOLF offshore of Mayport, Florida, with mitigation to minimize risk to marine mammals and turtles. If the Mayport area is selected, the shock tests would be conducted between 1 May and 30 September to minimize risk to sea turtles, which may be more abundant there during April.

EXECUTIVE SUMMARY

This document is a Final Environmental Impact Statement (FEIS) for shock testing the SEAWOLF submarine. The FEIS was prepared in accordance with Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions;" the National Environmental Policy Act (NEPA) of 1969; the regulations implementing NEPA issued by the Council on Environmental Quality (CEQ), 40 Code of Federal Regulations (CFR) Parts 1500-1508; and Navy regulations implementing NEPA procedures (32 CFR 775). The Department of the Navy is the lead agency and the National Marine Fisheries Service (NMFS) is a cooperating agency for the FEIS.

PROPOSED ACTION

The proposed action is to shock test the SEAWOLF submarine at an offshore location. The FEIS analyzes in detail alternative areas offshore of Mayport, Florida and Norfolk, Virginia. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations sometime between 1 April and 30 September 2000. If the Mayport area (the preferred alternative) is selected, the shock tests would be conducted between 1 May and 30 September 2000 to minimize risk to sea turtles, which may be more abundant at the Mayport area during April. The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the next detonation.

PURPOSE AND NEED

The USS SEAWOLF is the first of a new class of submarines being acquired by the Navy. The class consists of three submarines, with the second and third currently under construction. SEAWOLF class submarines are the largest and most capable fast attack submarines in the fleet. Features include reduced acoustic and electromagnetic signatures, improved speed, greater maximum operating depth, greater ordnance capacity, and other technological improvements reflecting the state-of-the-art in submarine design.

In accordance with Section 2366, Title 10, United States Code (10 USC 2366), a covered system, such as a submarine, cannot proceed beyond initial production until realistic survivability testing of the system is completed. Realistic survivability testing means testing for the vulnerability of the system in combat by firing munitions likely to be encountered in combat with the system configured for combat. This testing is commonly referred to as "Live Fire Test & Evaluation" (LFT&E). The Navy has established a LFT&E program to complete the survivability testing of SEAWOLF Class submarines as required by 10 USC 2366. The SEAWOLF LFT&E program includes a ship shock test. A ship shock test is a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. Shock tests simulate near misses from underwater explosions similar to those encountered in combat.

The purpose of the project is to shock test the USS SEAWOLF so that the resultant data can be used to assess the survivability of the submarine. This project is needed because computer modeling and component testing on machines or in surrogates does not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. Only by testing the manned submarine with the appropriate systems operating can an adequate assessment of the survivability of the ship be determined in accordance with 10 USC 2366. Shock tests have proven their value as recently as the Persian Gulf War when ships were able to survive battle damage and continue their mission because of ship design, crew training, and survivability lessons learned during previous shock tests.

The SEAWOLF was christened in June 1995 and delivered to the Navy in the spring of 1997. Because of the long series of at-sea testing that must be completed first, shock testing did not occur in 1997 as originally planned. Therefore, the Navy has rescheduled the shock test for the spring/summer of 2000. Shock testing must be completed and the ship must be thoroughly inspected prior to its release for unrestricted operations.

The delay of the SEAWOLF shock test from 1997 to 2000 does not change the environmental analysis provided in the FEIS. The impacts identified and the mitigation developed are based on the time of the year that the test is conducted, and no impacts have been identified that are variable other than seasonally each year. Therefore, the methodology for determining impacts remains valid and the Navy has decided to issue the FEIS even though the planned year of the test has changed. During 1997, the Navy conducted additional aerial surveys of the Mayport area to further confirm and validate the marine mammal and sea turtle population density data obtained during the 1995 aerial surveys. These additional data have been incorporated into the FEIS.

ALTERNATIVES

The FEIS evaluates a "no action" alternative and alternative areas for the proposed shock testing. Alternative offshore areas for shock testing are compared from operational and environmental perspectives. A preferred alternative has been identified based on these comparisons.

No Action

Under the "no action" alternative, no new activities affecting the physical environment would be conducted to predict the response of SEAWOLF class submarines to underwater detonations. This alternative would avoid all environmental impacts of shock testing.

As described in Section 1.1 of the FEIS, the Navy has established a Live Fire Test and Evaluation (LFT&E) program to complete the survivability testing of the SEAWOLF class submarines. The program consists of three major areas that together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. The SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Only by testing a manned ship with the appropriate systems operating can the shock response of the entire ship, including the interaction of ship systems and components, be obtained and an adequate assessment of the survivability of the submarine be determined in accordance with 10 USC 2366. The intent of 10 USC 2366 is to ensure that the combat survivability of the weapon system (submarine) is assessed before the system is exposed to hostile fire. The information obtained during the shock test is used to improve the shock resistance of the ship and therefore reduce the risk of injury to the crew. The "no action" alternative would prevent the Navy from being able to make the survivability assessment required by 10 USC 2366.

As the "no action" alternative involves no activity affecting the physical environment, it is not individually analyzed further in the FEIS. The "no action" alternative is implicit in the environmental analysis throughout the document. The Existing Environment section provides a "no action" benchmark against which the proposed action can be evaluated. The Environmental Consequences section compares impacts of an action (shock testing) with the alternative of "no action."

Alternative Areas for the Proposed Action

The remaining alternative discussed is the proposed action, which is to shock test the SEAWOLF at an offshore location. Several possible general areas for shock testing were evaluated by the Navy, as described below. The Navy has identified the general offshore areas that meet certain operational criteria, and has identified a preferred area. The final specific shock test site, within a particular area, would not be selected until 2 to 3 days before the test based on marine mammal and turtle surveys (see Mitigation).

Operational Requirements

Alternative areas for shock testing the SEAWOLF were evaluated by the Navy according to operational criteria. A location on the East Coast would best meet the Navy's operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. A suitable area must have a water depth of 152 m (500 ft) and be within a reasonable distance of required Navy facilities (Naval Station support facility, submarine repair facility, ordnance storage/loading facility, and supporting ships and aircraft). Calm seas and good visibility are needed, and there must be little or no ship traffic in the area.

Five East Coast areas were identified that could potentially meet the Navy's operational requirements: Mayport, Florida; Norfolk, Virginia; Groton, Connecticut; Charleston, South Carolina; and Key West, Florida. Charleston was eliminated because of the closure of the Charleston Navy Yard and Charleston Naval Station under the Base Closure and Realignment (BRAC) process (i.e., facilities and vessels to support the test would not be available). The water depth at the Key West area is too great for the planned shock testing. In addition, the Key West area lacks the industrial base to support submarine repairs or drydocking, and there is no surface vessel homeport nearby that could provide Navy assets (ships and planes) to support the test. The three remaining areas (Mayport, Norfolk, and Groton) were compared with respect to operational criteria. The analysis showed that only the Mayport and Norfolk areas meet all of the Navy's operational requirements and that these two areas are rated as nearly equal. Thus only the Mayport and Norfolk areas are included in the detailed environmental analysis in the FEIS.

Environmental Considerations

At both the Mayport and Norfolk areas, possible test sites were first defined as any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species. Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as summarized below.

At the Mayport area, there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing locations.

At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks near the area. Four points within 1.85 km (1 nmi) of the area were identified as potential hard bottom and were excluded as test sites. All remaining points along the 152 m (500 ft) depth contour are considered potential shock testing sites.

Comparison of Alternatives

Table ES-1 summarizes the analysis of alternatives with respect to project purpose and need, operational criteria, and environmental impacts. As discussed above, the "no action" alternative (including computer modeling and component testing) is not a reasonable alternative because it would not provide the information and data necessary to support an assessment of the survivability of the ship in accordance with 10 USC 2366. Operational comparison of alternative areas for shock testing showed that the Mayport and Norfolk areas meet all of the Navy's operational requirements and are rated as nearly equal.

Potential environmental impacts of shock testing at the Mayport and Norfolk alternative areas are compared in **Table ES-2** and discussed below under Environmental Consequences. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the area. However, the two areas differ significantly with respect to potential impacts on marine mammals and sea turtles. The most significant environmental difference between the areas is the much lower risk of impacts to marine mammals at the Mayport area. Using 1995 survey data from both areas as the most appropriate basis for comparison, the risk of mortality and injury of marine mammals is about 5 to 7 times lower at Mayport than at Norfolk, whereas the risk to sea turtles is about the same at the two areas. This comparison strongly favors

Table ES-1 Summary of alternatives analysis.

Basis for Comparison	Alternative: **No Action** (Includes Maximum Reasonable Amount of Computer Modeling and Component Testing)	Alternative: **Shock Testing at an Offshore Location** – Groton Area	Alternative: **Shock Testing at an Offshore Location** – Mayport Area	Alternative: **Shock Testing at an Offshore Location** – Norfolk Area
Meets project purpose and need	No	Yes	Yes	Yes
Meets operational criteria	No further analysis (alternative does not meet project purpose and need)	No	Yes	Yes
Environmental impacts - General	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Most environmental impacts similar at the two areas (**see Table ES-2**)	
- Marine mammals	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Mayport has about 5 to 7 times lower risk of marine mammal death or injury [a]	
- Sea turtles	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	About the same risk of sea turtle death or injury at both areas [a]	

[a] Relative risk based on Table 2-6, using 1995 survey data from both areas as the most appropriate basis for comparison. If additional survey data from Mayport in 1997 are compared with Norfolk 1995 data, the risk to marine mammals would be 3.5 to 5 times lower at Mayport than at Norfolk, and the risk to sea turtles would be about 2 times lower at Norfolk than at Mayport.

Table ES-2. Comparison of potential environmental impacts of shock testing at the Mayport and Norfolk areas.

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
		IMPACTS EVALUATED UNDER NEPA [a] (impacts onshore and within U.S. territorial seas)	
Physical Environment	4.1.1	No significant direct or indirect impacts on geology and sediments, air quality and noise, or water quality.	Mayport and Norfolk similar.
Biological Environment	4.1.2	No significant direct or indirect impacts on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds.	Mayport and Norfolk similar.
Socioeconomic Environment	4.1.3	No significant direct or indirect impacts on the local economy, including ship traffic and the fishing and tourism industries.	Mayport and Norfolk similar.
		IMPACTS EVALUATED UNDER EXECUTIVE ORDER 12114 (impacts outside U.S. territorial seas)	
Physical Environment			
Geology and sediments	4.2.1.1	Metal fragments will be deposited on the seafloor. No cratering or sediment disturbance expected.	Mayport and Norfolk similar.
Air quality	4.2.1.2	Temporary, localized increase in concentrations of explosion products in the atmosphere. No hazard to marine or human life.	Mayport and Norfolk similar.
Water quality	4.2.1.3	Temporary, localized increase in concentrations of explosion products in the ocean. No hazard to marine life.	Mayport and Norfolk similar.

Table ES-2. (Continued).

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
Biological Environment			
Plankton	4.2.2.1	Plankton near the detonation point would be killed, but populations would be rapidly replenished through reproduction and mixing with adjacent waters.	Mayport and Norfolk similar.
Fish	4.2.2.2	Pelagic (water column) fish near the detonation point may be killed or injured. Many of the same species occur at both areas. Demersal (bottom) fish will not be affected.	Mayport and Norfolk similar.
Marine mammals	4.2.2.3	Mitigation will minimize risk, but marine mammals could be killed or injured if not detected within the Safety Range. At greater distances, animals may experience brief acoustic harassment, with negligible effects on marine mammal individuals and populations.	About 5 to 7 times lower risk of marine mammal death or injury at Mayport.[b]
Sea turtles	4.2.2.4	Mitigation will minimize risk, but turtles could be killed or injured if not detected within the Safety Range. At greater distances, turtles may experience brief acoustic harassment, with negligible effects on sea turtle individuals and populations.	About the same risk of sea turtle death or injury at both areas.[b]
Benthos	4.2.2.5	No direct effect on benthic organisms is expected. No habitat disturbance is expected. Metal fragments deposited on the seafloor will be colonized by invertebrates and attract fish.	Mayport and Norfolk similar.
Seabirds	4.2.2.6	Seabirds above the detonation point could be killed or stunned by the plume of water ejected into the air. Other seabirds resting or feeding at the surface could be killed or injured by the shock wave. It is unlikely that more than a few birds would be affected.	Mayport and Norfolk similar.

Table ES-2. (Continued).

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
Socioeconomic Environment			
Commercial and recreational fisheries	4.2.3.1	Individuals of commercial or recreational fishery species may be killed or injured, but no significant impact on fishery stocks is expected. Commercial and recreational fishing activities within 18.5 km (10 nmi) of the detonation point will be temporarily interrupted.	Mayport and Norfolk similar.
Ship traffic	4.2.3.2	Ship traffic passing within 18.5 km (10 nmi) of the detonation point would need to alter course or be escorted from the area.	Mayport and Norfolk similar.

[a] Shore support operations and movement of vessels and aircraft within territorial seas are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

[b] Relative risk based on Table 2-6, using 1995 survey data from both areas as the most appropriate basis for comparison. If additional survey data from Mayport in 1997 are compared with Norfolk 1995 data, the relative risk to marine mammals would be 3.5 to 5 times lower at Mayport than at Norfolk, and the risk to sea turtles would be about 2 times lower at Norfolk than at Mayport.

Mayport as the preferred alternative. If the additional survey data collected at Mayport in 1997 are compared with 1995 Norfolk data, the risk of marine mammal mortality and injury would be 3.5 to 5 times lower at Mayport, but the risk to sea turtles would be 2 times lower at Norfolk. This comparison also indicates that Mayport has the lowest overall risk of significant environmental impacts. Considering all components of the physical, biological, and socioeconomic environment, potential impacts would be less at the Mayport area.

Preferred Alternative

The preferred alternative is to shock test the SEAWOLF submarine offshore of Mayport, Florida, between 1 May and 30 September with mitigation to minimize risk to marine mammals and turtles. This alternative meets the project purpose and need, satisfies operational criteria, and minimizes environmental impacts. The Norfolk area also meets the project purpose and need and satisfies operational criteria; however, the higher density of marine mammals in the area could increase the risk of impacts.

ENVIRONMENTAL CONSEQUENCES

Impact discussions in the Environmental Consequences section are divided into separate subsections to distinguish between those aspects of the proposed action evaluated under NEPA and those evaluated under Executive Order 12114. NEPA applies to activities and impacts within U.S. territory, whereas Executive Order 12114 applies to activities and impacts outside territorial seas. The proposed action includes operations that would occur both within and outside U.S. territory. Shock testing and associated mitigation operations would occur at least 87 km (47 nmi) offshore at the Mayport area or 54 km (29 nmi) at the Norfolk area, well outside U.S. territorial seas. No impacts from the actual test (detonation of explosives) would occur in U.S. territory. The only operations that would occur within territorial limits are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing site). These shore support activities and vessel and aircraft movements are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Under the NEPA evaluation, no significant direct or indirect impacts are expected at either Mayport or Norfolk; therefore, the rest of this discussion focuses on impacts evaluated under Executive Order 12114.

The proposed action involves underwater detonations that would produce a shock wave and noise, release chemical products into the ocean and atmosphere, and deposit metal fragments on the seafloor. During each test, there would be increased vessel traffic, including ships and aircraft monitoring for marine mammals and turtles. Routine ship traffic (including commercial and recreational fishing vessels) would be temporarily excluded from the test area.

Underwater explosions would release chemical products into the ocean and atmosphere and deposit metal fragments on the seafloor. Due to the low initial concentrations and rapid dispersion of the chemical products, they would pose no hazard to marine or human life. Predicted atmospheric concentrations are well below human safety standards within

305 m (1,000 ft) downwind. Predicted concentrations in the surface pool above the detonation point are below water quality criteria. The small metal fragments would gradually corrode but are not expected to produce significant adverse impacts on the seafloor; they would provide a substrate for growth of epibiota and attract fish.

Fish and other small marine life near the detonation point would be killed or injured by the shock wave. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Mitigation). Small pelagic fish with swimbladders (e.g., dwarf herring, round scad, Atlantic menhaden, and chub mackerel) are the ones most likely to be affected if present within about 1,400 m (4,600 ft) of the detonation point. Larger pelagic fish such as billfish, dolphinfish, tunas, and wahoo may be affected within a radius of about 762 m (2,500 ft). Fish without a swimbladder (e.g., sharks) are unlikely to be affected unless they are within about 22 m (73 ft) of the detonation point. Although individual fish would be killed and injured, no impact on fish populations is expected because the species found at the Mayport and Norfolk areas are abundant and widely distributed. Other small marine life such as plankton would also be affected but would be rapidly replenished through population growth and mixing with adjacent waters. Because benthic and demersal organisms would experience only the direct, positive pressure wave and reflections from the bottom, bottom dwelling fish and invertebrates are unlikely to be affected at either area.

Potentially significant impacts on marine mammals include mortality, injury, and acoustic harassment. The mortality criterion used in the FEIS is the onset of extensive lung hemorrhage. The injury criterion is 50% probability of eardrum rupture. Although eardrum rupture *per se* is not a serious or life threatening injury, it is a standard and useful indicator of potential injuries to marine mammals. The acoustic harassment criterion is temporary threshold shift (TTS). TTS is a change in the threshold of hearing (the quietest sound that the animal can hear), which could temporarily affect an animal's ability to hear calls, echolocation sounds, and other ambient sounds.

Marine mammals could be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Marine mammals at greater distances may experience acoustic harassment. At either Mayport or Norfolk, mitigation would result in selection of a small test site with very low densities of marine mammals (see Mitigation). In addition, pre-detonation aerial surveys, surface observations, and passive acoustic monitoring would be used to minimize the risk of death or injury. Mitigation would be about equally effective at either area (estimated to be 93%). However, because of the large difference in marine mammal densities between areas, the risk of a marine mammal being killed or injured would be significantly lower at Mayport than at Norfolk. The 1995 aerial survey data from both areas are the most appropriate basis for comparing estimated impacts, because data are available from both Mayport and Norfolk during the same time period. Based on these data, maximum potential impacts from five detonations at Mayport are estimated to be 1 mortality, 1 injury, and 1,247 marine mammals experiencing acoustic harassment. Maximum potential impacts from five detonations at the Norfolk area are 5 mortalities, 7 injuries, and 7,805 acoustic harassments. Therefore, the potential for mortality, injury, and acoustic harassment is about 5 to 7 times lower at Mayport than at Norfolk. If the 1997 Mayport survey data were used for the calculations, the estimates would be 1 mortality, 2 injuries, and 1,788 marine mammal acoustic harassments, which would be 3.5 to 5 times lower than at Norfolk.

Potentially significant impacts on sea turtles could include mortality, injury, and acoustic harassment. In the FEIS, the same criteria developed for marine mammals were used to estimate potential impacts on sea turtles. At either Mayport or Norfolk, mitigation would result in selection of a small test site with very low densities of sea turtles. However, mitigation would be much less effective for sea turtles than for marine mammals because adult sea turtles are relatively small, do not swim in groups, are rarely on the surface, and do not make sounds. At either Mayport or Norfolk, mitigation effectiveness is estimated to be about 8%. Loggerhead turtles make up most of the population at both areas and are the species most likely to be affected. Juvenile and hatchling sea turtles are unlikely to be affected because detonation would be postponed if large sargassum rafts (the preferred habitat of these turtles) were present within the Safety Range.

The 1995 aerial survey data are the most appropriate basis for comparing estimated sea turtle impacts, because data are available from both Mayport and Norfolk during the same time period. Based on these data, maximum potential impacts from five detonations at Mayport are estimated to be 4 mortalities, 6 injuries, and 652 turtles experiencing acoustic harassment. Estimated maximum impacts from five detonations at Norfolk are 4 mortalities, 6 injuries, and 468 turtles experiencing acoustic harassment. Therefore, the potential for sea turtle mortality and injury is about the same at either Mayport or Norfolk. If the 1997 Mayport data were used for the calculations, the estimates would be 8 mortalities, 14 injuries, and 1,679 acoustic harassments, which would be twice the number of turtle mortalities and injuries as Norfolk and about 3.6 times more acoustic harassments than Norfolk.

A few seabirds (if present on the water surface or in the air immediately above the detonation point) could be killed or stunned by the plume of water ejected into the air. As part of the mitigation plan, the Navy would postpone detonation if flocks of seabirds were sighted within 1.85 km (1 nmi) of the detonation point. This would avoid any large mortality of seabirds. The U.S. Fish and Wildlife Service has concluded that there are no endangered or threatened bird species or critical habitat that would be adversely affected by the proposed action (see Appendix G).

Fishing vessels and other ships and aircraft would be excluded from an area of 9.3 km (5 nmi) radius during each shock test. Ships within a 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the area. The most common fishing activities at both areas are surface and bottom longlining and trolling. Due to the short duration of the tests and advance warning through *Notices to Airmen and Mariners*, the interruption is not expected to significantly affect commercial or recreational fisheries or other ship traffic at either Mayport or Norfolk.

MITIGATION

Mitigation, as defined by the Council on Environmental Quality, includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. The proposed action includes mitigation designed to minimize risk to marine mammals and turtles. The main mitigation measures include (1) a schedule shift at Mayport (no testing in April to avoid higher densities of sea turtles); and (2) a detailed marine mammal and sea turtle mitigation plan that includes test area selection and pre- and post-detonation monitoring. The marine mammal and sea turtle mitigation plan is summarized below and described in detail in Section 5.0 of the FEIS. Other mitigation measures described in the FEIS include environmental buffer zones to avoid impacts to certain environmental features; an exclusion zone to avoid impacts to routine vessel and air traffic; and measures to deal with unexploded ordnance in the unlikely event of a misfire.

Schedule Shift to Avoid High Turtle Densities at Mayport

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September 2000. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are believed to be highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. Because there was no April survey in 1997, the high turtle numbers seen during April 1995 could not be confirmed. However, based on the 1995 data and the likely concentration of loggerheads in offshore waters prior to the nesting season, exclusion of April from the test schedule at Mayport is considered a reasonable precaution. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

Marine Mammal and Sea Turtle Mitigation Plan

A detailed Marine Mammal and Sea Turtle Protection/Mitigation Plan is presented in Section 5.0. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994. Those shock trial operations included two 4,536 kg (10,000 lb) detonations and no deaths or injuries of marine mammals were detected.

The mitigation plan represents the final step in a sequence of actions to avoid or reduce environmental impacts. The Mayport and Norfolk areas were initially selected based on the Navy's operational requirements. Then, portions of the Norfolk area were excluded based on environmental considerations, as noted above. The schedule for testing at Mayport was shifted to avoid high turtle densities that may occur during April. Finally, the results of impact analysis in the Environmental Consequences section were used to identify a preferred alternative area (Mayport) based on the lower density of marine mammals.

The mitigation plan would build upon these previous efforts to avoid or reduce environmental impacts. The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large sargassum rafts or jellyfish concentrations (both are indicators that turtles may be present), large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation or if any marine mammals or turtles were detected in the Safety Range following a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary. Communications with stranding network personnel would be maintained throughout the SEAWOLF shock test period.

The concept of a ***Safety Range*** is integral to the mitigation plan. Detonation would be postponed if marine mammals or turtles were detected within the Safety Range radius of 3.7 km (2 nmi) around the detonation point. The radius of the Safety Range is based on the maximum distance for non-lethal injury to a marine mammal and is more than twice the maximum distance for lethality to marine mammals and turtles. A 1.85 km (1 nmi) ***Buffer Zone*** has also been added to the Safety Range to accommodate the possible movement of animals into the Safety Range. That is, the area encompassed within a 5.6 km (3 nmi) radius from the detonation point would be monitored in an effort to detect any marine mammals or turtles approaching the Safety Range.

The mitigation plan includes three components: (1) aerial surveys/monitoring; (2) shipboard monitoring from the operations vessel and the Marine Animal Recovery Team (MART) vessel; and (3) passive acoustic monitoring using the Marine Mammal Acoustic Tracking System (MMATS). Aerial and shipboard monitoring teams would identify and locate animals on the surface, whereas the acoustic monitoring team would detect and locate calls from submerged marine mammals. This combination of monitoring components would be used to detect marine mammals or turtles within the Safety Range and to minimize the risk of impacts to these animals.

PUBLIC INVOLVEMENT AND CHANGES TO THE EIS

The preparation of an Environmental Impact Statement provides three main opportunities for public involvement. First, there is "scoping," the early and open process for identifying issues to be addressed in the Draft Environmental Impact Statement (DEIS). To begin the scoping process for this EIS, a Notice of Intent was published in the *Federal Register* and five local newspapers (*Washington Post*, *Virginian Pilot*, *Florida Times Union*, *Beaches Leader*, and *Southeast Georgian*) during March 1995. It was also sent to federal, state, and local elected officials and agency representatives, and other interested parties. Three public scoping meetings were held during March 1995 to explain the project and allow the public to voice their concerns. In addition to the comments received during the public meetings, 13 written responses were received by the end of the comment period on 1 May 1995. The public meeting and written comments were reviewed to make sure that all issues would be addressed in the DEIS.

The second major opportunity for public participation came when the Navy distributed the DEIS to interested persons for review and comment (see Appendix A for the distribution list). The notice of availability for the DEIS was published in the Federal Register on June 14, 1996 (61 FR 30232). The public review period originally ended on July 31, 1996, but was subsequently reopened and extended to September 17, 1996. The Navy hosted three public hearings in Silver Spring, Maryland; Norfolk, Virginia; and Atlantic Beach, Florida to receive oral and written comments on the DEIS. In addition to the public hearing comments, 22 sets of written comments were received from federal, state, and local agencies, as well as several organizations and individuals. All oral and written comments are addressed in Appendix H of the FEIS.

Significant changes to the EIS in response to public comments are summarized in **Table ES-3**. In particular, the FEIS includes numerous improvements to the Marine Mammal and Sea Turtle Mitigation Plan that further reduce the risk of impacts to these animals.

A third opportunity for public input is the 30-day public review period following publication of the notice of availability for the FEIS. The Navy has distributed the FEIS to interested persons (including all DEIS commenters) for review. After closure of the public review period, the Navy will issue its Record of Decision (ROD) for publication in the Federal Register.

COORDINATION AND CONSULTATION WITH THE NMFS

The NMFS has two regulatory roles in the SEAWOLF project. First, the NMFS is responsible for administering the Endangered Species Act as it applies to sea turtles and most marine mammals. The DEIS served as a Biological Assessment which the Navy submitted to the NMFS, requesting formal consultation under Section 7 of the Endangered Species Act. The NMFS subsequently issued a Biological Opinion, which is included in Appendix G of the FEIS.

The NMFS also has a regulatory role under the Marine Mammal Protection Act. When the DEIS was published, the Navy submitted a separate application to the NMFS for an "incidental take authorization" under section 101(a)(5)(A) of the Marine Mammal Protection Act. The NMFS published a Proposed Rule in the Federal Register on August 2, 1996 (61 FR 40377) and participated in joint public hearings to receive comments. The Proposed Rule specifies mitigation, monitoring, and reporting requirements for SEAWOLF shock testing. A Final Rule must be issued before shock testing can proceed.

As noted above, the NMFS is also a cooperating agency with the Navy in preparing the EIS. Because of its regulatory responsibilities under the Endangered Species Act and the Marine Mammal Protection Act, the NMFS limited its role in preparation of the EIS to providing review and comment. A formal comment letter from the agency is included among the DEIS comments addressed in Appendix H.

Table ES-3. Summary of significant changes to the SEAWOLF Environmental Impact Statement in response to public comments.

MITIGATION (Section 5.0)

- Changed mitigation aircraft to Partenavia (or equivalent), which provides a "belly" window for a third aerial observer. Increases likelihood of detecting marine mammals and turtles.
- Tightened line-spacing of pre-detonation aerial monitoring transects to 0.25 nmi (instead of 1 nmi). Increases likelihood of detecting marine mammals and turtles.
- Agreed to postpone detonation if large sargassum rafts are present within the safety range. Protects juvenile and hatchling turtles associated with sargassum.
- Agreed to avoid sargassum-rich areas to the extent possible during site selection. Protects juvenile and hatchling turtles associated with sargassum.
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- Agreed to avoid the western wall of the Gulf Stream during site selection. Protects aggregations of sea turtles.
- Refined acceptable weather criteria. Ensures that conditions are acceptable for detecting marine mammals and turtles.
- Developed species-specific postponement criteria for animals present in the buffer zone, based on their dive durations. Provides additional protection for deep-diving species (such as sperm whales and beaked whales). Also, if a northern right whale were sighted, detonation would be postponed until the animal was positively determined to be outside the buffer zone and at least one additional aerial survey of the safety range and buffer zone showed that no other right whales are present.
- Extended post-detonation monitoring to continue for seven days after the last detonation. Increases the likelihood of detecting marine mammals or turtles affected by detonations.
- Expanded description of plans to coordinate with stranding networks.

OTHER CHANGES:

- Incorporated newly available data on temporary threshold shift in bottlenose dolphins (the first such auditory data available for a marine mammal) (Appendix E).
- Incorporated additional aerial survey data for marine mammals and turtles at the Mayport area (Section 3.0 and Appendix B).
- Provided more information about variability in marine mammal and turtle densities (Section 3.0 and Appendix B).
- Provided more information about sound source characteristics for the detonations (Section 4.0 and Appendix E).
- Discussed the relationship between marine mammal acoustic impacts and harassment (as defined in the 1994 amendments to the Marine Mammal Protection Act).
- Reviewed additional literature to support "detection factors" used to calculate marine mammal and turtle densities and impacts (Appendix B).
- Reviewed additional literature on underwater explosion effects on sea turtles (Appendix D).

FINAL ENVIRONMENTAL IMPACT STATEMENT
SHOCK TESTING THE SEAWOLF SUBMARINE

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Acronyms and Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
BRAC	Base Closure and Realignment
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CL	Ceiling concentration
DEIS	Draft Environmental Impact Statement
DOI	Department of the Interior
EPA	Environmental Protection Agency
FEIS	Final Environmental Impact Statement
GPS	Global Positioning System
HBX	High Blast eXplosive
LFT&E	Live Fire Test & Evaluation
MART	Marine Animal Recovery Team
MBTA	Migratory Bird Treaty Act
MMATS	Marine Mammal Acoustic Tracking System
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSSN	New Attack Submarine
OPNAVINST	Chief of Naval Operations Instruction
OSHA	Occupational Safety and Health Administration
OTC	Officer in Tactical Command
PERSTEMPO	Personnel Tempo (Navy regulations)
PTS	Permanent threshold shift
ROD	Record of Decision
STEL	Short-term exposure limit
TTS	Temporary threshold shift
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

This document is a Final Environmental Impact Statement (FEIS) for shock testing the SEAWOLF submarine. The Department of the Navy is the lead agency and the National Marine Fisheries Service (NMFS) is a cooperating agency for the FEIS.

1.1 BACKGROUND

The USS SEAWOLF is the first of a new class of submarines being acquired by the Navy. The class consists of three submarines, with the second and third currently under construction. SEAWOLF class submarines are the largest and most capable fast attack submarines in the fleet. Features include reduced acoustic and electromagnetic signatures, improved speed, greater maximum operating depth, greater ordnance capacity, and other technological improvements reflecting the state-of-the-art in submarine design.

In accordance with Section 2366, Title 10, United States Code (10 USC 2366), a covered system, such as a submarine, cannot proceed beyond initial production until realistic survivability testing of the system is completed. Realistic survivability testing means testing for the vulnerability of the system in combat by firing munitions likely to be encountered in combat with the system configured for combat. This testing and assessment is commonly referred to as "Live Fire Test & Evaluation" (LFT&E). The purpose of the legislation and this testing is to ensure that the vulnerability of the system under combat conditions, in this case a submarine, is known. However, realistic testing by firing real torpedoes at the ship or detonating a real mine against the ship's hull could result in the loss of a multi-billion dollar Navy asset. Therefore, the Navy has established a LFT&E program to complete the survivability testing of the SEAWOLF Class submarines as required by 10 USC 2366. The LFT&E program consists of three major areas, which together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship.

Computer modeling is conducted to predict the general shock response motions of the SEAWOLF Class submarine to underwater explosions. The computer analysis predicts accelerations, velocities, and displacement values that correspond to shock inputs to submarine equipment and systems. These predictions can be compared with component shock test qualification results or previously recorded shock test data to establish an engineering baseline for possible equipment/component damage. These comparisons are used to assess the survivability of the ship.

However, computer modeling alone cannot accurately predict the survivability of the submarine. A major problem with existing computer models is that they predict response motions but not failure modes. Computer modeling predictions are best used to evaluate the structural integrity of foundations, cabinets, or housings that support and enclose equipment. For example, computer modeling can predict whether or not a steel foundation would bend or deform, or whether attachment welds or hold down bolts would fail, but they cannot predict the broad range of complex failure mechanisms which could occur inside sophisticated electronic components or complex mechanical systems. Also, the predictions address the structural integrity of the item, not the operability of equipment or systems which is demonstrated during equipment shock qualification tests and a ship shock test.

Although computer models are helpful in designing new ships, combat experience has demonstrated that unknown or unexpected failure modes cannot be adequately predicted with models. Furthermore, the unique and complex design features challenge computer models due to the complexity of the component or system and because there is little empirical evidence (data) to validate the predictions of the models.

Component and surrogate testing also provides essential information regarding the survivability of the submarine. Nearly 6,000 SEAWOLF components will be shock tested/qualified as part of the SEAWOLF LFT&E program. The Navy tests components on specially designed test machines and fixtures in the laboratory. These machines provide a rapid acceleration to the equipment installed on the fixture. The damage, or lack of damage, resulting from the test assists in the assessment of the components performance under a shock load. These laboratory test machines are limited by the weight of the item to be tested; therefore, the Navy has developed and constructed submarine sections, called surrogates, to house the very large components. The Navy tests these large surrogate sections in specially constructed underwater explosion test facilities also known as "ponds." The usefulness of this testing is limited because the equipment is often not energized or operational, and the entire system is typically so large that it cannot fit completely into even the largest surrogate section. Therefore the shock effects of the overall system and the system's interaction with other ship systems and structure cannot be fully evaluated.

Shock testing of the entire ship provides much of the information missing from computer modeling and analysis and component shock testing. A ship shock test is a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. Shock tests simulate near misses from underwater explosions similar to those encountered in combat. The ship is manned with the appropriate systems operating. The shock response of the ship systems and the interaction of the entire ship and with the other systems and components is obtained. Only by testing the entire ship in such a configuration can an adequate assessment of the survivability of the ship be determined in accordance with 10 USC 2366.

1.2 PROJECT PURPOSE AND NEED

The purpose of this project is to shock test the USS SEAWOLF so that the resultant data can be used to assess the survivability of the submarine. Ship shock tests have been performed in the past. Typically the lead ship of a new class of ships constructed for the Navy is shock tested to assess the ship's survivability and vulnerability. Occasionally the shock testing of the lead ship of a class is postponed, due to scheduling conflicts, to a later ship in the class. However, the Navy's goal is to test the first ship in each new class so that improvements can be cost effectively applied to later ships of that class.

This project is needed because computer modeling and component testing on machines or in surrogates does not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. The entire manned submarine must be shock tested at sea.

Shock tests have proven their value as recently as the Persian Gulf War when ships were able to survive battle damage and continue their mission because of ship design, crew training, and survivability lessons learned during previous shock tests.

1.3 PROPOSED ACTION

The proposed action described in this FEIS is to shock test the SEAWOLF submarine at an offshore location. The FEIS analyzes in detail alternative areas offshore of Mayport, Florida and Norfolk, Virginia (**Figure 1-1**). Details of the proposed action are presented in Section 2.2. The proposed action includes mitigation to minimize risk to marine mammals and turtles, as described in Section 5.0.

The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations. A 4,536 kg (10,000 lb) charge is selected to ensure that the entire submarine is subjected to the desired level of shock intensity. The use of smaller charges would require many more detonations to excite the entire ship to the desired shock intensity level.

The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the next detonation. The series of detonations would occur sometime between 1 April and 30 September. If the Mayport area, the preferred alternative, is selected, the shock tests would be conducted between 1 May and 30 September to minimize risk to sea turtles, which may be more abundant at the Mayport area during April.

The SEAWOLF was christened in June 1995 and delivered to the Navy in the spring of 1997. Because of the long series of at-sea testing that must be completed first, shock testing did not occur in 1997 as originally planned. Therefore, the Navy has rescheduled the shock test for the spring/summer of 2000. Shock testing must be completed and the ship must be thoroughly inspected prior to its release for unrestricted operations.

The delay of the SEAWOLF shock test from 1997 to 2000 does not change the environmental analysis provided in the FEIS. The impacts identified and the mitigation developed are based on the time of the year that the test is conducted, and no impacts have been identified that are variable other than seasonally each year. Therefore, the methodology for determining impacts remains valid and the Navy has decided to issue the FEIS even though the planned year of the test has changed. During 1997, the Navy conducted additional aerial surveys of the Mayport area to further confirm and validate the marine mammal and sea turtle population density data obtained during the 1995 aerial surveys. These additional data have been incorporated into the FEIS.

1.4 BASIS FOR PREPARING THE ENVIRONMENTAL IMPACT STATEMENT

The FEIS was prepared in accordance with Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions;" the National Environmental Policy Act (NEPA) of 1969; the regulations implementing NEPA issued by the Council on Environmental Quality (CEQ), 40 Code of Federal Regulations (CFR) Parts 1500-1508; and Navy regulations implementing NEPA procedures (32 CFR 775). NEPA sets out the procedures Federal agencies must

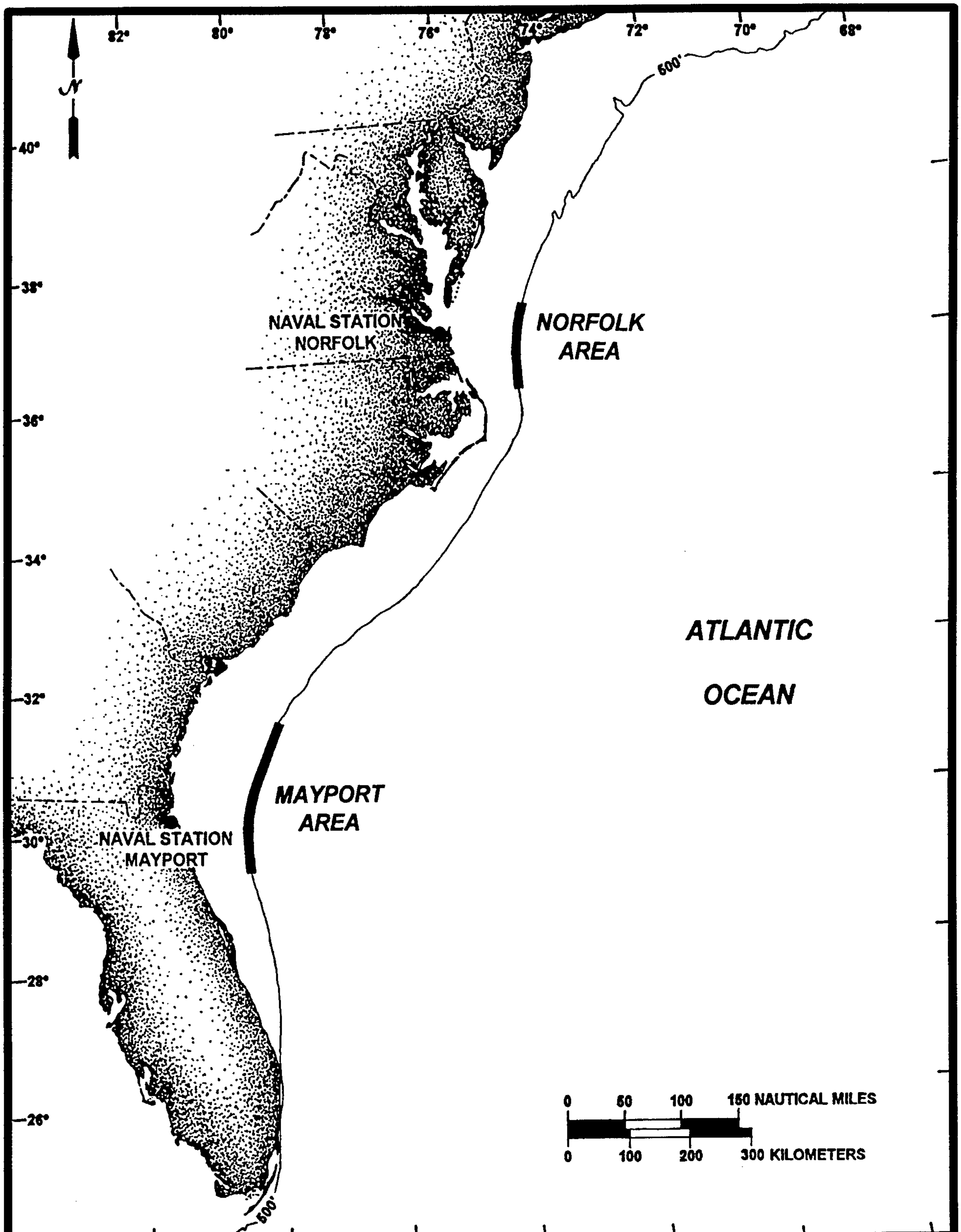

Figure 1-1. Location of the Mayport and Norfolk areas for SEAWOLF shock testing.

follow in analyzing environmental impacts of major Federal actions within U.S. territory. Executive Order 12114 sets out the procedures Federal agencies must follow in analyzing environmental impacts of major Federal actions occurring outside U.S. territory in the global commons or within the territory of another nation. Executive Order 12114 is based upon the independent authority of the President, not the statutory authority of NEPA. It furthers the purposes of NEPA but is not governed by CEQ regulations.

While NEPA and Executive Order 12114 represent two distinct, independent processes, the Navy has conducted the analysis under these two processes concurrently for the proposed shock testing of the USS SEAWOLF because the proposed action includes operations that would occur both within and outside U.S. territorial seas. Shock testing and associated mitigation operations would occur in offshore waters well outside of territorial seas. The only operations that would occur within territorial seas are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing location). Shore support activities and vessel and aircraft movements are part of the routine operations associated with the existing shore bases and would not involve any unusual or extraordinary activities. Impact discussions in this FEIS (Section 4.0, Environmental Consequences) are divided into separate subsections to distinguish between those operations that are evaluated under NEPA and those that are evaluated under Executive Order 12114.

1.5 PUBLIC INVOLVEMENT

The preparation of an Environmental Impact Statement provides three main opportunities for public involvement.

First, there is "scoping," the early and open process for identifying issues to be addressed in the Draft Environmental Impact Statement (DEIS). To begin the scoping process for this EIS, a Notice of Intent was published in the *Federal Register* and five local newspapers (*Washington Post*, *Virginian Pilot*, *Florida Times Union*, *Beaches Leader*, and *Southeast Georgian*) during March 1995. It was also sent to Federal, state, and local elected officials and agency representatives, and other interested parties. The Notice of Intent explained how to submit oral and written comments. Three public scoping meetings were held during March 1995 to explain the project and allow the public to voice their concerns. Meeting dates, locations, number of attendees, and number of comments received are listed below:

- 23 March 1995 – National Oceanic and Atmospheric Administration auditorium, Silver Spring, Maryland. Nine people attended. No oral or written comments were received.
- 28 March 1995 – Granby High School auditorium, Norfolk, Virginia. Two people attended. No oral or written comments were received.
- 29 March 1995 – Mayport Middle School cafeteria, Atlantic Beach, Florida. Nineteen people attended, and five provided oral comments.

In addition to the comments received during the public meetings, 13 written responses were received by the end of the comment period on 1 May 1995. The public meeting and written comments were reviewed to make sure that all issues would be addressed in the EIS.

The second major opportunity for public participation came when the Navy distributed the DEIS to interested persons for review and comment (see Appendix A for the distribution list). The notice of availability for the DEIS was published in the Federal Register on June 14, 1996 (61 FR 30232). The public review period originally ended on July 31, 1996, but was subsequently reopened and extended to September 17, 1996.

The Navy hosted three public hearings in Silver Spring, Maryland; Norfolk, Virginia; and Atlantic Beach, Florida to receive oral and written comments on the DEIS. Hearing dates, locations, number of attendees, and number of comments received are listed below:

- 19 August 1996 – Silver Spring Metro Center, Silver Spring, Maryland. Three people attended (excluding Navy, NMFS, and contractor personnel), and one person provided oral comments.
- 20 August 1996 – Lafayette Winona Middle School auditorium, Norfolk, Virginia. Twenty-two people attended, and nine provided oral comments.
- 21 August 1996 – Mayport Middle School cafeteria, Atlantic Beach, Florida. Twelve people attended, and six provided oral comments.

In addition to the public hearing comments, 22 sets of written comments were received from Federal, state, and local agencies, as well as several organizations and individuals. All oral and written comments are addressed in Appendix H of the FEIS. **Table 1-1** summarizes changes to the EIS resulting from public comments. In particular, the FEIS includes numerous improvements to the Marine Mammal and Sea Turtle Mitigation Plan that further reduce the risk of impacts to marine life.

A third opportunity for public input is the 30-day public review period following publication of the notice of availability for the FEIS. The Navy has distributed the FEIS to interested persons (including all DEIS commenters) for review. After closure of the public review period, the Navy will issue its Record of Decision (ROD) for publication in the Federal Register.

1.6 COORDINATION AND CONSULTATION WITH THE NMFS

The NMFS has two regulatory roles in the SEAWOLF project. First, the NMFS is responsible for administering the Endangered Species Act as it applies to sea turtles and most marine mammals. The DEIS served as a Biological Assessment which the Navy submitted to the NMFS, requesting formal consultation under Section 7 of the Endangered Species Act. The NMFS subsequently issued a Biological Opinion, which is included in Appendix G of the FEIS.

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specifies mitigation, monitoring, and reporting requirements for SEAWOLF shock testing. A Final Rule must be issued before shock testing can proceed.

As noted above, the NMFS is also a cooperating agency with the Navy in preparing the EIS. Because of its regulatory responsibilities under the Endangered Species Act and the Marine Mammal Protection Act, the NMFS limited its role in preparation of the EIS to providing review and comment. A formal comment letter from the agency is included among the DEIS comments addressed in Appendix H.

1.7 FORMAT OF FINAL ENVIRONMENTAL IMPACT STATEMENT

The FEIS follows the format specified by Navy regulations (32 CFR 775). The document is issue-oriented, providing greater analytical detail on more significant concerns and less information on other topics. The FEIS contains the following major sections:

- Executive Summary – gives an overview of the document and its findings;
- Introduction – explains the project purpose and need, the public participation process, and the format of the FEIS;
- Alternatives – discusses alternatives including "no action," the proposed action, and alternative areas for the proposed action; compares alternatives and selects a preferred alternative;
- Existing Environment – describes the physical, biological, and socioeconomic characteristics of the environment that might be affected by shock testing;
- Environmental Consequences – analyzes potential impacts of shock testing on the physical, biological, and socioeconomic environment;
- Mitigation and Monitoring – describes measures to avoid, minimize, or reduce environmental impacts; and
- Other sections and appendices – as listed in the Table of Contents.

2.0 ALTERNATIVES

Alternatives for meeting the project purpose and need are described and evaluated in this section. The alternatives are (1) no action and (2) shock testing the SEAWOLF at an offshore location. A "winter" (October through March) testing alternative is not analyzed because it would not meet operational requirements as described later in this section. Alternative offshore areas for shock testing are compared from operational and environmental perspectives. A preferred alternative has been identified based on these comparisons.

As discussed in Section 1.1, the SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Therefore, computer modeling and component testing are not reasonable stand-alone alternatives to shock testing. Instead, they are considered part of the "no action" alternative.

2.1 NO ACTION

Under this alternative, no new activities affecting the physical environment would be conducted to predict the response of SEAWOLF class submarines to underwater detonations. This alternative would avoid all environmental impacts of shock testing.

As described in Section 1.1, the Navy has established a Live Fire Test & Evaluation (LFT&E) program to demonstrate the survivability of SEAWOLF class submarines. The program consists of three major areas that together provide the data necessary to assess the SEAWOLF's survivability: computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. The SEAWOLF LFT&E program already includes the maximum reasonable amount of computer modeling and component testing. Only by testing the entire manned ship with the appropriate systems operating can the shock response of the entire ship, including the interaction of ship systems and components, be obtained and an adequate assessment of the survivability of the submarine be determined in accordance with 10 USC 2366. The intent of 10 USC 2366 is to ensure that the combat survivability of the weapon system (submarine) is assessed before the system is exposed to hostile fire. The information obtained during the shock test is used to improve the shock resistance of the ship and therefore reduce the risk of injury to the crew. The "no action" alternative would prevent the Navy from being able to make the survivability assessment required by 10 USC 2366.

As the "no action" alternative involves no activity affecting the physical environment, it is not individually analyzed further in the FEIS. The "no action" alternative is implicit in the environmental analysis throughout the document. The Existing Environment section provides a "no action" benchmark against which the proposed action can be evaluated. The Environmental Consequences section compares impacts of an action (shock testing) with the alternative of "no action."

2.2 SHOCK TESTING THE SEAWOLF AT AN OFFSHORE LOCATION

2.2.1 Description of Testing

The remaining alternative discussed is the proposed action, which is to shock test the SEAWOLF at an offshore location. The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations. The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems prior to the next detonation. The series of detonations would occur sometime between 1 April and 30 September. This time period is based on the Navy's operational and scheduling requirements. If the Mayport area is selected, there would be no testing in April, when turtle densities may be higher at that area (see Section 2.2.3.1).

The test site would be selected from within a general "area" such as the Mayport and Norfolk areas described later in this section. Once the general area is selected, the final specific site for shock testing would be selected 2 to 3 days before the test, based on marine mammal and turtle surveys (see Section 2.2.3.2). The operational site for testing would be a 1.85 km (1 nmi) diameter zone centered on the explosive charge (**Figure 2-1**). An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic.

Prior to the shock test, the submarine would be examined, configured, and prepared to accommodate the shock testing equipment. The pre-test status of each ship compartment would be documented. Shore support and facilities (see below) would be readied, and the crew would be trained for the test.

For shock testing, an operations vessel would moor in a water depth of 152 m (500 ft) at the test site. Test personnel would deploy a one-mile long test array (Figure 2-1). The array would consist of an explosive charge placed about 30 m ± 3 m (100 ft ± 10 ft) below the water surface, marker buoys, instrumentation, connecting ropes, and the "gate," a small diameter rope that the submarine would break as it passes through the array. For each test, the submarine would submerge about 20 m (65 ft) below the water surface and navigate toward the marker buoys located on each side of the gate. As the submarine passes through the gate, the explosive would be detonated from the operations vessel. The submarine would then surface, and after an initial inspection for damage, travel back to the shore facility for post-test inspections and preparations for the next test. For each subsequent test, the gate would be moved closer to the explosive so the submarine experiences a more severe shock.

A conventional Navy explosive (High Blast eXplosive, HBX-1) would be used for each shock test. HBX-1 consists of the following components (by weight): cyclotrimethylene trinitramine - 39.32%; trinitrotoluene - 37.76%; aluminum powder - 17.10%; wax - 4.57%; and miscellaneous fillers - 1.25%. The charge would be held in a cylindrical steel container measuring 1.5 m (5 ft) in diameter by 1.7 m (5.6 ft) long with a total weight of 1,297 kg (2,860 lb) in air. The largest possible fragment from the explosion that would settle to the seafloor would be the top plate and crossbar, which together weigh 204 kg (450 lb). After detonation, the test array would be recovered and floats and rigging debris would be removed.

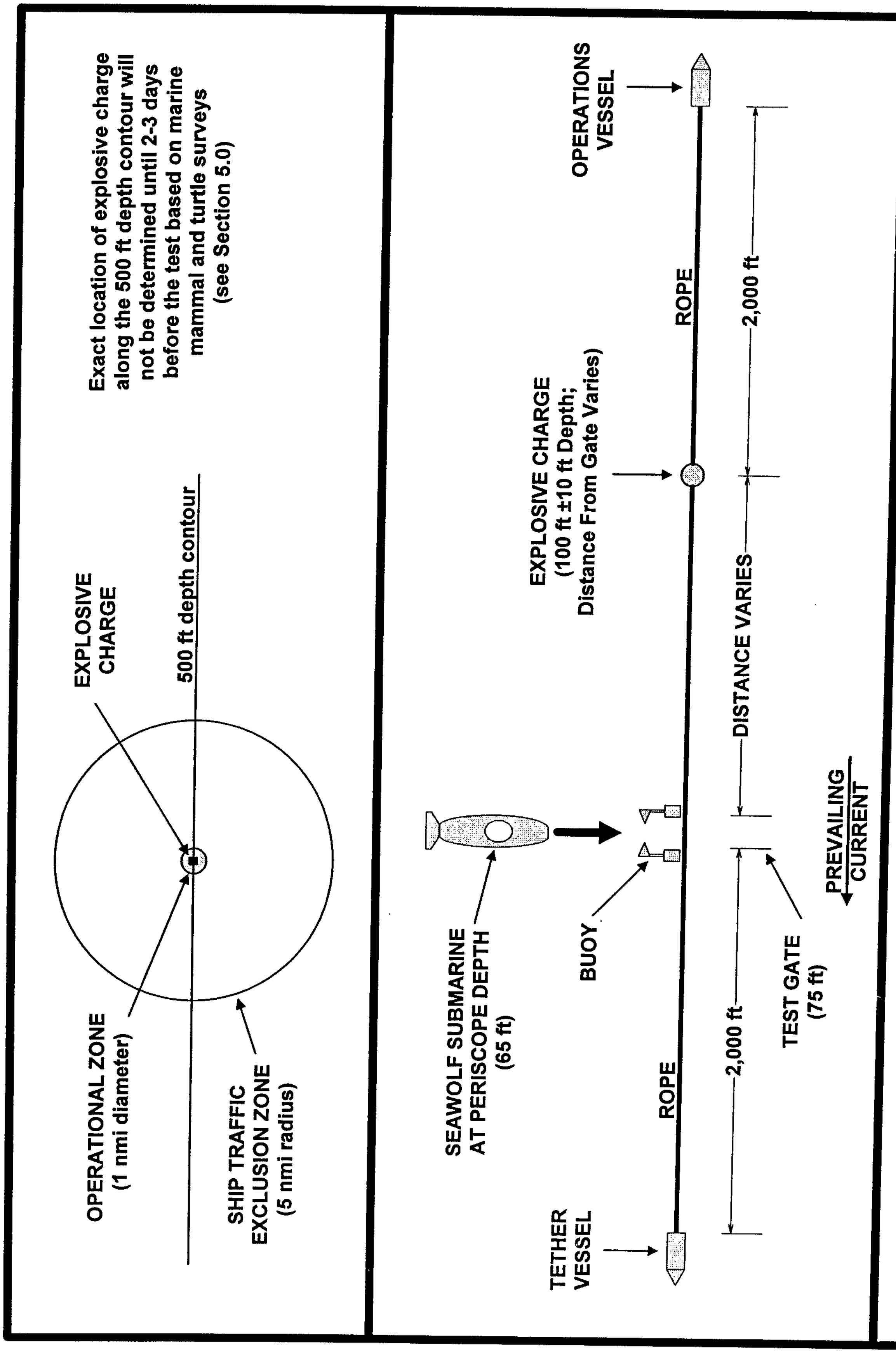


Figure 2-1. Test array, operational zone, and ship traffic exclusion zone for SEAWOLF shock testing.

Shore support for the SEAWOLF Ship Shock Test Team would consist of five to six rented trailers (temporary facilities) in an office configuration with water closet, wash basin, and air conditioning. Each trailer would have electric power, telephone service, a few desks, a bottled water dispenser, and probably word processors or personal computers. Type of sewerage service would depend upon the layout of the base's facilities, i.e., directly into base lines or pumped out by truck. In addition, there would be an instrumentation trailer and possibly a small supply trailer (cable, spare parts, etc.). Additional space would be leased outside the base, if required. The Shock Test Explosives Operations Team would have expendables such as rope, rigging materials, and floats stored on shore to replenish what is used for each shot.

2.2.2 Alternative Areas

Several possible general areas for shock testing were evaluated by the Navy, as described below. The final, specific site for shock testing would not be selected until 2 to 3 days before the test based on marine mammal and turtle surveys (see Section 2.2.3.2). However, the Navy has identified general offshore "areas" that meet certain operational criteria, and has a preferred area. The final test site would be selected within the preferred area if this alternative is selected.

2.2.2.1 Operational Requirements

A location on the East Coast would best meet operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. Scheduling the test on the west coast or in the Gulf of Mexico would increase the time the ship is away from the homeport, complicate or prolong repairs, and further delay deployment. Under Navy Personnel Tempo (PERSTEMPO) regulations, a ship is required to spend a day in homeport for every day it is away from homeport for purposes of crew quality of life and efficiency (OPNAVINST 3000.13A, 21 December 1990). A shock test conducted away from the homeport is typically a 3.5 to 4 month deployment, including time spent having special equipment installed at the shore support facility, completing test runs and training, and conducting the actual shock testing. Scheduling the test away from the East Coast would maximize time spent away from the homeport and minimize the SEAWOLF's availability for deployment as part of fleet resources.

The Navy screened possible East Coast shock testing areas according to operational criteria. Potential areas were first defined as locations having a water depth of 152 m (500 ft) that are within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. This water depth is sufficient to minimize the effect of a bottom reflected pressure wave on the submarine and shallow enough to allow mooring of the operations vessel with the test array. This depth would also permit recovery of the crew and submarine in the unlikely event of a control failure. Other criteria include proximity to an ordnance storage/loading facility and Navy assets (ships and aircraft) necessary to support the test needs. There must also be little or no shipping traffic in the area. Finally, calm seas and good visibility are needed for the test, so a location that has a preponderance of such is needed. The rationale for each of these operational requirements is explained in separate subsections below.

Five East Coast areas were identified that could potentially meet the Navy's operational requirements: Mayport, Florida; Norfolk, Virginia; Groton, Connecticut; Charleston, South Carolina; and Key West, Florida. Charleston was eliminated because of the closure of the Charleston Navy Yard and Charleston Naval Station under the Base Closure and Realignment (BRAC) process (i.e., facilities and vessels to support the test would not be available). The water depth of 275 m (900 ft) at the Key West area is too great for the planned shock testing. In addition, the Key West area lacks the industrial base to support submarine repairs or drydocking, and there is no surface vessel homeport nearby that could provide Navy assets (ships and planes) to support the test.

The following sections evaluate the remaining three areas (Mayport, Norfolk, and Groton) according to the Navy's operational criteria. A summary and comparison is presented after the individual criteria have been discussed.

Proximity to Naval Station Support Facility

A Naval Station which can provide limited maintenance and depot level support for submarines (e.g., tradespeople, spare parts, cranes) must be located within 185 km (100 nmi) from the test site to repair/replace damaged equipment and systems. The distance is based upon a worst case scenario where the SEAWOLF would require towing to a Naval Station after a test. Standard towing speed for a submarine is 4 to 5 nautical miles per hour (knots or kts) under favorable conditions. The tow would begin at the test site during the remaining daylight hours. The submarine would be required to enter port during daylight hours to reduce the possibility of a collision. Since the distance from shore to an area having the required water depth would be too great to allow the submarine to come into port on the same day, the next day was chosen as the maximum travel time. This limits the risks of a submarine tow, the hazards of night towing, the encounter of less than favorable sea conditions, and crew illness. Therefore, a one day (24 hour) transit at 4 to 5 kts would equate to a distance of approximately 185 km (100 nmi).

All three remaining areas are within 185 km (100 nmi) of a shock test support facility. For the Mayport area, the support facility would be the Naval Submarine Base Kings Bay, with distances ranging from to 139 to 185 km (75 to 100 nmi). For the Norfolk area, the support facility would be Naval Station Norfolk, with distances ranging from 148 to 185 km (80 to 100 nmi). For the Groton area, the support facility would be New London Submarine Base, with distances ranging from 139 to 185 km (75 to 100 nmi).

Proximity to Submarine Repair Facility

Close proximity to a submarine repair facility is imperative for the SEAWOLF shock test. A repair facility must be within 185 km (100 nmi) to provide drydocking, special trades, equipment, and materials to perform post-test inspections and prepare for the next test. The distance is based upon a worst case scenario where the SEAWOLF would require towing to a repair facility after a test. Standard towing speed for a submarine is 4 to 5 kts under favorable conditions. The tow would begin at the test site during the remaining daylight hours. The submarine would be required to enter port during daylight hours to reduce the possibility of a collision. Since the distance from shore to an area having the required water depth would be too great to allow the submarine to come into port on the same day, the next day was chosen as the maximum travel time. This limits the risks of a submarine tow, the hazards of night towing, the encounter of less than favorable sea conditions, and crew illness. Therefore, a one day (24 hour) transit at 4 to 5 kts would equate to a distance of approximately 185 km (100 nmi).

If testing occurred offshore of Mayport, then the Naval Submarine Base Kings Bay would serve as the repair facility. Distances to the repair facility range from 139 to 185 km (75 to 100 nmi). If testing occurred offshore of Norfolk, then the Norfolk Naval Shipyard would serve as the repair facility; distances to the repair facility range from about 148 to 185 km (80 to 100 nmi). If Groton were selected, the shipbuilder's yard in Groton could be used for repairs. Distances range from about 139 to 185 km (75 to 100 nmi).

Proximity to Ordnance Storage/Loading Facility

Prior to each test, an explosive would be loaded onto the operations vessel at an ordnance storage/loading facility. The facility must have qualified personnel and equipment to handle the explosives and must be located within about 370 km (200 nmi), which allows a 20- to 24-hr transit at 8 to 10 kts. Greater distances could increase the time to prepare for the next test and preclude windows of opportunity to test on weather-favorable days.

All three areas are within 370 km (200 nmi) of ordnance storage/loading facilities. If the Mayport area is selected, then explosives would be stored and loaded either at the Naval Weapons Station in Charleston, South Carolina, a distance of 167 to 370 km (90 to 200 nmi); or at Naval Station Mayport, a distance of 117 to 185 km (63 to 100 nmi). For testing offshore of Norfolk, explosives would be stored and loaded at the Naval Weapons Station in Yorktown, Virginia, a distance of about 185 to 222 km (100 to 120 nmi). If Groton were selected, then the explosives would be stored and loaded at the Naval Weapons Station in Earle, New Jersey, about 195 to 287 km (105 to 155 nmi) away.

Availability of Navy Assets

Navy ships would be needed at the test site to monitor, divert, and escort non-test vessels away from the exclusion zone, provide communications, track the SEAWOLF, and perform other tasks. Airplanes and helicopters would serve as observation and photographic platforms before, during, and after the test and would also be available for emergency response and rescue. For sufficient vessels and aircraft (and alternates) to be available, a large Navy installation must be within 185 km (100 nmi) of the test site. This would allow a 8- to 10-hr transit time for support craft steaming at 10 to 12 kts. The distance would also allow each support aircraft to remain on-site for about 3 to 3.5 hr, with an adequate fuel reserve for safety.

The availability of Navy assets is an important consideration given the need for a variety of Navy vessels and aircraft for shock test support. In recent years, obtaining Navy assets (both air and surface) has become increasingly difficult as both the budget and the size of the Navy have decreased. Supporting a shock test reduces fleet assets available to meet the other mission goals of the Atlantic Fleet. Therefore, to minimize transit times and make the most effective use of Navy assets, it is imperative that the SEAWOLF shock testing be conducted at a location which is close to a large Navy installation with available ships and aircraft to support the test.

Because large Navy installations are located at Mayport, Florida, and Norfolk, Virginia, the Navy is in the best position to support shock testing at these two areas. Transit distances range from 117 to 185 km (63 to 100 nmi) for sites in the Mayport area and 148 to 185 km (80 to 100 nmi) for sites in the Norfolk area. Shock testing at Groton would be very difficult because there are no nearby Navy installations with the fleet operational assets required to support shock testing. The nearest Naval Base/Stations at Newport, Rhode Island and Staten Island, New York are now closed. The Naval Underwater Warfare Center (NUWC) Newport is a Naval laboratory and does not have the assets necessary to support shock testing. Naval Station Philadelphia is also closed. Earle Naval Weapons Station in Colts Neck, New Jersey is homeport to only a few ships, none of which are of the type needed to support shock testing. Therefore, the nearest Naval Station which would have available assets to support shock testing in the Groton area is Naval Station Norfolk, with distances ranging from 463 to 556 km (250 to 300 nmi).

Proximity to SEAWOLF Homeport

Proximity to New London, Connecticut is desirable because it is the proposed homeport for the SEAWOLF (Department of the Navy, 1995c). The Groton area is obviously closest to the SEAWOLF homeport, about 139 to 185 km (75 to 100 nmi). New London is about 1,250 to 1,482 km (675 to 800 nmi) from the Mayport area and about 555 to 675 km (300 to 365 nmi) from the Norfolk area.

Water Depth

A water depth of 152 m (500 ft) is sufficient to minimize the effect of a bottom reflected pressure wave on the submarine and shallow enough to allow mooring of the operations vessel with the test array. This depth would permit recovery of the crew and submarine in the unlikely event of a control failure.

All three areas satisfy the water depth requirement. That is, the areas were initially defined as all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of the shock test support facility.

Ship Traffic

An area with little or no ship traffic is preferred; established shipping and submarine transit lanes should be avoided. Ships passing near the shock test site could delay shock testing. An exclusion zone of 9.3 km (5 nmi) radius would be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. Notices to Airmen and Mariners would be published in advance of each test. Any traffic entering an 18.5 km (10 nmi) radius around the detonation point would be warned to alter course or would be escorted from the site. Testing could be delayed while support vessels divert and escort the traffic away from the test site.

Any of the three areas would be acceptable from the standpoint of ship traffic. None are located in or near shipping lanes or submarine transit lanes. However, data from port authorities for ports near each location indicate that the Mayport area has about half as much commercial ship traffic as either the Norfolk or Groton areas (**Table 2-1**). The Groton area has the lowest density of military traffic, and the Norfolk area has the highest. Overall, the Mayport area is the most favorable and the Norfolk area is least favorable.

Table 2-1. Ship traffic levels near the Mayport, Norfolk, and Groton areas. Sources: Georgia Port Authority, Hampton Roads Maritime Association, Jacksonville Port Authority, and Maritime Association of New York. Mayport ship traffic includes 50% of the traffic destined for Savannah, Georgia.

Type of Ship Traffic	Mayport	Norfolk	Groton
Commercial Ship Traffic			
Ships per year	2,400	5,300	4,750
Ships per day	7	15	13
Military Ship Traffic Density	Moderate	High	Low

Weather and Sea State

Safe deployment, maintenance, and recovery of the test array, as well as effective mitigation, require good weather and sea conditions. Personnel on the operations vessel need a stable work platform while handling equipment and materials. Divers need calm seas to connect and reconnect the submarine "gate." Ideal test conditions are seas of 0.6 m (2 ft) or less, a light wind, and unlimited visibility. Conditions become marginal when seas approach 1.8 m (6 ft), winds approach 34 kph (21 mph), and visibility is less than 9.3 km (5 nmi). In addition, there are specific sea state and visibility requirements for visual observations of marine mammals and sea turtles during the pre-detonation monitoring (see Section 5.0).

Data from the Naval Oceanography Command (Department of the Navy, 1986, 1989) were used to evaluate the potential areas (**Table 2-2**). The data are based on monthly means for April through September.

Generally, the Mayport area has the highest probability of favorable conditions and the lowest probability of marginal or unsuitable conditions. Conditions at the other two areas are similar with the exception of fog and visibility. Groton has a high incidence of fog (up to 30.8%) and low visibility during summer months [visibility less than 9.3 km (5 nmi) up to 25.2% of the time], posing a significant operational safety risk that would result in testing delays.

Weather conditions during the rest of the year (October through March) would not be suitable for shock testing at any of the three areas. Rough seas and high winds occur much more frequently during winter months. For example, during October through March, seas greater than 1.8 m (6 ft) occur on average about 36% of the time at Norfolk and 33% of the time at Groton, as compared with about 15-16% during April through September. These conditions would lead to frequent delays and would increase the likelihood that shock testing

Table 2-2. Comparison of weather and sea state conditions at the Mayport, Norfolk, and Groton areas (Data from: Department of the Navy, 1986, 1989).

Weather/Sea State Condition	Percent Occurrence of Weather/Sea State Condition (April-September Grand Mean and Range of Monthly Means)		
	Mayport	Norfolk	Groton
Ideal Operational Conditions			
Seas ≤0.6 m (≤2 ft)	41.7 (34.1-49.9)	37.1 (28.7-44.8)	40.1 (36.4-47.4)
Visibility ≥18 km (≥10 nmi)	65.0 (61.5-68.3)	55.2 (51.3-61.2)	46.9 (42.1-56.4)
Unsuitable or Marginal Conditions			
Seas > 1.8 m (>6 ft)	8.3 (2.4-13.5)	15.2 (8.1-23.1)	15.6 (5.0-24.8)
Visibility <9.3 km (<5 nmi)	2.0 (1.2-2.9)	8.1 (5.7-10.4)	17.5 (10.7-25.2)
Ceiling <305 m (1,000 ft) or Visibility <9.3 km (<5 nmi)	~10	~10-20	~15-30
Wind >34 kph (>21 mph)	~10	~10	~10
Fog	0.2 (0.1-0.4)	5.0 (1.5-8.6)	21.0 (12.0-30.8)

and mitigation efforts would be conducted under marginal conditions that are less than ideal for detection of marine mammals and turtles.

Conclusions

Table 2-3 compares Mayport, Norfolk, and Groton according to the operational criteria. For each criterion (except for ship traffic and proximity to SEAWOLF homeport, which use ranks), the areas are scored on a scale of 0 to 4. Mayport and Norfolk have nearly identical totals (36 and 33, respectively), whereas Groton scores substantially lower (24). Groton scored poorly on criteria for incidence of fog, visibility, and proximity to Navy assets (air and surface). The high incidence of fog and low visibility at Groton during summer months could result in frequent testing delays, reduce the effectiveness of mitigation measures, and pose safety problems for support vessels and aircraft. The lack of nearby Navy assets to support shock testing also makes this an unfavorable location from an operational perspective.

In conclusion, Mayport, Florida and Norfolk, Virginia are the areas that meet all of the Navy's operational requirements. These two areas are the focus of detailed environmental analysis in this FEIS. **Figure 2-2** shows the Mayport area, which is located offshore of Georgia and northeast Florida. **Figure 2-3** shows the Norfolk area, which is located offshore of Virginia and North Carolina.

2.2.2.2 Environmental Considerations at Mayport and Norfolk

At both the Mayport and Norfolk areas, possible test sites were first defined as any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species (Department of the Navy, 1995a). Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as described below.

Marine Sanctuaries

There are no existing or proposed marine sanctuaries near the Mayport area. However, at the Norfolk area, a buffer zone was developed for the proposed Norfolk Canyon National Marine Sanctuary. Norfolk Canyon is the southernmost submarine canyon in a series of prominent deepwater features along the U.S. East Coast. The Norfolk Canyon area proposed for National Marine Sanctuary designation provides habitat for a distinctive assortment of living marine resources, including two species of soft coral rarely encountered elsewhere.

The NMFS has recommended a buffer zone of 4.6 km (2.5 nmi) to protect the unique benthic fauna of the Norfolk Canyon area from the effects of the shock test (Appendix G). Therefore, all of the 152 m (500 ft) depth contour passing through the proposed sanctuary, as well as 4.6 km (2.5 nmi) buffers on either side, were excluded from the Norfolk area as potential test sites (Figure 2-3). Based on calculations presented in the Environmental Consequences section, this buffer zone is more than adequate to protect marine mammals, sea turtles, fish, and benthic fauna.

Table 2-3. Evaluation of Mayport, Norfolk, and Groton areas according to operational criteria.

Criterion	Basis for Scoring	Scoring of Alternative Areas			Comments
		Mayport	Norfolk	Groton	
Facilities and Assets					
Shock test shore support facility within 185 km (100 nmi)	Portion of area meeting criterion: 0 = 0% 1 = 1-49% 2 = 50-74% 3 = 75-99% 4 = 100%	4	4	4	All areas are within 185 km (100 nmi) of a shock test support facility.
Submarine repair facility within 185 km (100 nmi)	(same as above)	4	4	4	All areas are within 185 km (100 nmi) of a submarine repair facility.
Ordnance storage/loading facility within 370 km (200 nmi)	(same as above)	4	4	4	
Naval assets (surface) within 185 km (100 nmi)	(same as above)	4	4	0	Sources within 185 km (100 nmi) of Groton area are on base closure list.
Naval assets (air) within 185 km (100 nmi)	(same as above)	4	4	0	Sources within 185 km (100 nmi) of Groton area are on base closure list.
Proximity to SEAWOLF homeport	Rank, from farthest (1) to nearest (3)	1	2	3	Groton is proposed SEAWOLF homeport
Environmental Factors Affecting Operations					
Water depth of 152 m (500 ft)	Portion of area meeting criterion: 0 = 0% 1 = 1-49% 2 = 50-74% 3 = 75-99% 4 = 100%	4	4	4	By definition, all areas meet this requirement.
Ship traffic	Rank, from highest (1) to lowest (3) density	3	1	2	Mayport has about half as much commercial ship traffic as Norfolk or Groton. Norfolk has the highest density of military ship traffic.
Rough seas [average occurrence of seas >1.8 m (>6 ft)]	0 = >50% 1 = 30-49% 2 = 20-29% 3 = 10-19% 4 = <10%	4	3	3	
Incidence of fog (average)	0 = >15% 1 = 11-15% 2 = 6-10% 3 = 1-5% 4 = <1%	4	3	0	Groton has up to 30.8% incidence of fog during summer months, which could delay testing.
TOTAL SCORE (higher is better)		**36**	**33**	**24**	

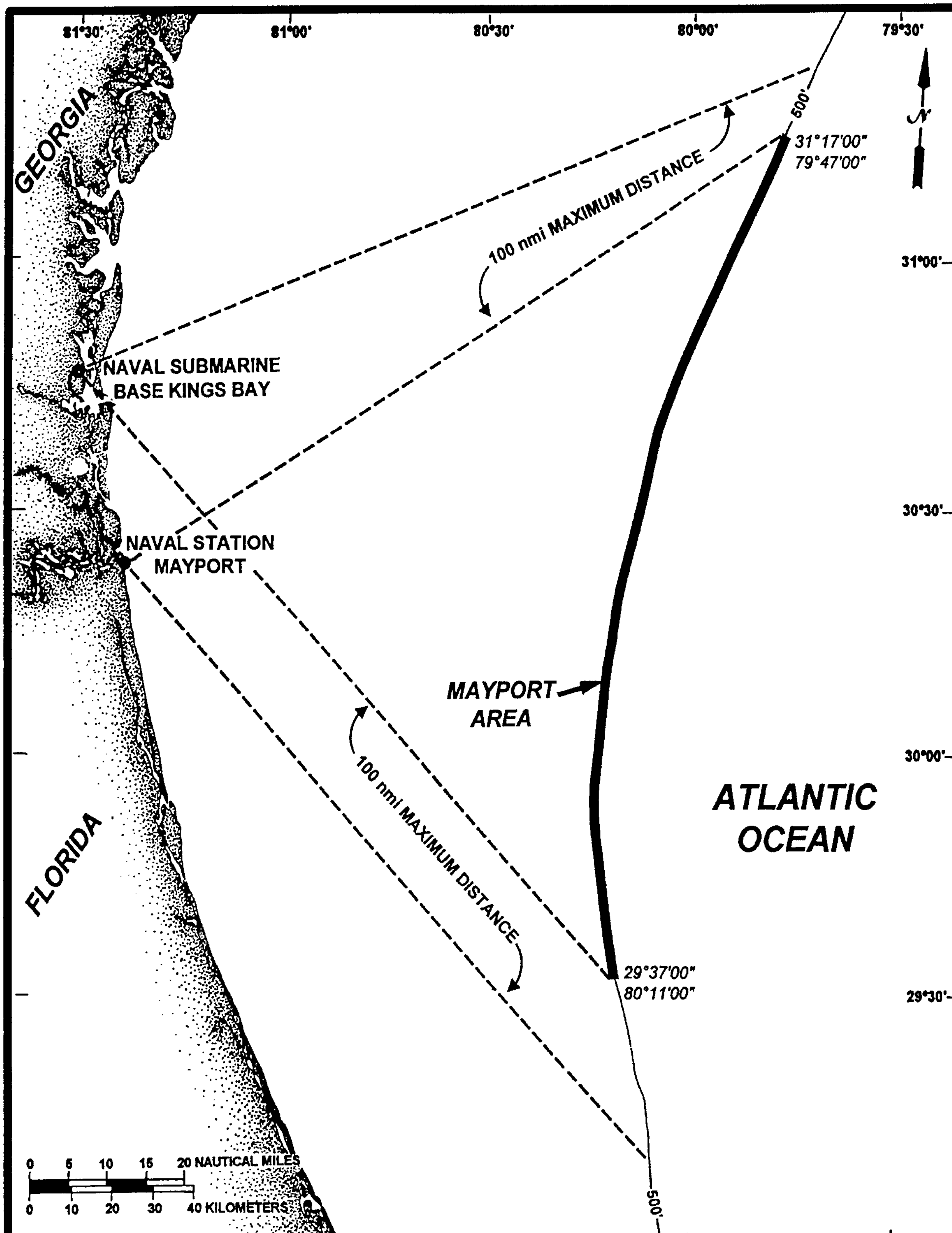


Figure 2-2. The Mayport area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Mayport and Naval Submarine Base Kings Bay.

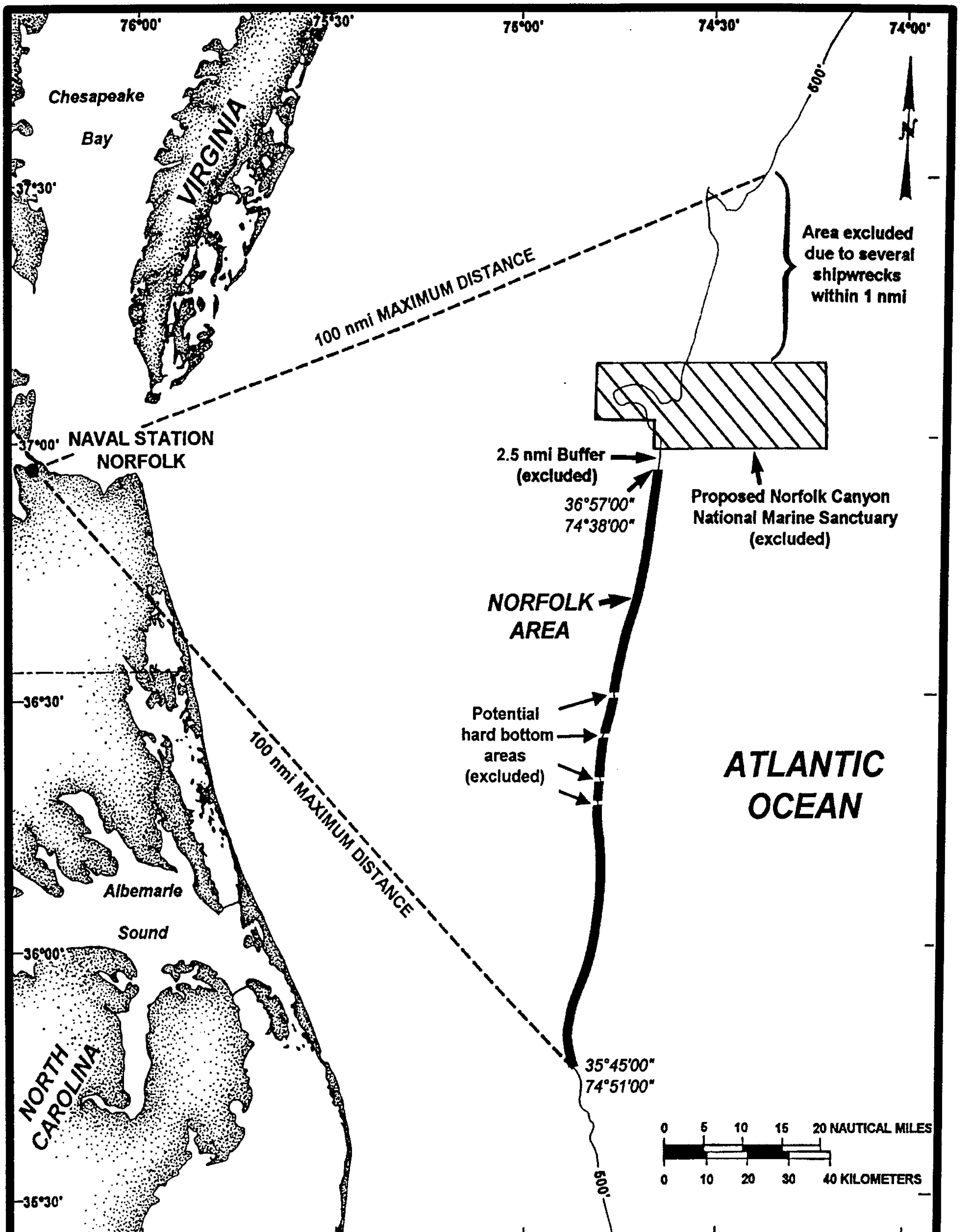


Figure 2-3. The Norfolk area. The area includes all points along the 152 m (500 ft) depth contour within 185 km (100 nmi) of Naval Station Norfolk, except the excluded areas indicated.

Artificial Reefs, Hard Bottom Areas, and Shipwrecks

Buffer zones were developed for artificial reefs, hard bottom areas, and shipwrecks to protect fish that congregate at these features. Calculations in the Environmental Consequences section show that over 90% of swimbladder fish would survive a 4,536 kg (10,000 lb) explosion if the fish were 1.85 km (1 nmi) from the detonation point. These calculations apply to fish near the surface; those near the bottom would be much less vulnerable at this distance. Therefore, a 1.85 km (1 nmi) buffer is considered more than sufficient to protect these features.

At the Mayport area, an initial review revealed no known artificial reefs, hard bottom areas, or shipwrecks within 1.85 km (1 nmi) of the 152 m (500 ft) depth contour (Department of the Navy, 1995a). For the FEIS, the Navy also reviewed reports on the SEAMAP bottom mapping program for Georgia and northeastern Florida (Van Dolah et al., 1994) and conducted a computer search of the SEAMAP database. The data confirm that the seafloor near the Mayport area is predominantly soft bottom, with no hard bottom identified within 1.85 km (1 nmi) of the area. At the Norfolk area, there are no artificial reefs or hard bottom areas, but several shipwrecks exist in the northern part of the area. The entire portion of the area north of the proposed Norfolk Canyon National Marine Sanctuary was eliminated for this reason (Figure 2-3). An initial review indicated no known hard bottom areas or reefs within 1.85 km (1 nmi) of the Norfolk area (Department of the Navy, 1995a). For the FEIS, the Navy also reviewed the report on the SEAMAP bottom mapping program for North Carolina (Moser et al., 1995) and conducted a computer search of the SEAMAP database. The data confirm that the seafloor near the Norfolk area is predominantly soft bottom. However, four points within 1.85 km (1 nmi) of the area were identified as potential hard bottom and were excluded as test sites (Figure 2-3).

Ocean Disposal Sites

A buffer zone for ocean disposal sites was adopted to ensure that shock testing does not conflict with any ongoing disposal activities. An appropriate buffer zone for ocean disposal sites is 18.5 km (10 nmi), which is the radius within which all ship traffic would be warned to alter course or be escorted from the site. There are no ocean disposal sites within 18.5 km (10 nmi) of either the Mayport or Norfolk area (Department of the Navy, 1995a).

Critical Habitat

Based on information received from the NMFS (Appendix G), critical habitat for one endangered species, the northern right whale, exists near Mayport. No critical habitat for other endangered or threatened marine mammals or sea turtles exists within or near the Mayport or Norfolk area.

The northern right whale critical habitat is located along the northeast Florida coast well inshore of the Mayport area (see Appendix B, Figure B-1). The distance between the Mayport area and the critical habitat ranges from 76 to 115 km (41 to 62 nmi), greatly exceeding the safe ranges for marine mammals (3.7 km or 2 nmi) and swimbladder fish (1.85 km or 1 nmi). As discussed in the Environmental Consequences section, other marine organisms (such as zooplankton upon which northern right whales feed) are more resistant to explosions and would be more than adequately protected by a 1.85 km (1 nmi) buffer. More importantly, because of their seasonal migrations, northern right whales are not expected to be present within the Mayport critical habitat area after late March. During the May through September period proposed for shock testing, most northern right whales are found feeding north of Cape Cod (Kraus et al., 1993). Of 401 northern right whale sightings off Mayport between 1950 and 1995, none occurred during May through September (Kenney, 1995). This finding is further supported by the aerial surveys conducted over the Mayport area; no northern right whales were identified during the six month period from April through September 1995 or May through September 1997 (Department of the Navy, 1995b, 1998).

Conclusions

At the Mayport area, there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas within the buffer zones allocated for these features. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing sites (Figure 2-2).

At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks within a distance of 1.85 km (1 nmi). In addition, four points within 1.85 km (1 nmi) of the area were identified as potential hard bottom and were excluded as test sites. All remaining points along the 152 m (500 ft) depth contour are considered potential shock testing sites (Figure 2-3).

2.2.3 Mitigation Measures

Mitigation, as defined by the Council on Environmental Quality, includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. The proposed action includes mitigation measures designed to minimize risk to marine mammals and turtles. Mitigation measures include (1) a schedule shift at Mayport (no testing in April to avoid higher densities of sea turtles); and (2) a detailed marine mammal and sea turtle mitigation plan that includes site selection and pre- and post-detonation monitoring. The marine mammal and sea turtle mitigation plan is summarized below and described in more detail in Section 5.0. Other mitigation measures include an exclusion zone to avoid impacts to routine vessel and air traffic, and measures to deal with unexploded ordnance in the unlikely event of a misfire.

2.2.3.1 Schedule Shift to Avoid High Turtle Densities at Mayport

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. Because there was no April survey in 1997, the high turtle numbers seen during April 1995 could not be confirmed. However, based on the 1995 data and the likely concentration of loggerheads in offshore waters prior to the nesting season, exclusion of April from the test schedule at Mayport is considered a reasonable precaution.

A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

2.2.3.2 Marine Mammal and Sea Turtle Mitigation Plan

A detailed Marine Mammal and Sea Turtle Protection/Mitigation Plan is presented in Section 5.0. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994 off the coast of southern California where marine mammal population densities are significantly greater than either the Norfolk or Mayport areas. Those shock trial operations included two 4,536 kg (10,000 lb) detonations and no deaths or injuries of marine mammals were detected (Naval Air Warfare Center, 1994). The mitigation plan for SEAWOLF shock testing would similarly avoid impacts and minimize risk to marine mammals and sea turtles in three main ways:

- Site selection. Initial, general site selection would be based on operational requirements and surveys. Within the general area selected for the shock test (e.g., Mayport or Norfolk), aerial surveys would be conducted to select a small test site having the fewest marine mammals and turtles. Results of a survey three weeks prior to the shock test would be used to select a single primary test site and two secondary test sites. One of these would be selected as the final test site based on aerial survey 2 to 3 days before each detonation.

- Pre-detonation monitoring. Starting six hours before each test, aerial and shipboard observers would search for marine mammals and turtles at the test site. Passive acoustic surveys would also be used to detect marine mammal calls. If any marine mammal or sea turtle were detected within the Safety Range of 3.7 km (2 nmi) radius around the detonation point, testing would be postponed. Testing would also be postponed if large sargassum rafts or jellyfish concentrations (both are indicators that turtles may be present) were detected in the Safety Range, or if flocks of seabirds or large fish schools were detected within 1.85 km (1 nmi) of the detonation point. Postponement would also occur in certain circumstances when a marine mammal or turtle is detected in a Buffer Zone extending from 3.7 to 5.6 km (2 to 3 nmi) from the detonation point. Detonation would not occur until monitoring indicated that the Safety Range is and will remain clear of marine mammals, sea turtles, large sargassum rafts, and large concentrations of jellyfish.

- Post-detonation monitoring. After the explosion, aerial and shipboard observers would survey the test site. A Marine Animal Recovery Team led by a marine mammal veterinarian would attempt to recover and treat any injured animals. If the survey showed that marine mammals or turtles were killed or injured or if any marine mammals or turtles are detected in the Safety Range immediately following a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary. Communications with stranding network personnel would be maintained throughout the SEAWOLF shock test period.

2.2.3.3 Vessel Exclusion Zone

An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. Notices to Airmen and Mariners would be published in advance of each test. An immediate HOLD on the test would be ordered if any unauthorized craft entered the exclusion zone and could not be contacted. The HOLD would continue until the exclusion zone was clear of unauthorized vessels. The size of the exclusion zone is necessary for operational security and to allow large vessels sufficient time to change course. It is also intended to minimize broad-band noise from ship engines, which could interfere with passive acoustic monitoring for marine mammals.

2.2.3.4 Unexploded Ordnance

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all mitigation measures in place as summarized above). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea.

2.3 COMPARISON OF ALTERNATIVES

Table 2-4 summarizes the analysis of alternatives with respect to project purpose and need, operational criteria, and environmental impacts. The "no action" alternative (including computer modeling and component testing) is not a reasonable alternative because it would not provide the information and data necessary to support an assessment of the survivability of the ship as required by 10 USC 2366. The "no action" alternative was not analyzed further, although a "no action" alternative is implicit in the environmental analysis throughout the document.

Alternative areas for the proposed shock testing of the SEAWOLF were evaluated by the Navy according to operational criteria. A location on the East Coast would best meet operational needs because that is where the SEAWOLF will be homeported and where all sea trials will occur. Three East Coast areas (Mayport, Norfolk, and Groton) were compared in detail with respect to operational criteria including proximity to a shock test support facility, submarine repair facility, ordnance storage/loading facility, and Navy assets, as well as other factors such as water depth, ship traffic, and weather/sea state. The analysis showed that the Mayport and Norfolk areas meet all of the Navy's operational requirements and are rated as nearly equal (Table 2-3).

Potential environmental impacts of shock testing at the Mayport and Norfolk areas are analyzed in the Environmental Consequences section of the FEIS and summarized in **Table 2-5**. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. These include minor and/or temporary impacts to the physical and biological environments and existing human uses of the test site. However, the two areas differ significantly with respect to potential impacts on marine mammals and sea turtles, as discussed below.

Table 2-4. Summary of alternatives analysis.

Basis for Comparison	Alternative			
	No Action (Includes Maximum Reasonable Amount of Computer Modeling and Component Testing)	**Shock Testing at an Offshore Location**		
		Groton Area	Mayport Area	Norfolk Area
Meets project purpose and need	No	Yes	Yes	Yes
Meets operational criteria	No further analysis (alternative does not meet project purpose and need)	No	Yes	Yes
Environmental impacts - General	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Most environmental impacts similar at the two areas (**see Table 2-5**)	
- Marine mammals	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	Mayport has about 5 to 7 times lower risk of marine mammal death or injury [a]	
- Sea turtles	No further analysis (alternative does not meet project purpose and need)	No further analysis (alternative does not meet operational requirements)	About the same risk of sea turtle death or injury at both areas [a]	

[a] Relative risk based on Table 2-6, using 1995 survey data from both areas as the most appropriate basis for comparison. If additional survey data from Mayport in 1997 are compared with Norfolk 1995 data, the risk to marine mammals would be 3.5 to 5 times lower at Mayport than at Norfolk, and the risk to sea turtles would be about 2 times lower at Norfolk than at Mayport.

Table 2-5. Comparison of potential environmental impacts of shock testing at the Mayport and Norfolk areas.

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
		IMPACTS EVALUATED UNDER NEPA [a] (impacts onshore and within U.S. territorial seas)	
Physical Environment	4.1.1	No significant direct or indirect impacts on geology and sediments, air quality and noise, or water quality.	Mayport and Norfolk similar.
Biological Environment	4.1.2	No significant direct or indirect impacts on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds.	Mayport and Norfolk similar.
Socioeconomic Environment	4.1.3	No significant direct or indirect impacts on the local economy, including ship traffic and the fishing and tourism industries.	Mayport and Norfolk similar.
		IMPACTS EVALUATED UNDER EXECUTIVE ORDER 12114 (impacts outside U.S. territorial seas)	
Physical Environment			
Geology and sediments	4.2.1.1	Metal fragments will be deposited on the seafloor. No cratering or sediment disturbance expected.	Mayport and Norfolk similar.
Air quality	4.2.1.2	Temporary, localized increase in concentrations of explosion products in the atmosphere. No hazard to marine or human life.	Mayport and Norfolk similar.
Water quality	4.2.1.3	Temporary, localized increase in concentrations of explosion products in the ocean. No hazard to marine life.	Mayport and Norfolk similar.

Table 2-5. (Continued).

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
Biological Environment			
Plankton	4.2.2.1	Plankton near the detonation point would be killed, but populations would be rapidly replenished through reproduction and mixing with adjacent waters.	Mayport and Norfolk similar.
Fish	4.2.2.2	Pelagic (water column) fish near the detonation point may be killed or injured. Many of the same species occur at both areas. Demersal (bottom) fish will not be affected.	Mayport and Norfolk similar.
Marine mammals	4.2.2.3	Mitigation will minimize risk, but marine mammals could be killed or injured if not detected within the Safety Range. At greater distances, animals may experience brief acoustic harassment, with negligible effects on marine mammal individuals and populations.	About 5 to 7 times lower risk of marine mammal death or injury at Mayport.[b]
Sea turtles	4.2.2.4	Mitigation will minimize risk, but turtles could be killed or injured if not detected within the Safety Range. At greater distances, turtles may experience brief acoustic harassment, with negligible effects on sea turtle individuals and populations.	About the same risk of sea turtle death or injury at both areas.[b]
Benthos	4.2.2.5	No direct effect on benthic organisms is expected. No habitat disturbance is expected. Metal fragments deposited on the seafloor will be colonized by invertebrates and attract fish.	Mayport and Norfolk similar.
Seabirds	4.2.2.6	Seabirds above the detonation point could be killed or stunned by the plume of water ejected into the air. Other seabirds resting or feeding at the surface could be killed or injured by the shock wave. It is unlikely that more than a few birds would be affected.	Mayport and Norfolk similar.

Table 2-5. (Continued).

Environmental Component	Section of FEIS Analyzing Impacts	Description of Potential Impact	Comparison of Alternative Areas
Socioeconomic Environment			
Commercial and recreational fisheries	4.2.3.1	Individuals of commercial or recreational fishery species may be killed or injured, but no significant impact on fishery stocks is expected. Commercial and recreational fishing activities within 18.5 km (10 nmi) of the detonation point will be temporarily interrupted.	Mayport and Norfolk similar.
Ship traffic	4.2.3.2	Ship traffic passing within 18.5 km (10 nmi) of the detonation point would need to alter course or be escorted from the area.	Mayport and Norfolk similar.

[a] Shore support operations and movement of vessels and aircraft within territorial seas are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

[b] Relative risk based on Table 2-6, using 1995 survey data from both areas as the most appropriate basis for comparison. If additional survey data from Mayport in 1997 are compared with Norfolk 1995 data, the relative risk to marine mammals would be 3.5 to 5 times lower at Mayport than at Norfolk, and the risk to sea turtles would be about 2 times lower at Norfolk than at Mayport.

Marine Mammal Impacts. Potential impacts on marine mammals are analyzed in detail in Section 4.2.2.3 of the FEIS and summarized in **Table 2-6**. Potentially significant direct impacts include mortality, injury, and acoustic harassment. At either Mayport or Norfolk, mitigation methods described in Section 5.0 would result in selection of a small test site with very low densities of marine mammals. In addition, most marine mammals would be detectable during pre-detonation aerial surveys, surface observations, and passive acoustic monitoring, minimizing the risk of death or injury. However, because of the large difference in marine mammal densities between areas, the risk of a marine mammal being killed or injured would be significantly lower at Mayport.

The 1995 aerial survey data are the most appropriate basis for comparing estimated impacts, because data are available from both Mayport and Norfolk during the same time period. Based on these data, maximum potential impacts from five detonations at Mayport are estimated to be 1 mortality, 1 injury, and 1,247 marine mammals experiencing acoustic harassment. Maximum potential impacts from five detonations at the Norfolk area are 5 mortalities, 7 injuries, and 7,805 acoustic harassments. Therefore, the potential for mortality, injury, and acoustic harassment is about 5 to 7 times lower at Mayport than at Norfolk. If the 1997 Mayport survey data were used for the calculations, the estimates would be 1 mortality, 2 injuries, and 1,788 marine mammal acoustic harassments, which would be 3.5 to 5 times lower than at Norfolk (Table 2-6). Mitigation would be about equally effective at either area (93%).

Sea Turtles. Potential impacts on sea turtles are analyzed in detail in Section 4.2.2.4 of the FEIS and summarized in **Table 2-6**. Potentially significant direct impacts include mortality, injury, and acoustic harassment. At either Mayport or Norfolk, mitigation methods described in Section 5.0 would result in selection of a small test site with very low densities of sea turtles. However, mitigation would be much less effective for sea turtles than for marine mammals because adult sea turtles are relatively small, do not swim in groups, are rarely on the surface, and do not make sounds. At either Mayport or Norfolk, mitigation effectiveness is estimated to be about 8%. Loggerhead turtles make up most of the population at both areas and are the species most likely to be affected. Juvenile and hatchling sea turtles are unlikely to be affected because detonation would be postponed if large sargassum rafts (the preferred habitat of these turtles) were present within the Safety Range.

The 1995 aerial survey data are the most appropriate basis for comparing estimated impacts, because data are available from both Mayport and Norfolk during the same time period. Based on these data, maximum potential impacts from five detonations at Mayport are estimated to be 4 mortalities, 6 injuries, and 652 turtles experiencing acoustic harassment. Estimated impacts from five detonations at Norfolk are 4 mortalities, 6 injuries, and 468 turtles experiencing acoustic harassment. Therefore, the potential for mortality and injury is about the same at either Mayport or Norfolk. If the 1997 Mayport data were used for the calculations, the estimates would be 8 mortalities, 14 injuries, and 1,679 acoustic harassments, which would be twice the number of turtle mortalities and injuries as Norfolk and about 3.6 times more acoustic harassments than Norfolk.

Table 2-6. Comparison of Mayport and Norfolk areas with respect to potential impacts on marine mammals and sea turtles.

Criterion	Mayport (1995 data)	Mayport (1997 data)	Norfolk (1995 data)
MARINE MAMMALS			
• Potential mortality (with mitigation), total number of animals from five detonations[a]	0-1	0-1	0-5
• Potential injury (with mitigation), total number of animals from five detonations[a]	0-1	0-2	0-7
• Potential acoustic harassment (with mitigation), total number of animals from five detonations[a]	92-1,247	171-1,788	488-7,805
• Mitigation effectiveness[b]	93%	93%	93%
SEA TURTLES			
• Potential mortality (with mitigation), total number of animals from five detonations[a]	0-4	0-8	0-4
• Potential injury (with mitigation), total number of animals from five detonations[a]	0-6	0-14	0-6
• Potential acoustic harassment (with mitigation), total number of animals from five detonations[a]	15-652	34-1,679	0-468
• Mitigation effectiveness [b]	8%	8%	8%

[a] From Table 4-9 (marine mammals) or Table 4-12 (sea turtles). Expected number of animals within maximum ranges for mortality, injury, or acoustic harassment, taking into account mitigation effectiveness for each species.

[b] From Table 4-9 (marine mammals) or Table 4-12 (sea turtles). Mitigation effectiveness for mortality and injury is equal to the percent of total animals present during a single shock test likely to be detected by aerial and surface observers.

Conclusion. Most environmental impacts of shock testing would be similar at Mayport or Norfolk. However, the two areas differ significantly with respect to potential impacts on marine mammals and sea turtles. The most significant environmental difference between the areas is the much lower risk of impacts to marine mammals at the Mayport area. Using the 1995 survey data from both areas as the most appropriate basis for comparison, the risk of mortality and injury of marine mammals is about 5 to 7 times lower at Mayport than at Norfolk, whereas the risk to sea turtles is about the same at the two areas. This comparison strongly favors Mayport as the preferred alternative. If the 1997 Mayport survey data are compared with 1995 Norfolk data, the risk of marine mammal mortality and injury would be 3.5 to 5 times lower at Mayport, but the risk to sea turtles would be 2 times lower at Norfolk. This comparison also indicates that Mayport has the lowest overall risk of significant environmental impacts. Considering all components of the physical, biological, and socioeconomic environment, potential impacts would be less at the Mayport area.

2.4 PREFERRED ALTERNATIVE

Based on the preceding discussion, the preferred alternative is to shock test the SEAWOLF submarine offshore of Mayport, Florida, between 1 May and 30 September with mitigation to minimize risk to marine mammals and turtles. This alternative meets the project purpose and need, satisfies operational criteria, and minimizes environmental impacts. The Norfolk area also meets the project purpose and need and satisfies operational criteria; however, the higher density of marine mammals in the area could increase the risk of impacts.

For the preferred alternative, the FEIS estimates that marine mammal impacts could include up to 1 mortality, 2 injuries, and 1,788 harassments (these numbers are based on the higher densities observed during 1997 Mayport surveys). In comparison, the DEIS estimated 1 mortality, 5 injuries, and 570 acoustic harassments. The difference reflects significant changes to the impact criteria and calculations for marine mammals (see Appendix C for summary and rationale), as well as incorporation of new Mayport survey data. As a final layer of conservatism in estimating potential impacts of the preferred alternative, the Navy has decided to retain the DEIS estimates where they are higher than the FEIS estimates. Therefore, the maximum marine mammal impacts of the preferred alternative are estimated to be 1 mortality, 5 injuries, and 1,788 harassments.

Similarly, for the preferred alternative the FEIS estimates that sea turtle impacts could include up to 8 mortalities, 14 injuries, and 1,679 acoustic harassments (these numbers are based on the higher densities observed during 1997 Mayport surveys). In comparison, the DEIS estimated 6 mortalities, 30 injuries, and 293 acoustic harassments. As a final layer of conservatism in estimating potential impacts of the preferred alternative, the Navy has decided to retain the DEIS estimates where they are higher than the FEIS estimates. Therefore, the maximum turtle impacts of the preferred alternative are estimated to be 8 mortalities, 30 injuries, and 1,679 harassments.

3.0 EXISTING ENVIRONMENT

This section describes a baseline of the physical, biological, and socioeconomic environment of the Mayport and Norfolk areas. It focuses on topics that are most relevant to evaluating potential impacts of the proposed action. Additional information for the Mayport area is provided in the environmental documentation prepared by the Department of the Navy (1995a).

The environment is similar at the Mayport and Norfolk areas because both are located along the East Coast at the same water depth and about the same distance from shore. To avoid redundancy, separate sections for Mayport and Norfolk are not presented. Instead, the environment at the two areas is contrasted within each major subsection.

3.1 PHYSICAL ENVIRONMENT

3.1.1 Geology and Sediments

Mayport

The Mayport area lies near the shelf break, a region of relatively steep slope that separates the continental shelf from the Florida-Hatteras continental slope. The continental shelf, which extends out to the 200 m (656 ft) depth contour, is about 117 km (63 nmi) wide offshore of Mayport. The Florida-Hatteras continental slope extends seaward of the area down to depths of about 2,000 m (6,560 ft). The shelf break region where the area is located has a bottom slope of about 3%.

Sediments at the Mayport area are mainly sand (Department of the Interior [DOI], Minerals Management Service [MMS], 1983a). Small portions of the area have mainly silty sand, and sediments along the southern portion of the area are a mixture of sand, silt, and clay. There are no known hard bottom areas or reefs within 1.85 km (1 nmi) of the Mayport area (Department of the Navy, 1995a). For the FEIS, the Navy also reviewed reports on the SEAMAP bottom mapping program for Georgia and northeastern Florida (Van Dolah et al., 1994) and conducted a computer search of the SEAMAP database. The data confirm that the seafloor near the Mayport area is predominantly soft bottom, with no hard bottom identified within 1.85 km (1 nmi) of the area.

Norfolk

The Norfolk area lies just inshore of the continental shelf/slope break, which is at a depth of about 200 m (656 ft). The continental shelf is about 120 km (65 nmi) wide east of Norfolk. The continental slope is seaward of the shelf edge and extends down to depths of about 2,000 m (6,560 ft). The shelf break region where the area is located is steeper than the Mayport area, with bottom slope ranging from about 3% to 8%.

Sediments overlying the southern portion of the Norfolk area are primarily sand. Areas of sand, silt, and clay occur offshore of the central and northern portions of the Norfolk area (DOI, MMS, 1983b). An initial review indicated no known hard bottom areas or reefs within 1.85 km (1 nmi) of the Norfolk area (Department of the Navy, 1995a). For the FEIS, the

Navy also reviewed the report on the SEAMAP bottom mapping program for North Carolina (Moser et al., 1995) and conducted a computer search of the SEAMAP database. The data confirm that the seafloor near the Norfolk area is predominantly soft bottom. However, four points within 1.85 km (1 nmi) of the area were identified as potential hard bottom and were excluded as test sites.

3.1.2 Physical Oceanography and Meteorology

The Gulf Stream is a major influence on the physical oceanography of both the Mayport and Norfolk areas. Though the continental shelf is broad at both areas, at the Mayport area the Gulf Stream flows northward over the slope and generally along the continental shelf edge, but at the Norfolk area it veers easterly and flows some distance away from the continental shelf. The northeasterly turn of the Gulf Stream occurs at a feature called the Charleston Bump, located northeast of the Mayport area (**Figure 3-1**). Cape Hatteras is an important point along the path of the Gulf Stream, as this is where it begins its more easterly turn into the North Atlantic and is no longer constrained by the continental shelf and slope. Between the Charleston Bump and Cape Hatteras, the Gulf Stream exhibits features such as rings, meanders, and filaments that can affect shelf waters (Texas Instruments, Inc., 1979; Science Applications International Corporation, 1984; Florida Institute of Oceanography, 1986).

Mayport

Currents and water masses at the Mayport area are mainly influenced by the Gulf Stream's deflections, meanders, and flow. Off northeastern Florida, the Gulf Stream flows consistently northward. Mean current speeds at the Mayport area range from 180 cm/sec (3.5 kt) near the surface to 40 cm/sec (0.8 kt) near the bottom (Lee and Waddell, 1983). Additional current speed measurements from the region range from 30 cm/sec (0.6 kt) in December to 50 cm/sec (1.0 kt) in July (Department of the Navy, 1989).

The two main water masses at the Mayport area are shelf water and the Gulf Stream. The average position of the Gulf Stream's western wall is over or just inshore of the area throughout the year. Although the Gulf Stream's position remains fairly stable in this region, lateral meandering does occur (Bane et al., 1981; Lee et al., 1981; Department of the Navy, 1995a). Depending on their phase, meanders can cause the Gulf Stream to be shoreward or well seaward of the area. Frontal eddies, filaments, warm core rings, and cold core rings may form during development of a meander and move across the Mayport area and onto the shelf.

Wave heights offshore northeastern Florida vary seasonally and average 1.2 m (3.9 ft). Waves are smallest from April through September (0.8 to 1.2 m, or 2.6 to 3.9 ft) and largest from October to March (1.3 to 1.6 m, or 4.3 to 5.2 ft). Waves greater than 1 m (3.3 ft) occur most frequently during winter and least frequently during summer (Department of the Navy, 1989).

Shipboard observations indicate that the Mayport area has good visibility (≥18.5 km or 10 nmi) most of the time during the April through September period (Department of the Navy, 1989). The area also has a low incidence of fog during these months. Data are presented in Section 2.2.2.1.

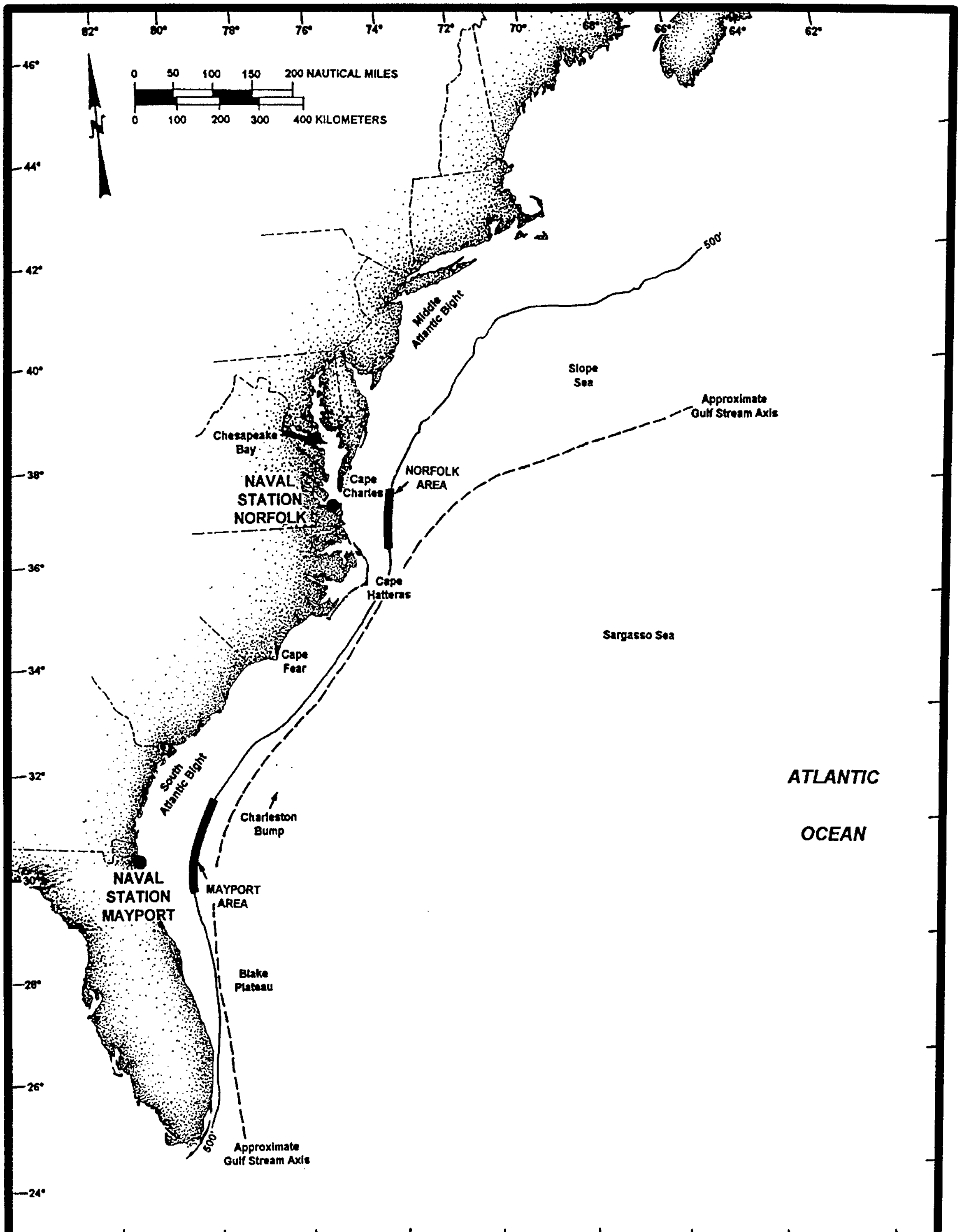


Figure 3-1. Regional oceanographic features of the Atlantic coast and the approximate Gulf Stream axis (Adapted from: Science Applications International Corporation, 1993).

Norfolk

The Gulf Stream flows east away from the shelf/slope boundary at the Norfolk area, and the position of its western wall changes seasonally (Department of the Navy, 1995a). During spring, the average position of the western wall is more than 37 km (20 nmi) east of the area. During fall, the Gulf Stream meanders northward and over the area (Marine Geosciences Applications, Inc., 1984). The circulation regime in the area is dynamic due to a confluence of several water masses including the Slope Sea Gyre, shelf water, and Gulf Stream. Frontal eddies, filaments, warm core rings, and cold core rings form as the result of Gulf Stream meandering along the shelf and slope.

Current speeds at the Norfolk area vary seasonally and are greatly influenced by Gulf Stream meanders. Current speeds average 30 cm/sec (0.6 kt). When the Gulf Stream is displaced in winter (October to January), surface currents range from about 20 to 50 cm/sec (0.4 to 1.0 kt) to the south (Science Applications International Corporation, 1987). When the Gulf Stream returns to its original position, this southerly flow decreases.

Annual mean wave height observed on board ships and reported by the National Climatic Data Center (1992) was 1.2 m (3.9 ft). Wave heights were lowest from April through September (0.9 to 1 m, or 2.9 to 3.3 ft) and highest from October to March (1.1 to 1.5 m, or 3.6 to 4.9 ft). The percent frequency of waves higher than 1 m (3.3 ft) at the Norfolk area ranges from 60% to 90% in winter months (Department of the Navy, 1989).

Shipboard observations indicate the Norfolk area has good visibility (≥18.5 km or 10 nmi) most of the time during the April through September period (Department of the Navy, 1989). The area has a low incidence of fog during these months. Data are presented in Section 2.2.2.1.

3.1.3 Water Quality

Water quality at the Mayport and Norfolk areas has been described by the Department of the Navy (1995a). Because both areas are well offshore, water quality is excellent, with high water clarity, low concentrations of suspended matter, dissolved oxygen concentrations at or near saturation, and low concentrations of contaminants such as trace metals and hydrocarbons.

3.2 BIOLOGICAL ENVIRONMENT

This section describes the potentially affected biological environment of the Mayport and Norfolk areas. Hard bottom habitats, both natural and artificial, are not discussed because none are present within 1.85 km (1 nmi) of the Mayport area and potential hard bottom areas at Norfolk were excluded (see Section 2.2.2.2).

3.2.1 Plankton

Information on phytoplankton, primary productivity, zooplankton, ichthyoplankton, neuston, and *Sargassum* communities at the Mayport and Norfolk areas has been summarized by the Department of the Navy (1995a). A discussion of ichthyoplankton is included here due to the importance of commercial and recreational fisheries in the region. *Sargassum* communities are also described as they are an important habitat for small fish and juvenile sea turtles.

3.2.1.1 Ichthyoplankton

Most fish inhabiting the Atlantic Ocean have eggs and larvae that become part of the planktonic community for about 10 to 100 days (depending on the species). Variability in survival and transport of ichthyoplankton (fish eggs and larvae) is thought to be an important factor affecting the size of adult fish populations (Underwood and Fairweather, 1989; Doherty and Fowler, 1994).

Very few fish eggs and larvae are found in the Gulf Stream. Thus, abundances of ichthyoplankton at either the Mayport or Norfolk area could be expected to vary substantially depending on the position of the Gulf Stream and its filaments and meanders.

Mayport

Fish eggs and larvae found in the South Atlantic Bight are mainly from warm temperate and tropical regions (Powles and Stender, 1976). The warm temperate species are spawned within the Bight, whereas the tropical eggs and larvae are carried into the area from more southerly spawning locations. Several of the region's commercially important species including Atlantic menhaden, Atlantic croaker, spot, summer flounder, and southern flounder migrate from nearshore shelf waters to the shelf edge to spawn (Miller et al., 1984). The larvae of these species are transported back across the shelf and eventually into inshore/estuarine nursery areas.

Within the South Atlantic Bight, fish eggs and larvae are generally distributed in an onshore/offshore pattern (Powles and Stender, 1976). Depending on the position of the Gulf Stream front, the ichthyoplankton at the Mayport area is likely to be a mixture of slope and shelf/slope groups. The slope group is typified by lanternfish throughout the year. During spring, mackerel larvae reach peak abundance. Members of the slope group at other times of the year include inshore species such as gobies, wrasses, and flounders. The shelf/slope group includes fish such as lefteye flounders, jacks, mullets, bluefish, filefish, goatfish, and sea basses; several of these are economically important species. The composition and abundance of ichthyoplankton at any particular time will depend upon the position of the Gulf Stream front (Govoni, 1993).

Norfolk

Fish eggs and larvae found in the Mid-Atlantic Bight come from warm temperate, cold temperate, and boreal regions (Doyle et al., 1993). In general, the most abundant fish eggs and larvae found during winter months are those of cold temperate species originating in more northerly waters. During spring, summer, and fall months the ichthyoplankton is dominated by warm temperate species originating from more southerly waters.

Within the Mid-Atlantic Bight, fish eggs and larvae are generally distributed in an onshore/offshore pattern including inner shelf, outer shelf, and slope/oceanic groups (Doyle et al., 1993). Factors such as temperature, salinity, frontal boundary positions, and locations of adult spawning sites contribute to the formation and maintenance of these groups

(Grosslein and Azarovitz, 1982; Cowen et al., 1993). Depending on the position of the Gulf Stream front, the outer shelf and slope/oceanic groups would be the most likely to occur at the Norfolk area. The lanternfish *Benthosema glaciale* and *Ceratoscopelus maderensis* define the slope/oceanic group (Doyle et al., 1993). *Benthosema glaciale* reaches peak abundance in winter and spring, whereas *C. maderensis* is most abundant in spring, summer, and fall. The slope/oceanic group also includes shelf species whose distribution extends somewhat into the slope/oceanic areas. In spring, Atlantic mackerel larvae are abundant, and in summer silver hake and some flatfish larvae occur with *C. maderensis*. The outer shelf group includes witch flounder, silver hake, Atlantic bonito, cusk-eels, and species from more southerly waters such as razorfish, lefteye flounders, and gobies (Hare and Cowen, 1991; Cowen et al., 1993; Doyle et al., 1993).

3.2.1.2 Sargassum Communities

An important component of the planktonic community is the floating brown alga *Sargassum*, a seaweed that permanently drifts at the surface in warm waters (Fine, 1970). The Gulf Stream provides a fairly constant input of drifting weed and its associated fauna to the Atlantic community. It has been estimated that *Sargassum* covers nearly two million square miles at a density of two to five tons per square mile (Dooley, 1972).

Sargassum normally occurs in scattered individual clumps ranging in size from 10 to 50 cm (4 to 20 in.) in diameter. Clumps may be spaced several hundred meters apart (Butler et al., 1983). Accumulation of *Sargassum* and other flotsam in lines is often an indicator of a convergence zone between water masses. Convergence zones are sites of considerable biological activity, and many species including juvenile sea turtles and pelagic fish will gather along these zones whether *Sargassum* or other flotsam is present or not (Carr, 1986). Fishermen also use flotsam as visual cues to find convergence zones.

Over 100 different species have been identified as associated with floating *Sargassum* (Morris and Mogelberg, 1973), although the number of routine resident species within a typical *Sargassum* community is considerably lower (Butler et al., 1983). *Sargassum* is also important as cover for many temporary associates such as juvenile fish and sea turtles. Some of the temporary associates are seasonal residents, whereas others are intermittent residents or accidental strays (Butler et al., 1983).

As many as 54 fish species are closely associated with floating *Sargassum* at some point in their life cycle, but only two spend their entire lives there: the sargassumfish and the sargassum pipefish (Adams, 1960; Dooley, 1972; Bortone et al., 1977). Most fish associated with *Sargassum* are temporary residents, such as juveniles of species which reside in shelf or coastal waters as adults (McKenney et al., 1958; Berry, 1959; Parin, 1970; Dooley, 1972; Bortone et al., 1977). However, several larger species of recreational or commercial importance including dolphinfish, yellowfin tuna, blackfin tuna, skipjack tuna, Atlantic bonito, little tunny, and wahoo feed on the small fish and invertebrates attracted to *Sargassum* (Morgan et al., 1985).

Sargassum communities at the Mayport and Norfolk areas should be generally similar. However, *Sargassum* communities off Virginia are less diverse than those off the Florida coast (Stoner and Greening, 1984).

3.2.2 Pelagic Fish

Pelagic (water column) fish are often grouped by their water mass preference. Those species preferring shelf waters are classified as coastal pelagic, and those species preferring oceanic waters (particularly the western edge of the Gulf Stream) are classified as oceanic pelagic. Both areas have a mixture of oceanic and coastal pelagic fish. Additional information on commercially and recreationally important fishery species is provided in Section 3.3.1.

Mayport

Because the Mayport area is dominated by the Gulf Stream, fish found there are primarily oceanic pelagic. This group includes highly migratory species such as dolphinfish, blue marlin, white marlin, sailfish, swordfish, tunas, and wahoo. In general, oceanic pelagic species associate with the western edge of the Gulf Stream and travel near this edge as they migrate through the area. Flotsam accumulates along the Gulf Stream/shelf water interface where downwelling occurs (Carr, 1986). Dolphinfish, tunas, and wahoo feed on small fish and invertebrates associated with drifting *Sargassum* and other flotsam (Manooch et al., 1983; Manooch and Mason, 1984; Morgan et al., 1985). The flotsam/*Sargassum* community has been described above under Plankton.

Although coastal pelagic fish normally occur inshore of the area, some species may occasionally occur near the Mayport area during migratory movements or extreme lateral (eastward) deflections of the Gulf Stream. Spanish mackerel, king mackerel, little tunny, jacks, requiem sharks, and cobia represent the larger predatory members of the coastal pelagic group found in this area. Smaller coastal pelagic fish include Atlantic menhaden, round scad, dwarf herring, butterfish, and chub mackerel. Wenner et al. (1980) collected dwarf herring, round scad, and butterfish in trawl samples taken just north of the Mayport area offshore of Savannah, Georgia between a water depth of 110 to 183 m (361 to 600 ft).

Norfolk

Highly migratory forms such as yellowfin tuna, bigeye tuna, bluefin tuna, white marlin, spearfish, blue marlin, sailfish, swordfish, wahoo, and dolphinfish comprise the oceanic pelagic species group at the Norfolk area. All life stages (eggs, larvae, juveniles, adults) of these species are closely associated with the Gulf Stream and could occur in the area. Some species, particularly dolphinfish, tunas, and wahoo feed upon small fish attracted to *Sargassum* and other flotsam (Manooch et al., 1983; Manooch and Mason, 1984; Morgan et al., 1985). Oceanic pelagic fish are present year round in the area, with billfish, dolphinfish, and tunas reaching peak abundances during spring, summer, and fall months.

Grosslein and Azarovitz (1982) reported that sharks were the most well represented group of coastal pelagic fish in the vicinity of the Norfolk area. Although primarily migrants or strays from outside their principal range, 47 shark species were reported from the coastal and oceanic waters near the Norfolk area (Grosslein and Azarovitz, 1982). About a dozen of the shark species caught were large, and all were seasonal migrants. Most of these sharks did not normally occur in large numbers. Among the five most commonly encountered species in the depth of the Norfolk area, the sandbar shark is generally restricted to shelf waters. Other commonly encountered sharks were the blue shark, dusky shark, mako sharks, and hammerheads. Although occasionally found in relatively shallow water, these sharks usually frequent deep ocean waters and are considered oceanic pelagic.

A small number of bony, coastal pelagic fish were reported from the approximate depth of the Norfolk area (Grosslein and Azarovitz, 1982). As with the sharks, most of these species were migrants, and not found in the area during the entire year. The predominant species were the Atlantic mackerel, bluefish, Atlantic menhaden, alewife, and butterfish. Holland and Keefe (1977) also reported bycatch of chub mackerel during trawling out to 380 m (1,247 ft) off Virginia. Other coastal pelagic species potentially occurring near the Norfolk area include little tunny, king mackerel, Spanish mackerel, and cobia. These species are usually more abundant inshore, but could venture into the area.

3.2.3 Marine Mammals

Marine mammals potentially occurring at the Mayport and Norfolk areas are listed in **Table 3-1**. The table indicates the potential presence of each species based on historical sightings, 1990-1995 strandings (Odell, 1996; Potter, 1996), and aerial surveys (Department of the Navy, 1995b, 1998). Species descriptions are provided in Appendix B.

To supplement historical information, monthly aerial surveys were conducted at the Mayport and Norfolk areas from April through September 1995 (Department of the Navy, 1995b). Methods are summarized in Appendix B. Parallel survey transects were 1.85 km (1 nmi) apart, with each transect extending 7.4 km (4 nmi) to the east and west of the 152 m (500 ft) depth contour at each area. Standard methods were used, as developed by the NMFS (Blaylock, 1994; Hoggard, 1994; Mullin, 1994). Observers on both sides of the aircraft scanned a swath of sea surface for marine mammals. The total area viewed during each survey was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area.

Additional surveys were conducted at Mayport (the preferred alternative area) during May through September 1997 using essentially the same methods (Department of the Navy, 1998). However, the Partenavia aircraft used in 1997 had bubble windows that eliminated the "blind spot" beneath the plane. The area viewed along each transect in 1997 was about 20% greater than in 1995. Total area viewed during each 1997 survey was about 3,551 km^2 (1,035 nmi^2) instead of 2,948 km^2 (858 nmi^2). Observed densities in 1997 were calculated using this larger area.

Observed densities from aerial surveys do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted mean densities were developed for each species as explained in Appendix B. **Figure 3-2** shows observed and adjusted mean densities of total marine mammals at Mayport and Norfolk on each of the aerial surveys. Mean density estimates for each species seen during the surveys are listed in **Table 3-2** (Mayport), and **Table 3-3** (Norfolk).

Table 3-1. Species of marine mammals potentially occurring at the Mayport and Norfolk areas based on literature, recent strandings, and 1995 and 1997 aerial surveys.

Common and Scientific Name	Status[a]	Historical Presence[b]		Strandings, 1990-1995[c]		Aerial Surveys[d]		
		Mayport	Norfolk	Mayport	Norfolk	1995 Mayport	1997 Mayport	1995 Norfolk
BALEEN WHALES								
Blue whale (*Balaenoptera musculus*)	E, S	X	X	--	--	--	--	--
Bryde's whale (*Balaenoptera edeni*)	--	X	X	X	--	--	--	--
Fin whale (*Balaenoptera physalus*)	E, S	X	⊠	X	X	--	--	⊠
Humpback whale (*Megaptera novaeangliae*)	E, S	X	⊠	X	⊠	--	--	X
Minke whale (*Balaenoptera acutorostrata*)	--	X	⊠	--	X	--	--	X
Northern right whale (*Eubalaena glacialis*)	E, S	X	X	--	--	--	--	--
Sei whale (*Balaenoptera borealis*)	E, S	X	⊠	--	--	--	--	X
TOOTHED WHALES AND DOLPHINS								
Sperm Whales								
Dwarf sperm whale (*Kogia simus*)	S	X	X	X	X	--	--	--
Pygmy sperm whale (*Kogia breviceps*)	S	X	X	⊠	X	--	--	--
Sperm whale (*Physeter macrocephalus*)	E, S	X	X	X	X	X	X	X
Beaked Whales								
Blainville's beaked whale (*Mesoplodon densirostris*)	S	X	X	--	X	--	--	--
Cuvier's beaked whale (*Ziphius cavirostris*)	S	X	X	X	X	--	--	X
Gervais' beaked whale (*Mesoplodon europaeus*)	S	X	X	--	X	--	--	--
Northern bottlenose whale (*Hyperoodon ampullatus*)	--	--	X	--	--	--	--	--
Sowerby's beaked whale (*Mesoplodon bidens*)	S	--	X	--	--	--	--	--
True's beaked whale (*Mesoplodon mirus*)	S	X	X	--	X	--	--	--
Dolphins and Porpoises								
Atlantic spotted dolphin (*Stenella frontalis*)	S	⊠	⊠	X	X	⊠	⊠	●
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	S	--	X	--	X	--	--	--
Bottlenose dolphin (*Tursiops truncatus*)	PT, S	⊠	⊠	●	●	⊠	●	●
Clymene dolphin (*Stenella clymene*)	--	X	X	--	--	⊠[e]	●[e]	●[e]
Common dolphin (*Delphinus delphis*)	S	X	⊠	--	X	--	--	●

Table 3-1. (continued).

Common and Scientific Name	Status[a]	Historical Presence[b]		Strandings, 1990-1995[c]		Aerial Surveys[d]		
		Mayport	Norfolk	Mayport	Norfolk	1995 Mayport	1997 Mayport	1995 Norfolk
False killer whale (*Pseudorca crassidens*)	--	x	x	--	--	--	--	--
Fraser's dolphin (*Lagenodelphis hosei*)	--	x	x	--	--	--	--	--
Harbor porpoise (*Phocoena phocoena*)	PT	--	x	--	●	--	--	--
Killer whale (*Orcinus orca*)	--	x	x	--	--	--	--	--
Melon-headed whale (*Peponocephala electra*)	--	x	x	--	--	--	--	--
Pantropical spotted dolphin (*Stenella attenuata*)	S	⊠	⊠	--	--	●	x	●
Pygmy killer whale (*Feresa attenuata*)	--	x	x	--	--	--	--	--
Pilot whales (*Globicephala* spp.)[f]	S	⊠	⊠	--	⊠	--	⊠	●
Risso's dolphin (*Grampus griseus*)	--	⊠	⊠	--	x	●	●	●
Rough-toothed dolphin (*Steno bredanensis*)	--	x	x	--	--	--	⊠	--
Spinner dolphin (*Stenella longirostris*)	--	⊠	⊠	--	--	⊠	⊠	⊠
Striped dolphin (*Stenella coeruleoalba*)	--	x	x	--	⊠	⊠[e]	●[e]	⊠
PINNIPEDS								
Harbor seal (*Phoca vitulina*)	--	--	x	--	x	--	--	--

[a] Status: E = endangered and PT = proposed threatened under the Endangered Species Act; S = strategic stock under Marine Mammal Protection Act. The PT designation for bottlenose dolphin applies only to the coastal migratory stock, which is not likely to occur at either offshore area.

[b] Presence based on literature/reports: -- not present x presence possible ⊠ presence likely. Sources: Leatherwood et al., 1976; CETAP, 1982; Duffield et al., 1983; Payne et al., 1984; Lee, 1985a; Duffield, 1986; Kenney et al., 1986; Winn et al., 1986; Kenney and Winn, 1987; Kraus et al., 1988, 1993; Knowlton and Kraus, 1989; Manomet Bird Observatory, 1989; Hersh and Duffield, 1990; Kenney, 1990; Mayo and Marx, 1990; DOI, MMS, 1990; Kraus and Kenney, 1991; Mitchell, 1991; NMFS, 1991a,b; Payne and Heinemann, 1993; Schaeff et al., 1993; Blaylock and Hoggard, 1994.

[c] Total individuals stranded from 1990 through 1995: -- none x 1-9 ⊠ 10-99 ● 100 or more. Mayport column includes strandings from Cape Canaveral north through South Carolina between May 1 and September 30. Norfolk column includes strandings from Cape Hatteras north through New Jersey between April 1 and September 30. Data from Odell (1996) and Potter (1996).

[d] Number seen during 1995 or 1997 aerial surveys: -- none x 1-9 ⊠ 10-99 ● 100 or more.

[e] Entry based on presence of numerous *Stenella* spp. (not identified to species).

[f] The long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

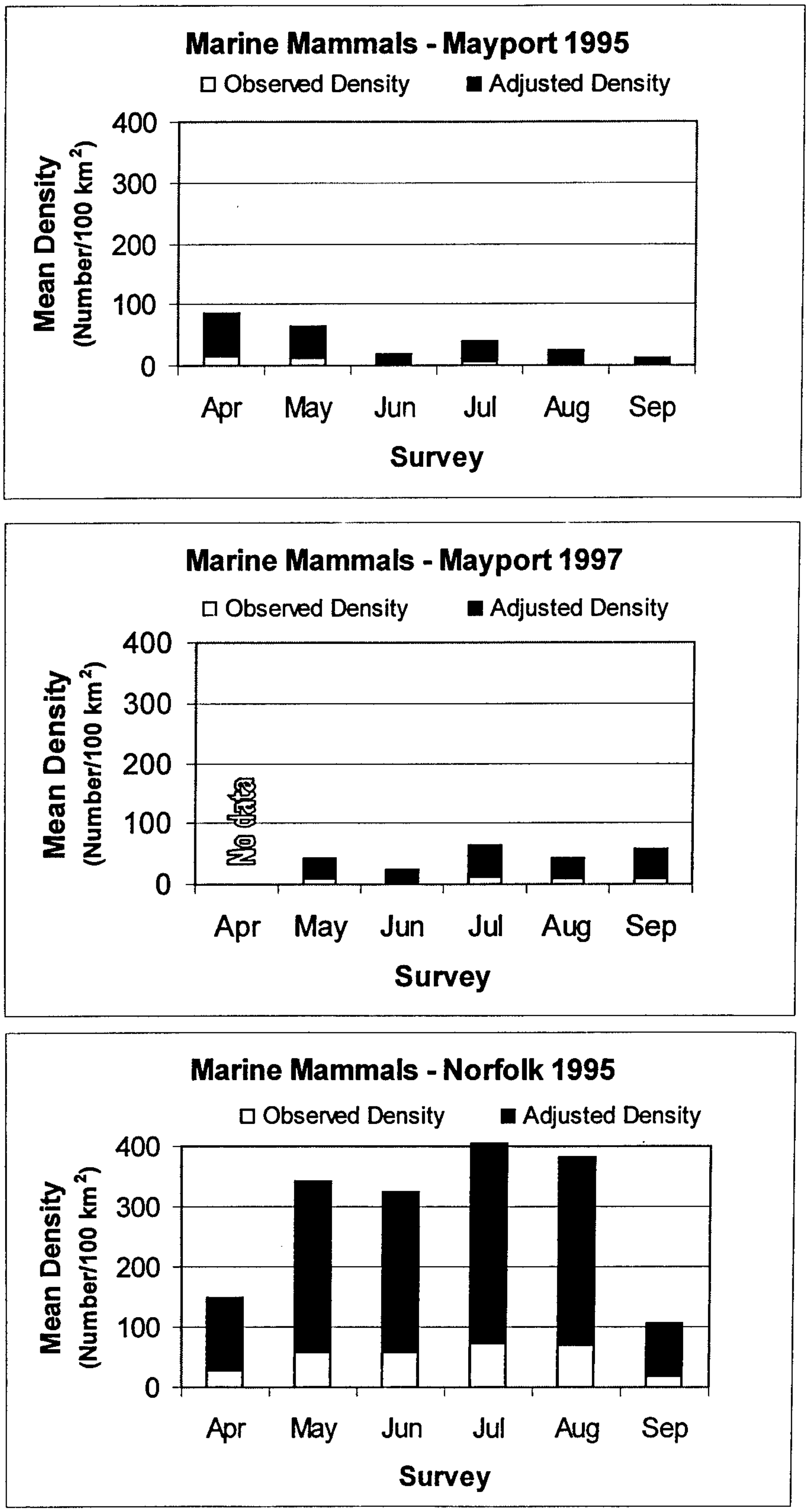


Figure 3-2. Marine mammal densities at the Mayport and Norfolk areas, based on aerial surveys conducted during April-September 1995 at both areas and May-September 1997 at Mayport (Data from: Department of the Navy, 1995b, 1998). Observed densities were adjusted to account for submerged and undetected individuals (see Appendix B).

Table 3-2. Observed and adjusted mean densities of marine mammals at the Mayport area based on 1995 and 1997 aerial surveys (Data from: Department of the Navy, 1995b. 1998). Because shock testing would not be conducted in April at Mayport, calculations are based on May-September surveys only.

Species	1995 Surveys		1997 Surveys	
	Observed Grand Mean Density (Animals/100 km^2)	Adjusted Grand Mean Density[a] (Animals/100 km^2)	Observed Grand Mean Density (Animals/100 km^2)	Adjusted Grand Mean Density[a] (Animals/100 km^2)
TOOTHED WHALES AND DOLPHINS				
Atlantic spotted dolphin	0.522	2.902	0.439	2.441
Bottlenose dolphin	0.529	2.940	3.323	18.461
Bottlenose/Atlantic spotted dolphin	0.176	0.980	0.907	5.038
Clymene/spinner/striped dolphin	0.129	0.716	0.817	4.537
Pantropical spotted dolphin	1.554	8.631	0.023	0.125
Pilot whale	0	0	0.113	0.626
Risso's dolphin	1.187	6.596	1.464	8.135
Rough-toothed dolphin	0	0	0.073	0.407
Sperm whale	0.014	0.151	0.011	0.125
Spinner dolphin	0.339	1.885	0.253	1.408
Unidentified dolphin	1.275	7.086	0.941	5.225
TOTAL MARINE MAMMALS	**6** (5.726)	**32** (31.886)	**8** (8.364)	**47** (46.528)

[a] Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

Table 3-3. Observed and adjusted mean densities of marine mammals at the Norfolk area based on 1995 aerial surveys (Data from: Department of the Navy, 1995b). Calculations are based on April-September surveys.

Species	Observed Grand Mean Density (Animals/100 km^2)	Adjusted Grand Mean Density[a] (Animals/100 km^2)
BALEEN WHALES		
Fin whale	0.522	5.795
Humpback whale	0.011	0.063
Minke whale	0.023	0.252
Sei whale	0.023	0.252
Sei/Bryde's whale	0.011	0.126
Unidentified *Balaenoptera*	0.136	1.512
Unidentified baleen whale	0.045	0.504
TOOTHED WHALES AND DOLPHINS		
Atlantic spotted dolphin	9.342	51.902
Bottlenose dolphin	5.828	32.376
Bottlenose/Atlantic spotted dolphin	0.726	4.031
Clymene/spinner/striped dolphin	2.778	15.432
Common dolphin	3.515	19.526
Cuvier's beaked whale	0.023	0.360
Pantropical spotted dolphin	4.932	27.400
Pilot whales	15.601	86.672
Risso's dolphin	1.349	7.496
Sperm whale	0.045	0.504
Spinner dolphin	0.703	3.905
Striped dolphin	0.272	1.512
Unidentified dolphin	4.376	24.313
Unidentified small whale	0.057	0.315
TOTAL MARINE MAMMALS	**50** (50.317)	**284** (284.248)

[a] Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

Mayport

Based on historical records and aerial survey results, 29 marine mammal species may occur at the Mayport area, including 7 baleen whales and 22 toothed whales (includes dolphins) (Table 3-1). Six of these are considered likely to occur (presence probable): Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, Risso's dolphin, spinner dolphin, and pilot whale. The other 23 species could occur in the area but are not especially likely to be found there (presence possible). This includes four species of beaked whales, whose likelihood of being present is difficult to judge because they are rarely seen due to their diving behavior.

Stranding records from May through September of 1990-1995 for the coast from Cape Canaveral to the North Carolina/South Carolina border are also summarized in Table 3-1. Only nine species appear in these "Mayport area" stranding records, the most common being the bottlenose dolphin (about 80% of total individuals). Only one species (the pygmy sperm whale) that was not seen during 1995 or 1997 aerial surveys appeared frequently in the stranding records. Conversely, there were no pantropical spotted dolphins in the stranding records and only a few Risso's dolphins, whereas both species were among the most abundant during 1995 aerial surveys. Few baleen whales stranded during the interval, in part because of their seasonal migrations to northern waters.

1995 Aerial Surveys. A total of 1,303 individuals representing at least seven species of marine mammals were seen at the Mayport area during the 1995 aerial surveys. Because there would be no shock testing in April at Mayport, mean densities for Mayport were calculated for the May-September period (i.e., excluding April). For this period, observed mean densities were about 6 individuals/100 km^2 and adjusted mean densities were about 32 individuals/100 km^2 (Table 3-2). The most abundant species were pantropical spotted dolphin, Risso's dolphin, bottlenose dolphin, and Atlantic spotted dolphin. About 22% of the total were unidentified dolphins.

Total marine mammal densities at the Mayport area were relatively low on all 1995 surveys (in comparison to the Norfolk area) (Figure 3-2). Densities at Mayport were highest on the first two surveys, when the most abundant species were pantropical spotted dolphin (April and May), bottlenose dolphin (April), and Risso's dolphin (May).

Figure 3-3 shows the abundance of marine mammals along individual transects at the Mayport area during 1995 surveys. Numbers of marine mammals on a transect ranged from 0 to 80 individuals; within any given survey, most transects had zero. Marine mammal abundance and frequency of occurrence was greatest during April and lowest during September. Marine mammals were generally more abundant and widespread in the southern half of the area.

Of 23 species with historical distributional records indicating "presence possible" at Mayport, 22 were not seen during the 1995 aerial surveys. This includes all 7 species of baleen whales and 15 species of toothed whales (includes dolphins). Species such as dwarf and pygmy sperm whales (*Kogia* spp.) were not seen, although they occur frequently in stranding reports from the southeastern U.S. (see Table 3-1). Some of these absences can be

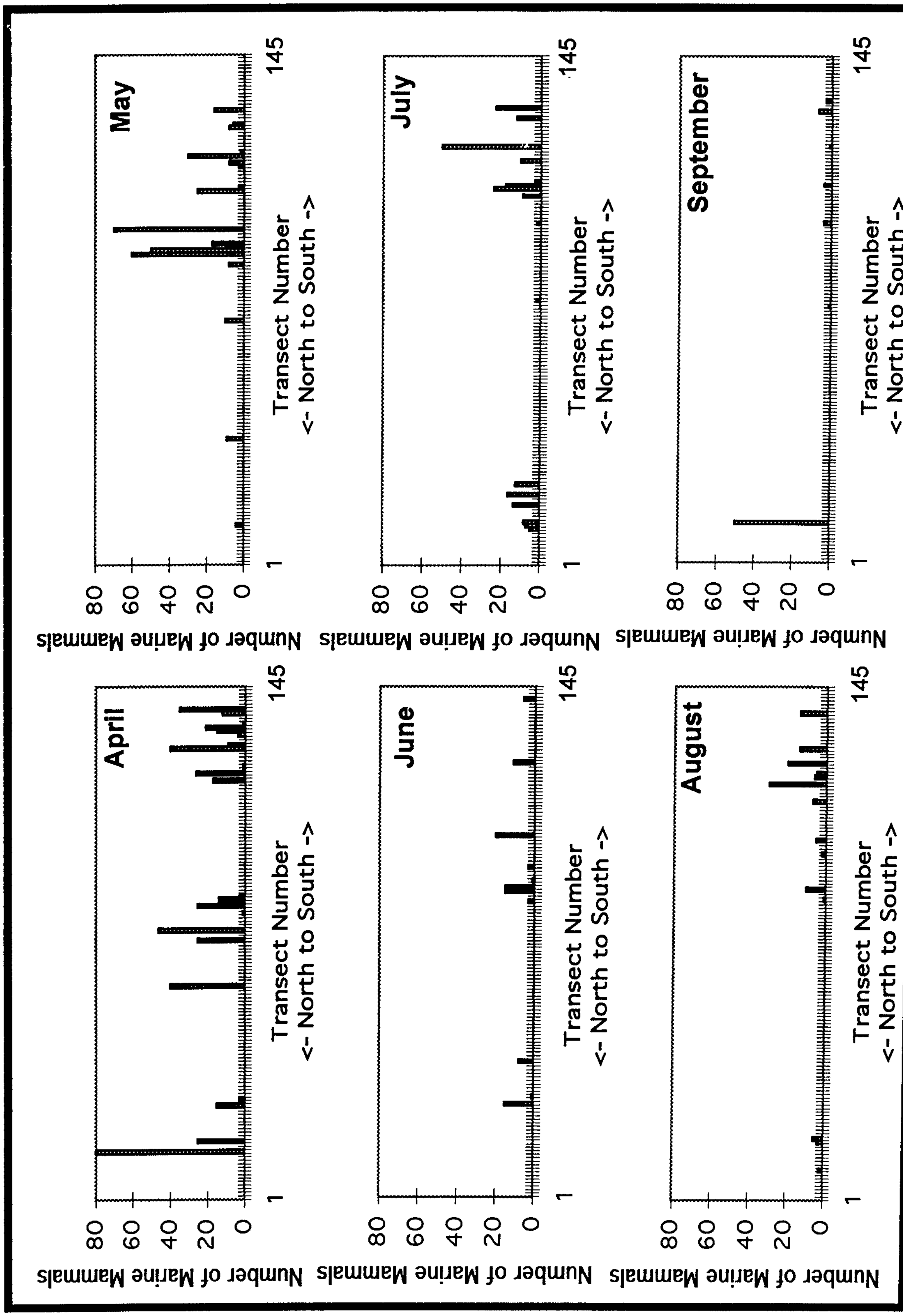


Figure 3-3. Marine mammal abundance along individual transects at the Mayport area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

explained by seasonality (i.e., many species tend to inhabit northern feeding grounds during spring, summer, and early fall). Other factors possibly explaining species absence include low abundance, depth and/or habitat preferences outside of the area, year-to-year variability, and behavioral traits such as aircraft avoidance and short surface times in deep diving species.

1997 Aerial Surveys. A total of 1,485 individuals representing at least eight species of marine mammals were seen at the Mayport area during the 1997 aerial surveys. For the May through September period of the surveys, observed mean densities were about 8 individuals/100 km^2 and adjusted mean densities were about 47 individuals/100 km^2 (Table 3-2). The most abundant species were bottlenose dolphin, Risso's dolphin, Clymene/spinner/striped dolphin (*Stenella* spp.), and Atlantic spotted dolphin. About 15% of the total were unidentified dolphins.

Comparison of the 1995 and 1997 Mayport surveys shows both similarities and differences. No mysticetes (baleen whales) were seen at Mayport during either year. All of the species seen during 1995 were also seen during 1997. However, two additional species (pilot whale and rough-toothed dolphin) were seen during the 1997 surveys only. As noted in Table 3-1, both species are considered as potentially occurring at Mayport.

Total mean densities were about 1.5 times higher during the 1997 surveys than during May-September 1995. However, the highest monthly densities for marine mammals were about the same both years (11.47 in May 1995 vs. 11.60 in July 1997). Also, despite the higher numbers in 1997, Mayport densities were still generally much less than those at Norfolk (Figure 3-2). Abundances of some individual species at Mayport differed greatly between years. For example, only a few pantropical spotted dolphins were seen in 1997, whereas in 1995 this was the most abundant species. Conversely, bottlenose dolphins were much more abundant in the 1997 surveys. The relative abundance of bottlenose dolphins in 1997 is more in accord with the stranding records (Table 3-1).

Figure B-6 in Appendix B shows the abundance of marine mammals along individual transects at the Mayport area during 1997 surveys. Numbers of marine mammals on a transect ranged from 0 to 72 individuals; transects with 0 individuals accounted for 73% to 88% of the total. Marine mammal abundance and frequency of occurrence was greatest during July and September, and lowest during June. There was no consistent spatial pattern in abundance or frequency of occurrence during the 1997 surveys. A month-by-month comparison with 1995 results suggests there is no consistent seasonal or spatial pattern within the May through September time period.

Listed Species. Six of the marine mammals potentially occurring at Mayport are listed as endangered as defined by the Endangered Species Act of 1973. These are the blue whale, fin whale, humpback whale, northern right whale, sei whale, and sperm whale. However, none are listed as "presence probable," and the only endangered species seen during 1995 and 1997 aerial surveys was the sperm whale (two individuals were sighted during each year). Because blue, fin, humpback, and northern right whales generally inhabit northern feeding grounds during spring, summer, and early fall, it is not surprising that none were seen near

Mayport during the April through September 1995 surveys or the May through September 1997 surveys. Similarly, there were few baleen whales in the May through September 1990-1995 stranding records. Critical habitat for the northern right whale is located off northeastern Florida but is well inshore of the Mayport area (see Appendix B).

Northern right whales are of special concern because of their highly endangered status; only about 300 individuals remain (Blaylock et al., 1995). Although two northern right whale strandings did occur in September 1989, the possibility of a northern right whale being present in the Mayport area during the potential test period (May through September) is remote. Northern right whales generally occur off Mayport from November/early December to April, with peak abundance between January and March (Kraus et al., 1993). Of 401 northern right whale sightings between 1950 and 1995, none occurred during May through September (Kenney, 1995). No northern right whales were seen during the April through September 1995 aerial surveys or the May through September 1997 surveys.

The coastal migratory stock of bottlenose dolphins was designated by NMFS as "depleted" under the Marine Mammal Protection Act on 6 April 1993. In 1994, the NMFS proposed listing the coastal migratory stock as threatened under the Endangered Species Act. This proposed designation remains pending. It is impossible to determine from aerial observations whether an individual dolphin belongs to the coastal or offshore stock. CETAP surveys north of Cape Hatteras showed a disjunct distribution between inshore and offshore bottlenose dolphin populations at the 25 m (82 ft) depth contour, suggesting that the stocks are separated by depth or distance from shore (Kenney, 1990). This pattern has been seen on later surveys (Hansen, 1996). South of Cape Hatteras, no separation of sightings by depth or longitude has been detected (Blaylock and Hoggard, 1994). However, data from survey cruises in 1985 and 1992 suggest that the deep-water ecotype inhabits waters along and beyond the outer continental shelf south of Cape Hatteras (Blaylock and Hoggard, 1994). Therefore, it is reasonable to assume that the bottlenose dolphins seen at the Mayport area, which is at the shelf edge, are mainly from the offshore stock rather than the coastal migratory stock proposed for threatened status.

Norfolk

Based on historical records, 34 marine mammal species may occur at the Norfolk area, including 7 baleen whales, 26 toothed whales (includes dolphins), and 1 seal (Table 3-1). Of these, 11 species are considered likely to occur (presence probable): fin whale, minke whale, sei whale, humpback whale, pilot whale, Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, common dolphin, Risso's dolphin, and spinner dolphin. The other 23 species could occur in the area but are not especially likely to be found there (presence possible). This includes six species of beaked whales, whose likelihood of being present is difficult to judge because they are rarely seen due to their diving behavior.

Stranding records from April through September of 1990-1995 for the coast from Cape Hatteras through New Jersey are also summarized in Table 3-1. A total of 19 species are in these "Norfolk area" stranding records, compared with 9 species for the Mayport area. Most of the stranded individuals (about 80%) were bottlenose dolphins or harbor porpoises. Although they stranded frequently, harbor porpoises were not seen during 1995 aerial surveys, presumably because the animals do not venture far offshore. Conversely, pantropical spotted dolphins were very common in the aerial surveys but no strandings were recorded. Pilot whales, which accounted for about one-third of the total individuals in the aerial surveys, were much less common in the strandings data (about 6%).

A total of 4,438 individuals representing at least 14 species of marine mammals were seen at the Norfolk area during the 1995 aerial surveys. Observed densities of marine mammals (all species combined) averaged about 50 individuals/100 km^2, and adjusted densities averaged about 284 individuals/100 km^2 (Table 3-3). About one-third of the mammals observed were pilot whales. Other abundant species were Atlantic spotted dolphin, bottlenose dolphin, pantropical spotted dolphin, common dolphin, and Risso's dolphin. About 9% of the total were unidentified dolphins.

During 1995 (the only year with comparable data from both areas), marine mammal densities at Norfolk were higher than at Mayport during all surveys (Figure 3-2). Densities at the Norfolk area were highest during the May, June, July, and August surveys. In part, this pattern is due to the abundance of pilot whales, which were most numerous during June, July, and August, especially within the southern half of the area.

Figure 3-4 shows the abundance of marine mammals along individual transects at the Norfolk area. Numbers of marine mammals on a transect ranged from 0 to 250 individuals. During May through August surveys, about half of the transects had one or more marine mammals present, but during April and September, most transects had none. Marine mammals were generally more abundant in the southern half of the area.

Of 23 species with historical distributional records indicating "presence possible," 19 were not seen during the 1995 aerial surveys. This includes 3 species of baleen whales, 15 species of toothed whales (includes dolphins), and 1 species of seal. Species such as dwarf and pygmy sperm whales (*Kogia* spp.) were not seen, although they occur frequently in stranding reports from the southeastern U.S. (see Table 3-1). The absence of these species may be due to factors such as low abundance, seasonality of occurrence, depth and/or habitat preferences outside of the area, year-to-year variability, and behavioral traits such as aircraft avoidance and short surface times in deep diving species.

Listed Species. Six of the marine mammals potentially occurring at Norfolk are listed as endangered as defined by the Endangered Species Act of 1973. These are the blue whale, fin whale, humpback whale, northern right whale, sei whale, and sperm whale. Four of these species (fin whale, humpback whale, sei whale, and sperm whale) were observed during April through July surveys. Fin whales were the most common large whale seen. No endangered species were seen during surveys after July, when it is presumed that these animals migrated to northern feeding grounds. No critical habitat for endangered marine mammal species is located near the Norfolk area.

As noted previously in the Mayport discussion, the coastal migratory stock of bottlenose dolphins has been designated as "depleted" under the Marine Mammal Protection Act and proposed for listing as threatened under the Endangered Species Act. It is impossible to

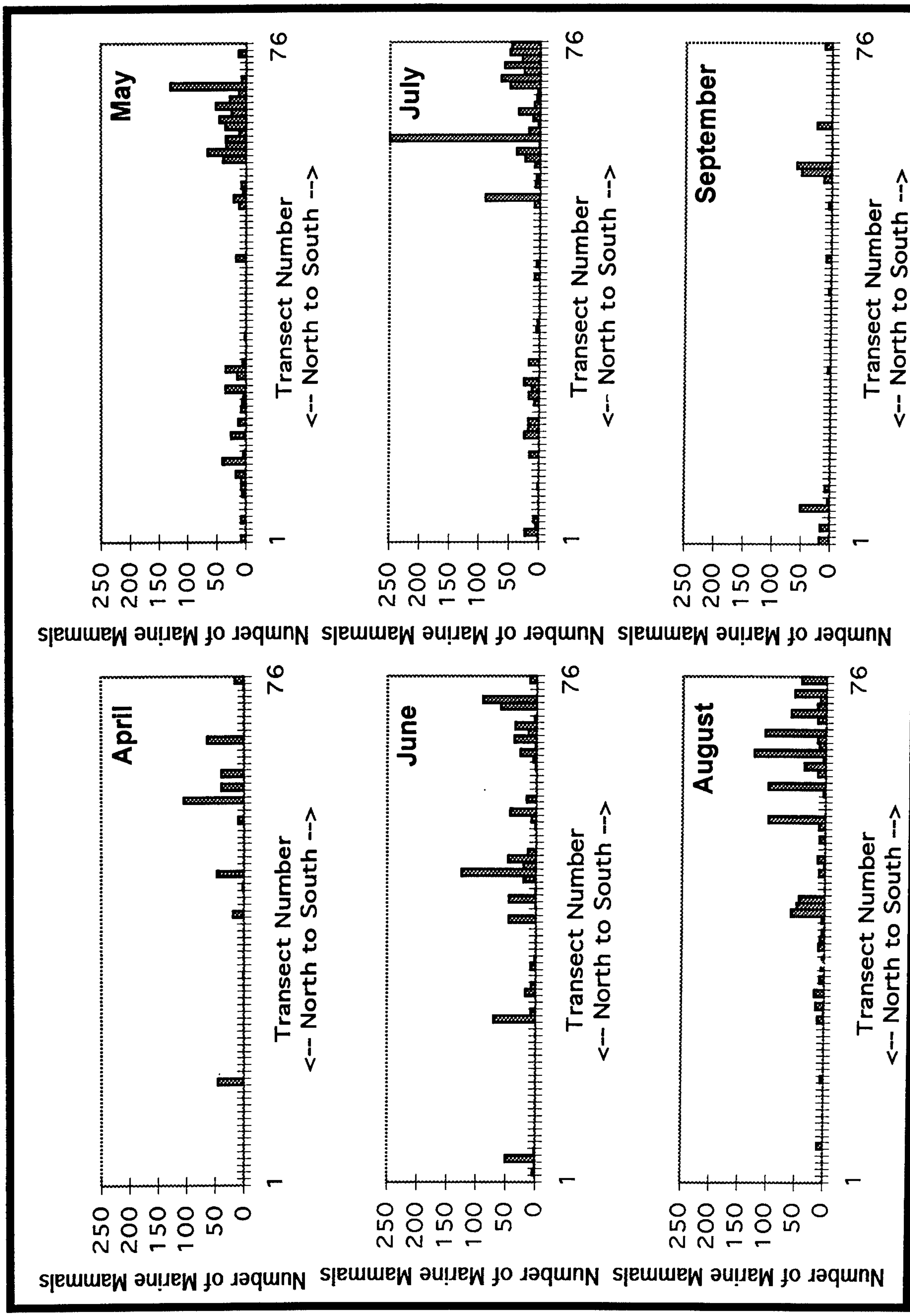


Figure 3-4. Marine mammal abundance along individual transects at the Norfolk area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

determine from aerial observations whether an individual dolphin belongs to the coastal or offshore stock. CETAP surveys north of Cape Hatteras showed a disjunct distribution between inshore and offshore bottlenose dolphin populations at the 25 m (82 ft) depth contour, suggesting that the stocks are separated by depth or distance from shore (Kenney, 1990). This pattern has been seen on later surveys (Hansen, 1996) and suggests that bottlenose dolphins at the Norfolk site (water depth of 152 m or 500 ft) would most likely belong to the offshore stock rather than the coastal migratory stock proposed for threatened status.

One additional marine mammal, the harbor porpoise, has been proposed for listing as a threatened species (Appendix G). The harbor porpoise is primarily a coastal species that is not likely to occur at the Norfolk area, and none of these animals were seen during the 1995 aerial surveys.

3.2.4 Sea Turtles

Five sea turtle species may occur at either the Mayport or Norfolk area: loggerhead, leatherback, green, hawksbill, and Kemp's ridley. **Table 3-4** summarizes the status and historical presence of each species and **Table 3-5** provides density estimates based on 1995 and 1997 aerial surveys. All five species are currently classified as either endangered or threatened under the Endangered Species Act of 1973. Species descriptions are provided in Appendix B.

Historical records suggest that loggerhead and leatherback sea turtles are likely to be the most common at either area; both loggerheads and leatherbacks inhabit pelagic (offshore) waters as adults. The three other turtle species (green, hawksbill, and Kemp's ridley) are typically found inshore and were not seen during 1995 aerial surveys (see below).

To supplement historical information, monthly aerial surveys were conducted at the Mayport and Norfolk areas from April through September 1995 (Department of the Navy, 1995b). Additional monthly surveys were conducted at Mayport from May through September 1997. Methods have been described above under Marine Mammals.

Observed densities from the 1995 and 1997 aerial surveys do not take into account submerged individuals or those that may have been on the surface but undetected. Therefore, adjusted densities were developed for each species as explained in Appendix B. Adjusted densities are about 33 times higher than observed densities, reflecting the fact that only about 10% of the sea turtle population is believed to be on the surface at a given time (Nelson et al., 1987; Thompson, 1995) and only about 30% of animals on the surface are believed to be detected from the air. Juveniles and smaller subadults are difficult to detect from the air, especially if associated with *Sargassum* or other flotsam. Loggerhead hatchlings are known to associate with *Sargassum* to facilitate their movement (Schwartz, 1988).

Figure 3-5 shows observed and adjusted densities of sea turtles at Mayport and Norfolk based on the 1995 and 1997 aerial surveys.

Table 3-4. Species of sea turtles potentially occurring at the Mayport and Norfolk areas based on literature and aerial surveys.

Common and Scientific Name	Status[a]	Historical Presence[b]		Aerial Surveys[c]		
		Mayport	Norfolk	Mayport 1995	Mayport 1997	Norfolk 1995
Loggerhead turtle (*Caretta caretta*)	T	++	++	++	++	++
Leatherback turtle (*Dermochelys coriacea*)	E	++	++	+	++	+
Green turtle (*Chelonia mydas*)	T	+	+	--	--	--
Hawksbill turtle (*Eretmochelys imbricata*)	E	+	+	--	--	--
Kemp's ridley turtle (*Lepidochelys kempii*)	E	+	+	--	--	--

NA = not applicable.

[a] Status: E = endangered species, T = threatened species.

[b] Historical presence: -- not present + presence possible ++ presence likely. Sources: Prichard and Marquez, 1973; Schwartz, 1978; Carr et al., 1979; Crouse, 1980, 1988; Lee and Palmer, 1981; CETAP, 1982; Murphy and Hopkins, 1984; Musick et al., 1984; Lee, 1985a; Lund, 1985; Lutcavage and Musick, 1985; Musick, 1986; Henwood and Ogren, 1987; Schroeder and Thompson, 1987; Dodd, 1988; Epperly and Veishlow, 1989; Knowlton and Weigle, 1989; Continental Shelf Associates, Inc., 1990; Marquez, 1990; NMFS and USFWS, 1991a,b, 1992a,b, 1993; USFWS, 1991; Meylan, 1992; Thompson and Huang, 1993.

[c] Number seen during 1995 aerial surveys: -- none + 1-9 individuals ++ 10 or more individuals

Table 3-5. Observed and adjusted mean densities of sea turtles at the Mayport and Norfolk areas based on 1995 and 1997 aerial surveys (Data from: Department of the Navy, 1995b, 1998). Calculations are based on May-September surveys for Mayport and April-September surveys for Norfolk.

Species	Observed Grand Mean Density (Individuals/100 km^2)	Adjusted Grand Mean Density[a] (Individuals/100 km^2)
MAYPORT AREA, 1995		
Loggerhead sea turtle	0.455	15.152
Leatherback sea turtle	0.041	1.131
Unidentified sea turtle	0.020	0.617
Total Sea Turtles	0.516	**17** (16.899)
MAYPORT AREA, 1997		
Loggerhead sea turtle	1.014	33.793
Leatherback sea turtle	0.220	6.102
Unidentified sea turtle	0.124	3.755
Total Sea Turtles	1.357	**44** (43.650)
NORFOLK AREA, 1995		
Loggerhead sea turtle	0.499	16.629
Leatherback sea turtle	0.011	0.315
Unidentified sea turtle	0.034	1.031
Total Sea Turtles	0.544	**18** (17.975)

[a] Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

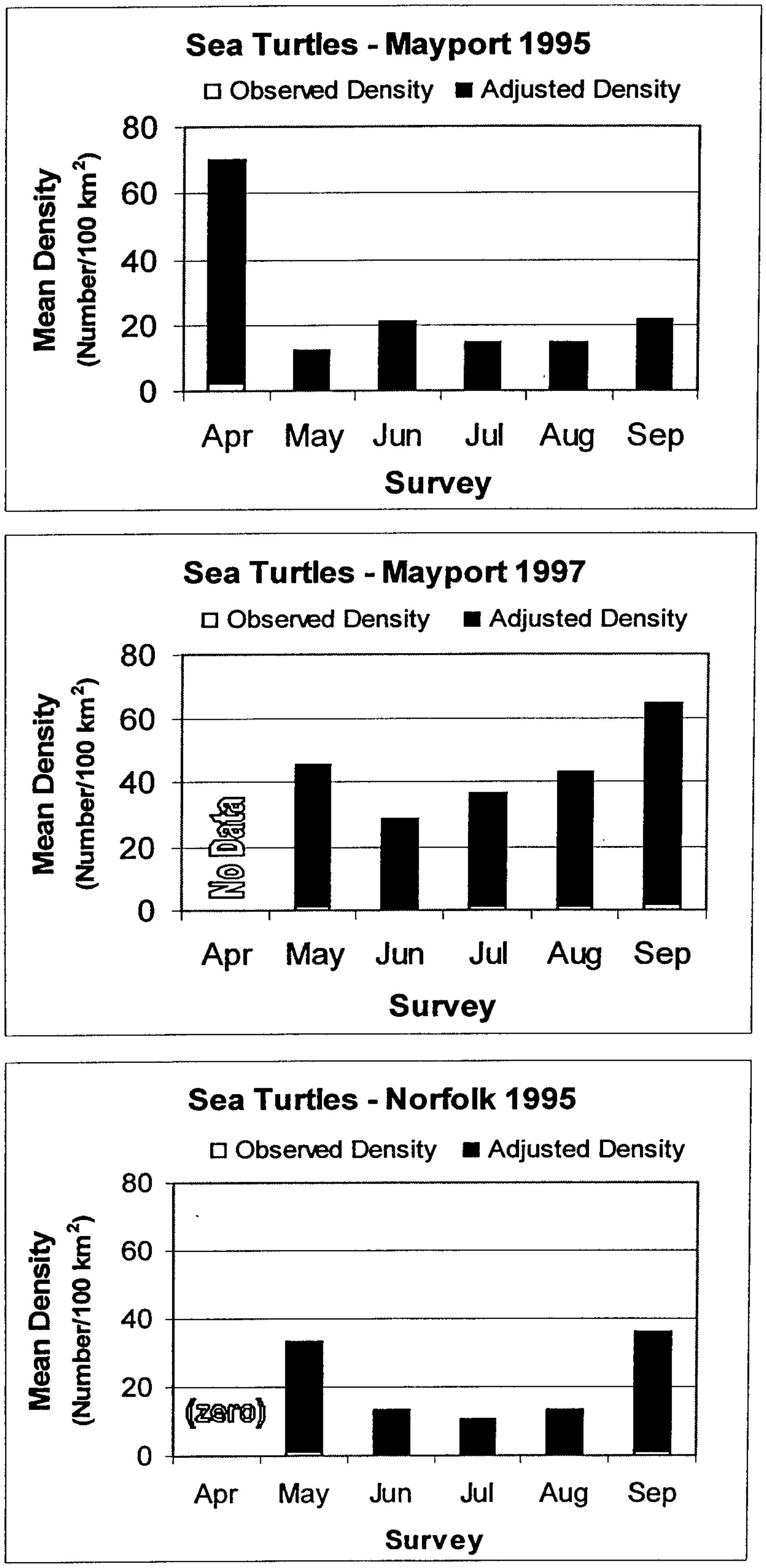


Figure 3-5. Sea turtle densities at the Mayport and Norfolk areas, based on aerial surveys conducted during April-September 1995 at both areas and May-September 1997 at Mayport (Data from: Department of the Navy, 1995b, 1998). Observed densities were adjusted to account for submerged and undetected individuals (see Appendix B).

Mayport

1995 Aerial Surveys. A total of 138 sea turtles were seen during the 1995 aerial surveys at the Mayport area. Of the total, 128 were loggerheads, 6 were leatherbacks, and 4 were unidentified. Because there would be no shock testing in April at Mayport, mean densities for Mayport were calculated for the May-September period (i.e., excluding April). For the May-September period, observed mean densities were 0.52 individuals/100 km^2 and adjusted mean densities were about 17 individuals/100 km^2.

Sea turtle densities at Mayport were highest during the first survey (April 1995) but showed no pattern during the rest of the surveys (Figure 3-5). About half of all the loggerheads counted during the surveys were seen during April. The high abundance during April may have been due to turtles converging on nearshore areas prior to nesting. Most loggerheads nest between May and September on the beaches of southeast Florida, with other nesting areas located in Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida. The eggs hatch in about two months, and hatchlings swim offshore where they inhabit *Sargassum* rafts. In the vicinity of the Mayport area, adult loggerhead turtles reportedly concentrate within middle shelf waters and are rarely seen in the Gulf Stream and associated deeper waters (Schroeder and Thompson, 1987).

Figure 3-6 shows the abundance of sea turtles along individual transects at the Mayport area during 1995 surveys. Numbers of turtles on a transect ranged from 0 to 5 individuals; within any given survey (and especially during May through September), most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during April and lowest during May. Sea turtles were generally more abundant and widespread in the southern half of the area during May, July, and August, but during the other months, there was no strong north-south pattern.

Due to the high abundance of sea turtles during April at Mayport, it would be difficult to find a test site with no turtles present (Figure 3-6). Therefore, if Mayport is chosen as the area for shock testing, there would be no testing during April (see Section 2.2.3.1).

1997 Aerial Surveys. A total of 240 sea turtles were seen during the 1997 aerial surveys at the Mayport area. Of the total, 179 were loggerheads, 39 were leatherbacks, and 22 were unidentified. For the May-September period, observed mean densities were 1.36 individuals/100 km^2 and adjusted mean densities were about 44 individuals/100 km^2.

Total turtle densities during 1997 were about 2.6 times higher than the 1995 numbers. Loggerheads, which accounted for 74% of total turtle sightings (compared with 88% for the same months in 1995), were about 2.2 times more abundant in 1997. Densities of leatherbacks, which accounted for 16% of total sightings (compared with 8% in 1995), were about 5 times higher in 1997. All of the monthly densities were higher in 1997 than in 1995. Improved visibility from the Partenavia aircraft used in 1997 could have been a factor (in addition to the difference in area viewed, which has already been taken into account in the density calculations).

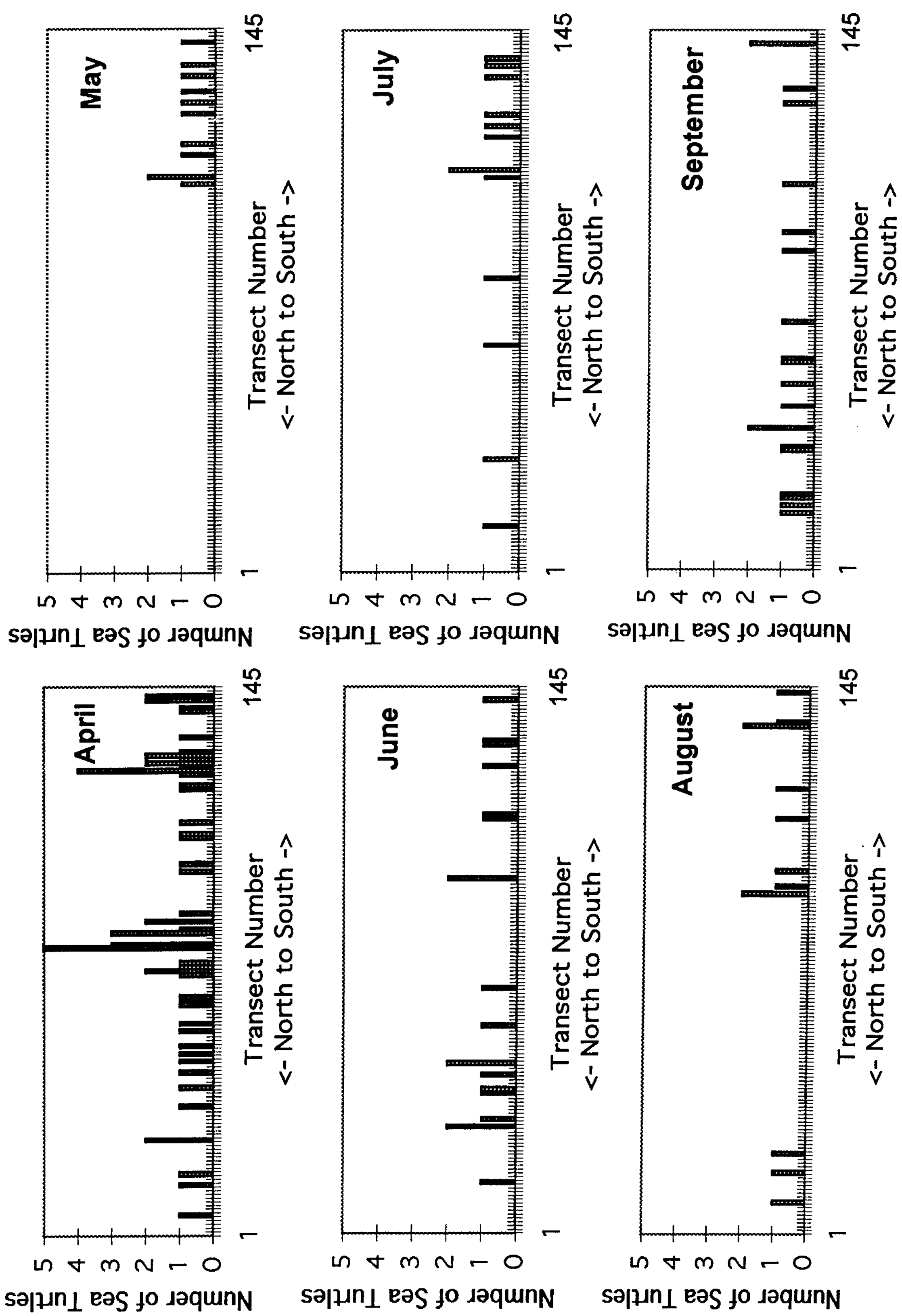


Figure 3-6. Sea turtle abundance along individual transects at the Mayport area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

Because there was no April survey in 1997, the high turtle numbers seen during April 1995 could not be confirmed. Based on the 1995 data and the likely concentration of loggerheads in offshore waters prior to the nesting season, exclusion of April from the test schedule at Mayport is considered a reasonable precaution.

Figure B-7 in Appendix B shows the abundance of sea turtles along individual transects at the Mayport area during 1997 surveys. Numbers of turtles on a transect ranged from 0 to 4 individuals; transects with 0 individuals accounted for 63% to 83% of the total. Sea turtle abundance and frequency of occurrence was greatest during September and lowest during June. There was no consistent spatial pattern in abundance or frequency of occurrence during the 1997 surveys. A month-by-month comparison with 1995 results suggests there is no consistent seasonal or spatial pattern within the May through September time period.

Norfolk

A total of 48 sea turtles were seen during the aerial surveys at the Norfolk area. Of the total, 44 were loggerheads, 1 was a leatherback, and 3 were unidentified. Observed mean densities (all species combined) were 0.54 individuals/100 km^2, and adjusted mean densities were about 18 individuals/100 km^2.

No sea turtles were seen at the Norfolk area during the first survey (April 1995) (Figure 3-3). Among the other surveys, densities were higher in May and September and lower in June, July, and August. Low densities during summer months may be due to movement of the turtle population inshore for nesting; Dodd (1988) reported nesting of loggerheads occurring along North Carolina beaches between April and late August.

Figure 3-7 shows the abundance of sea turtles along individual transects at the Norfolk area. Numbers of turtles on a transect ranged from 0 to 3 individuals; within any given survey, most transects had zero. Sea turtle abundance and frequency of occurrence was greatest during May and September; during June, July, and August, there were only a few sightings.

As noted above, most of the turtles seen during aerial surveys were loggerheads. This is consistent with results reported by Epperly et al. (1995), who found that loggerheads made up most or all of the accidental sea turtle catch by trawlers in North Carolina offshore waters. Similarly, aerial surveys by Keinath et al. (1996) in coastal North Carolina waters detected mostly loggerheads and only a few leatherbacks. The loggerhead is the only turtle species commonly found nesting along mid-Atlantic beaches.

3.2.5 Benthos

3.2.5.1 Invertebrates

Mayport

Infauna are animals that live within the sediment. Infaunal communities along the shelf edge near the Mayport area typically have low density and biomass and high species diversity. Worms (polychaetes) account for more than 50% of total numbers and biomass in most samples (Texas Instruments, Inc., 1979; Marine Resources Research Institute, 1985). Species composition changes mainly with water depth and to a lesser extent with latitude (Marine Resources Research Institute, 1985). Low benthic biomass in this area may be due

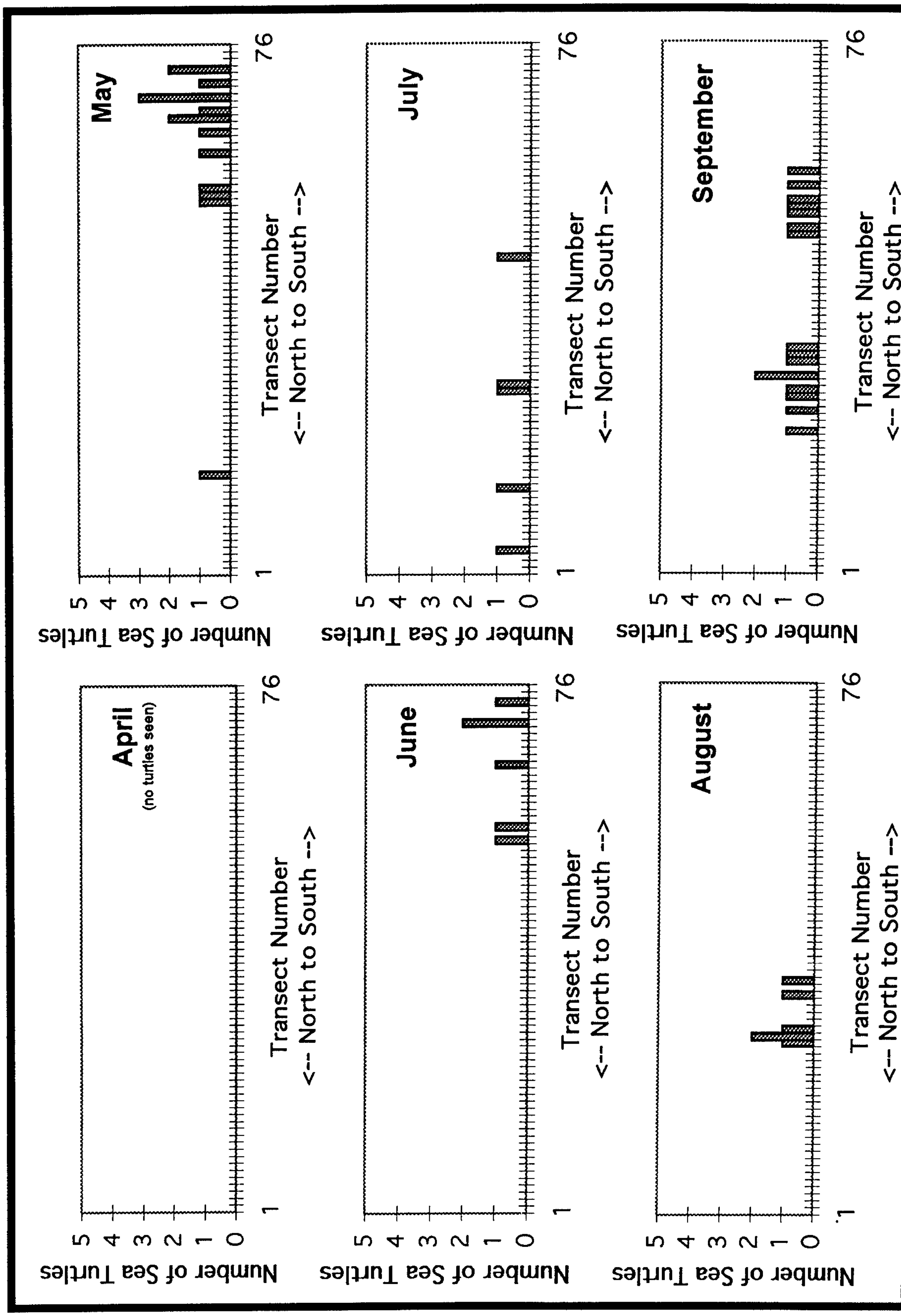


Figure 3-7. Sea turtle abundance along individual transects at the Norfolk area during 1995 aerial surveys (Data from: Department of the Navy, 1995b).

to overall low nutrient input resulting from the presence of a salinity front approximately 20 km (11 nmi) offshore (Texas Instruments, Inc., 1979).

Epifauna are animals that live on the sediment. The Mayport area is situated near the boundary between two distinct epifaunal zones: the outer shelf and the deep slope (Texas Instruments, Inc., 1979). The density and biomass of epifaunal invertebrates collected along the middle and outer shelf of this area varies with water depth, latitude, and season. Water depth appears to be more important than latitude in determining density and biomass. Crustaceans are generally the most conspicuous and abundant group of soft bottom epifauna (Texas Instruments, Inc., 1979; Marine Resources Research Institute, 1985). Several commercially important crustacean species including shrimp and the golden deepsea crab (*Chaceon fenneri*) are patchily distributed along the shelf and shelf edge within the vicinity of the area. Other principal groups include molluscs, echinoderms (e.g., starfish and sea biscuits), and anthozoans (e.g., sea anemones). The distribution of epifauna in the area appears to be governed largely by hydrographic patterns and the intermittent influence of Gulf Stream intrusions or eddies (Texas Instruments, Inc., 1979).

Norfolk

Infaunal communities near the Norfolk area are numerically dominated by four major groups: molluscs, echinoderms, annelid worms, and crustaceans (Wigley and Theroux, 1981; Steimle, 1990). Molluscs (primarily clams) were the most abundant group found near the area, and were distributed in a series of broad bands parallel to the coastline across the shelf and slope throughout the region. A high density band was found in the vicinity of the Norfolk area along the shelf edge and slope. Echinoderms (primarily brittle stars) were found in moderately high densities along the central and outer shelf. Annelid worms were widely distributed in all subareas of the region, though distribution was comparatively sparse within the area offshore of Chesapeake Bay. Crustaceans (particularly amphipods) are one of the most common groups found within shelf waters. Densities and biomass near the Norfolk area are about three times lower than those seen in from shallower depths.

Other abundant epifauna in this area included sponges and sea anemones. Wigley and Theroux (1981) reported that sponges were found in small areas scattered throughout the shelf edge offshore of Chesapeake Bay. Sea anemones were broadly distributed in low densities from Cape Cod to Cape Hatteras, particularly on the shelf edge and slope. The mean density of all coelenterates between 100 and 200 m (328 and 656 ft) in the vicinity of the area was 155 individuals/m^2.

The abundance and biomass of benthic organisms generally decrease with increasing water depth (Virginia Institute of Marine Science, 1979; Wigley and Theroux, 1981). The most pronounced changes in density were observed at or near the shelf edge. This trend may be due to the complex effects of hydrography (primarily temperature) and changing sediment characteristics with variations in shelf topography (Virginia Institute of Marine Science, 1979). Due to the relatively narrow shelf in this area, biomass of macrobenthos was found to be relatively small (as compared to stations to the north) and showed little difference with respect to depth across the shelf (Wigley and Theroux, 1981). Biomass levels in this area fluctuate seasonally, with peaks generally occurring in summer (Steimle, 1990). This seasonal component, however, appears to decrease with increasing depth (Virginia Institute of Marine Science, 1979).

3.2.5.2 Demersal Fish

Mayport

The demersal (bottom) fish assemblage of the Mayport area reflects the transition in benthic habitat from outer shelf to upper slope. The outer shelf supports over 140 demersal fish numerically dominated by croakers and drums, lefteye flounders, searobins, and lizardfish (Struhsaker, 1969; George and Staiger, 1979; Miller and Richards, 1980; Wenner et al., 1980; Low et al., 1982). Although some members of these families could occur in the water depth of the Mayport area, most inhabit shallower shelf waters.

Wenner et al. (1980) identified a distinctive group of fish from outer shelf/upper slope waters ranging from 111 to 366 m (364 to 1,200 ft) deep. This group included slender searobin, morid cod, pygmy argentine, spotted hake, Gulf Stream flounder, blackmouth bass, spinycheek bass, tilefish, shortnose greeneye, and blackbelly rosefish. With the exception of the tilefish (an important fishery species), the ecology of these species is not well known. Tilefish inhabit a narrow depth range of 100 to 290 m (328 to 950 ft) where they occupy burrows constructed in clay bottoms (Grossman et al., 1985; Able et al., 1993).

Four of the sites sampled by Wenner et al. (1980) offshore of southern Georgia were near the Mayport area. Several species at these sampling sites such as round scad, dusky flounder, smallmouth flounder, and snakefish are wide ranging and commonly found in middle and outer shelf waters, while others such as beardfish, red barbier, streamer searobin, and shortnose greeneye are restricted to outer shelf/upper slope waters.

Some concern has been expressed about the possible presence of deepwater grouper spawning aggregations at the Mayport area (see comment J2 in Appendix H). Four deepwater grouper species (speckled hind, Warsaw grouper, snowy grouper, and yellowedge grouper) could occur near the Mayport area. These groupers are of fishery importance and the South Atlantic Fishery Management Council considers them to be overfished. Although some groupers form spawning aggregations, the available information does not support the claim that spawning aggregations of any deepwater groupers could occur at the Mayport area. The only information on grouper spawning from the U.S. east coast comes from submersible observations made by Harbor Branch scientists working near *Oculina* reefs offshore of Ft. Pierce, Florida (Gilmore and Jones, 1992). Their study subjects were two shallow water species, gag and scamp. Neither species formed aggregations per se and neither made extended forays into the water column. Moreover, groupers are generally associated with hard bottom, but the seafloor at the Mayport area is predominantly soft bottom. Of the four deepwater species cited above, the yellowedge grouper is known to occur over soft bottom; they have been documented to cohabitate with burrow-dwelling tilefish (Jones et al., 1989) which occur off the Georgia coast. However, there is no information on spawning aggregations.

Norfolk

The demersal (bottom) fish fauna of the continental shelf in the area of the Norfolk area consists of about 130 species (Ross, 1985). The distribution and abundance of demersal fish over the shelf are influenced primarily by water depth and temperature (Grosslein, 1976; Grosslein and Azarovitz, 1982; Colvocoresses and Musick, 1984). The demersal fauna is a dynamic combination of year-round resident species, warm temperate species that migrate northward into the area in spring, and boreal (northern) species that migrate southward into the area in fall. Warm temperate species living on the outer shelf in the vicinity of the Norfolk area include scup, black seabass, summer flounder, spotted hake, butterfish, and northern searobin. Boreal species moving into the outer shelf area during fall include silver hake, goosefish, and red hake. On the upper slope, shortnose greeneye, blackbelly rosefish, and white hake occur in most collections from the area regardless of season and are considered upper slope residents (Musick, 1979; Colvocoresses and Musick, 1984).

3.2.6 Seabirds

The seabird fauna at the Mayport and Norfolk areas is similar because both areas are in offshore waters of the mid-Atlantic and southeastern U.S. Range, habitat, and general life history information for seabirds that may occur at the Mayport and Norfolk areas are summarized in Appendix B. The U.S. Fish and Wildlife Service (USFWS) has determined that no federally listed (endangered or threatened) bird species or their critical habitat are present at either area (see Appendix G).

Common seabirds found offshore of the mid-Atlantic and southeastern U.S. include representatives of the orders Charadriiformes (alcids, gulls, phalaropes, skuas, terns), Pelecaniformes (boobies, frigatebirds, gannets, tropicbirds), and Procellariiformes (albatrosses, petrels, shearwaters, storm petrels) (Clapp et al., 1982a,b, 1983; Hoopes et al., 1994; Lee, 1984, 1985b, 1986; Lee and Palmer, 1981; Lee and Socci, 1989). These seabirds include seasonal migrants and year-round residents, and they may feed on or below the sea surface. A significant portion of the seabird populations at the Norfolk area aggregate seasonally off the Outer Banks.

Coastal and offshore waters of the eastern U.S. also serve as a major migratory corridor for many other species of birds, such as shorebirds of the order Charadriiformes (plovers, sanderlings, sandpipers, willets) and coastal and terrestrial birds (National Geographic Society, 1987; Lee and Horner, 1989). These include, but are not restricted to the following groups: Anseriformes (ducks, geese), Ciconiiformes (egrets, herons, ibises), Falconiformes (falcons, hawks, ospreys), Gruiformes (coots, gallinules, rails), Passeriformes (crows, flycatchers, kinglets, sparrows, swallows, warblers, wrens), Pelicaniformes (cormorants, pelicans), and Podicepideformes (grebes). Most of these species are typically found inshore and do not feed or rest on the sea surface.

3.3 SOCIOECONOMIC ENVIRONMENT

3.3.1 Commercial and Recreational Fisheries

Table 3-6 summarizes the types of commercial and recreational fishing activities that take place at or near the Mayport and Norfolk areas. Landings data for both regions have been summarized by the Department of the Navy (1995a). Due to the way landings are reported, it is not possible to calculate how much of the regional catch comes from the specific locations of the Mayport and Norfolk areas.

Mayport

Most commercial and recreational fisheries such as shrimp trawling, reef fishing, and king mackerel fishing take place inshore of the area. However, certain species, particularly oceanic pelagic and deep reef species, known to occur in the vicinity of the Mayport area are sought by commercial and recreational fishers.

Shrimp trawling is a highly commercialized activity off northeastern Florida. However, the Mayport area lies well offshore of designated east coast shrimp beds, which lie in near coastal waters (CFR 46-31.0156, 1995).

Commercial fishers work the offshore waters of northeastern Florida for sharks, swordfish, and tunas. These species are caught with surface drifting longlines fished in the water column offshore of the shelf break. Longlines are set near the western edge of the Gulf Stream often with the aid of sophisticated onboard temperature sensors, depth finders, and positioning equipment. Longline sets can measure several nautical miles with up to 1,000 hooks per set. Bottom longlining for golden tilefish also occurs off Mayport.

Recreational anglers who travel to the Mayport area are seeking oceanic pelagic and to a lesser extent deep reef species. Despite the considerable minimum distance to the area from Mayport, some private and charter sport fishers regularly venture this far offshore to troll for billfish, dolphinfish, tunas, and wahoo. Most fishing occurs between the depths of 91 to 305 m (300 to 1,000 ft) (Furr, 1995).

Norfolk

Bottom trawling and surface longlining are the major commercial fisheries expected in the vicinity of the Norfolk area. Although the trawl fishery targets summer flounder, there is considerable bycatch of other species including black seabass, butterfish, and hake (Ross et al., 1988). This fishery takes place in fall and winter months in outer shelf waters from 40 to 100 m (131 to 328 ft) deep, just inshore of the Norfolk area. Squid (short-finned and long-finned), also taken by trawl, are fished in inner-shelf waters during spring and summer and outer-shelf waters during winter. Surface longlining produces sharks, swordfish, and tunas from waters of the shelf edge and seaward depending upon oceanic conditions (Taniguchi, 1987). Bottom longlining for golden tilefish also occurs in the area, but mainly to the north of the area (from Norfolk Canyon north).

Table 3-6. Commercial and recreational fishing activities occurring at or near the Mayport and Norfolk areas.

Fishing Method	Species Sought	
	Mayport	Norfolk
Commercial Fishing		
Surface longlining	Sharks, swordfish, tunas	Sharks, swordfish, tunas
Bottom longlining	Golden tilefish	Golden tilefish (mainly north of the area)
Bottom trawling	—	Summer flounder, black seabass, butterfish, hake, squid (trawling occurs mainly during winter)
Recreational Fishing		
Trolling	Billfishes, dolphinfish, tunas, wahoo	Billfishes, dolphinfish, tunas, wahoo

Recreational anglers seeking oceanic gamefish (e.g., billfish and tunas) may fish the waters near the Norfolk area (Richards, 1965; Figley, 1988). In 1983, there were 455 vessels (415 private, 40 charter) in Virginia's marlin and tuna sportfishing fleet. Figley (1988) reported that most middle Atlantic offshore fishermen restricted their activities to the area from Norfolk Canyon (which is north of the Norfolk area) northward to Block Canyon.

Charter and private boat fishermen operating off Virginia's eastern shore [out to the 183 m (600 ft) depth contour] catch dolphinfish, little tunny, skipjack tuna, yellowfin tuna, Atlantic bonito, and white marlin (Richards, 1965; Figley, 1988). In addition, blue marlin, swordfish, bigeye tuna, and albacore are also taken. The Norfolk area falls within these ranges and given the depth preferences of these fish, they may periodically be found at the area. Most of the charter boat catch, particularly for the more offshore waters, occurs between late April and mid-October. This is the period when weather permits the long excursions offshore to fish for these open water fish, and coincides with the occurrence of the fish in the area.

3.3.2 Other Socioeconomic Topics

Ship traffic near the Mayport and Norfolk areas has been discussed under Operational Requirements in Section 2.2.2.1. Other socioeconomic topics such as shipwrecks, offshore dredged material disposal sites, and marine sanctuaries are not discussed because they are not present in the area or are being avoided by the proposed action (see Section 2.2.2.2). A subsea communication cable crosses the Mayport area (National Oceanic and Atmospheric Administration, 1991), but its use was discontinued in 1993 (Wargo, 1994). Onshore socioeconomics are not discussed because existing facilities at Naval Station Mayport, Naval Submarine Base Kings Bay, and Naval Station Norfolk are more than adequate to handle all required services in support of shock testing.

4.0 ENVIRONMENTAL CONSEQUENCES

This section analyzes potential impacts of shock testing the SEAWOLF at two alternative offshore areas: Mayport, Florida and Norfolk, Virginia. The impact discussion focuses on significant issues identified through the scoping process. Other issues that do not require detailed analysis are discussed briefly at the beginning of each major subsection.

Because both areas are along the East Coast at the same water depth and about the same distance from shore, potential impacts are similar. To avoid redundancy, separate sections for Mayport and Norfolk are not presented. Instead, potential impacts at the two areas are contrasted within each major subsection.

Mitigation to minimize risk to marine mammals and turtles is taken into account in the impact analysis. Protective measures including test site selection and pre- and post-detonation monitoring are described in Section 5.0.

Potential radiological environmental effects from shock testing the SEAWOLF submarine are evaluated in Appendix F. The appendix provides information on the Naval Nuclear Propulsion Program which, pursuant to federal law, regulates nuclear safety and radioactivity associated with nuclear propulsion work. The Program provides comprehensive technical management of all aspects of Navy nuclear propulsion plant design, construction, and operation including careful consideration of reactor safety and radiological and environmental concerns. Past operations, including shock tests, have resulted in no significant radiological environmental impacts and demonstrated the Program's effectiveness. Continued application of the environmental practices that are standard throughout the Program will ensure the absence of any radiological environmental effect as a result of shock testing the SEAWOLF submarine.

Impact discussions are divided into separate subsections to distinguish between those aspects of the proposed action evaluated under NEPA and those evaluated under Executive Order 12114. As discussed in Section 1.4, NEPA applies to activities and impacts within U.S. territory, whereas Executive Order 12114 applies to activities and impacts outside territorial seas. The proposed action includes operations that would occur both within and outside U.S. territory. Shock testing and associated mitigation operations would occur at least 87 km (47 nmi) offshore at the Mayport area or 54 km (29 nmi) at the Norfolk area, well outside U.S. territorial seas. No impacts from the actual test (detonation of explosives) would occur in U.S. territory. The only operations that would occur within territorial limits are shore support activities and vessel and aircraft movements in territorial waters (i.e., transits between the shore base and the offshore shock testing site). These shore support activities and vessel and aircraft movements are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases.

4.1 IMPACTS UNDER NEPA

4.1.1 Physical Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on geology and sediments, air quality, and water quality are minimal, and no additional direct impacts are expected at either Mayport or Norfolk.

Chemical byproducts of the detonations would be rapidly dispersed at the test site (see Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality.

Due to the water depth of the explosion (30 m or 100 ft) and the distance from nearest shore [87 km (47 nmi) for Mayport and 54 km (29 nmi) for Norfolk], the detonations are expected to be virtually inaudible to human populations onshore, except in the event of unusual atmospheric conditions such as thermal inversions and low clouds. An underwater explosion generates the most noise when it takes place just below the surface. According to O'Keeffe and Young (1984), a reasonable assumption is that one can disregard the noise from explosions at reduced depths equal to or greater than 2.0 $ft/lb^{1/3}$, which in this case yields a depth of 13 m (43 ft), much less than the depth of the proposed detonations.

4.1.2 Biological Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on marine biota, including plankton, pelagic fish, marine mammals, sea turtles, benthic organisms, and seabirds are minimal, and no additional direct or indirect impacts are expected at either Mayport or Norfolk.

4.1.3 Socioeconomic Environment

Shore support operations and movement of vessels and aircraft within territorial limits are not unusual or extraordinary and are part of the routine operations associated with the existing shore bases. Impacts of these existing operations on commercial and recreational fisheries and ship traffic are minimal, and no additional direct or indirect impacts are expected at either Mayport or Norfolk.

Existing facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide most services in support of shock testing. The only additional facilities required would be temporary offices (five to six rented trailers), an instrumentation trailer, and possibly a small supply trailer (cable, spare parts, etc.) (see Section 2.2.1). Additional space would be leased outside the base, if required. No significant direct or indirect impacts on the local economy are expected at Mayport, Kings Bay, or Norfolk.

Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or recreational fishery stocks or fishing activities (see Section 4.2.3.1). Therefore, no significant impacts on the coastal fishing industry are expected.

Shrimp trawling is a highly commercialized activity in coastal waters off northeastern Florida. However, because the Mayport area lies well offshore of designated east coast shrimp beds, no direct or indirect impacts on shrimping would be expected.

Public concerns were expressed during scoping meetings that dead fish might wash ashore and affect tourism. A large fish kill would not be expected during SEAWOLF shock testing because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Large fish kills have not been seen following previous similar detonations (Department of the Navy, 1981; Naval Air Warfare Center, 1994). Any fish killed or injured by the explosions are most likely to drift to the northeast with the Gulf Stream. Due to the distance from shore and the strong currents, it is highly unlikely that dead fish would reach shore. Oceanographic modeling for a location a similar distance from the North Carolina coast has shown there is a <1% chance of floating material reaching shore (DOI, MMS, 1990). Therefore, no significant onshore or nearshore impacts from fish kills are expected.

4.2 IMPACTS UNDER EXECUTIVE ORDER 12114

4.2.1 Physical Environment

4.2.1.1 Geology and Sediments

Both the Mayport and Norfolk areas are predominantly sand bottom at this water depth. Potential impacts at the two areas should be similar.

Calculations based on the size of the explosive (4,536 kg or 10,000 lb), the depth of burst (30 m or 100 ft), and the total water depth (152 m or 500 ft) indicate there would be no cratering of the seafloor (Young, 1995b). The shock wave would reach the seafloor and be reflected from it, but would have no significant impact on bottom structure or form. The reflected wave would probably carry some resuspended sediment which would settle to the seafloor. Fragments of steel charge casings would settle to the bottom, but would have no significant impact on bottom structure or form. The largest possible fragment from the explosion is the top plate and crossbar, which together weigh 204 kg (450 lb). Due to low oxygen levels in bottom sediments, the steel fragments would likely corrode very slowly and would not be expected to significantly affect sediment metal concentrations.

As explained in Section 2.2.3.4, the likelihood of a charge not detonating is remote and only in the case of extreme emergency or to safeguard human life would the Navy dispose of the charge at sea. If the charge were released, it would sink to the bottom but would not be expected to have significant adverse impacts on bottom sediments. Studies of munitions dumping areas have shown no contamination from explosive materials (Hoffsommer et al., 1972; Wilkniss, 1973).

4.2.1.2 Air Quality and Noise

The alternative areas (Mayport and Norfolk) are well offshore and are located in an area that is not classified for priority pollutants under the Clean Air Act. Therefore, a Clean Air Act General Conformity Review is not applicable. Ambient air quality and impacts are expected to be similar at the two areas.

The spherical bubble produced by each explosion would expand to a maximum radius of 19 m (62.3 ft) (Young, 1995a). The bubble would migrate upward and collapse beneath the surface, where it would re-expand and emerge into the atmosphere. The water that is ejected would form a roughly hemispherical mass of plumes with an estimated maximum height of 165 m (540 ft). It is estimated that 90% of the gaseous explosion products would become airborne.

Airborne explosion products are assumed to stabilize in a spherical form and move downwind, with concentrations remaining the same for the first 30 m (100 ft) (Young, 1995a). This "cloud" would not be visible. Then, the airborne cloud would continue to move at the speed of the wind and become diluted and dispersed by atmospheric turbulence.

Table 4-1 lists initial and downwind concentrations of explosion products in the atmosphere. The calculations assume that the products would be uniformly mixed at the time of stabilization and that the cloud would expand as a result of natural turbulence (Young, 1995a).

There are no air quality standards developed specifically for underwater explosions. For comparison, limits used by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), and the National Institute for Occupational Safety and Health (NIOSH) can be used (Table 4-1). Relevant standards include the Ceiling Concentration (CL), which cannot be exceeded at any time; and the Short-Term Exposure Limit (STEL), which is usually a 15-minute time-weighted average. Limits are not given for asphyxiants, which are non-toxic gases that exclude oxygen from the lungs when present in high concentrations.

All of the predicted initial concentrations (except for carbon monoxide and ammonia) are below the OSHA, ACGIH, and NIOSH limits. For safety reasons, no personnel would be near the detonation point where the highest concentrations would occur. The initial concentrations would disperse rapidly in the atmosphere; all predicted concentrations would be well below the limits at 305 m (1,000 ft) downwind, a point which would be reached within a few minutes after detonation depending on wind speed (e.g., within 2 minutes in a 5-kt wind). Because of the low initial concentrations and rapid dispersion of explosion products, there would not be any risk to human health or marine life in the test site.

Personnel in ship spaces below the water line and all personnel in the submarine would be provided hearing protection. Potential noise impacts on marine mammals and turtles are discussed separately below in Sections 4.2.2.3 and 4.2.2.4.

Table 4-1. Atmospheric concentrations of explosion products compared with atmospheric exposure standards (Adapted from: Young, 1995a). Concentrations are based on a 4,536 kg (10,000 lb) HBX-1 charge detonated at 30 m (100 ft) below the sea surface.

Explosion Product	Concentration (ppm)			Exposure Standard (ppm except where noted)		
	Initial	305 m (1,000 ft) Downwind	1,524 m (5,000 ft) Downwind	OSHA PEL	ACGIH TLV	NIOSH REL
Carbon dioxide (CO_2)	37.9	1.2	0.107	--[a]	STEL: 30,000	CL: 30,000
Carbon monoxide (CO)	672	21.2	1.90	--[a]	STEL: 400	CL: 200
Ammonia (NH_3)	86.4	2.73	0.245	--[a]	STEL: 35	CL: 50
Ethane (C_2H_6)	100	3.16	0.283	Asphyxiant	Asphyxiant	Asphyxiant
Propane (C_3H_8)	19.6	0.619	0.0555	--[a]	Asphyxiant	--
Hydrogen cyanide (HCN)	7.06	0.223	0.0200	--[a]	CL: 10	CL: 5 mg CN/m^3/10M
Methane (CH_4)	5.03	0.159	0.0142	Asphyxiant	Asphyxiant	Asphyxiant
Methyl alcohol (CH_3OH)	0.205	0.0065	0.0006	--[a]	STEL: 250	CL: 800/15M
Formaldehyde (CH_2O)	0.108	0.0034	0.0003	--[a]	--[a]	--
Acetylene (C_2H_2)	0.161	0.0051	0.0005	CL: 2,500	Asphyxiant	CL: 2,500
Phosphine (PH_3)	0.171	0.0054	0.0005	--[a]	STEL: 1	--

Abbreviations:
OSHA = Occupational Safety and Health Administration; PEL = permissible exposure limit.
ACGIH = American Conference of Governmental Industrial Hygienists; TLV = threshold limit value.
NIOSH = National Institute for Occupational Safety and Health; REL = recommended exposure limit.
CL = ceiling concentration; STEL = short-term exposure limit.

[a] The only limit specified is a time-weighted average for an 8-hr day, 40-hr work week. This would not be relevant to the proposed detonations.

4.2.1.3 Water Quality

Ambient water quality at the Mayport and Norfolk areas is similar because both are located in deep oceanic waters at the edge of the Gulf Stream. Impacts of shock testing on water quality would be similar at the two areas.

Chemical products of deep underwater explosions are initially confined to a thin, circular area called the surface pool. It is estimated that 100% of the solid explosion products and 10% of the gases remain in the pool (Young, 1995a). This surface pool is fed by an upwelling current of water entrained by the rising bubble produced by the detonation. After the turbulence of the explosion has dispersed, the pool stabilizes and chemical products become uniformly distributed. The surface pool is usually not visible after about five minutes. As the pool continues to grow, the chemical products are diluted and become undetectable. Because of continued dispersion and mixing, there would be no buildup of explosion products in the water column.

Table 4-2 lists predicted water column concentrations of explosion products in the surface pool at the time of stabilization (Young, 1995a). The table compares the concentrations with water quality criteria developed to protect marine or human life. The EPA (1986) has published water quality criteria for ammonia and cyanide, but not for the other explosion products. The two solids, carbon and aluminum oxide, are both found in nature and are not hazardous materials. For the other products, criteria to protect marine life (Suter and Rosen, 1988) or humans (Sittig, 1985) were used. All of the predicted concentrations are below the criteria, indicating no hazard to marine life.

4.2.2 Biological Environment

4.2.2.1 Plankton

Plankton at either Mayport or Norfolk would be affected mainly by the physical force of the shock wave from the proposed detonations. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3).

Physical effects would be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (**Figure 4-1**). This is a region of near total physical trauma within which no organisms would be expected to survive. The maximum lateral extent of the cavitation region is estimated at 494 m (1,620 ft) for a 4,536 kg (10,000 lb) charge (Appendix D). This region would extend from the surface to a depth of about 24 m (80 ft). Due to the rapid replenishment of plankton through population growth and/or turbulent mixing with adjacent waters, no lasting impacts on plankton communities are expected at either the Mayport or Norfolk area.

Sargassum communities (described in Section 3.2.1.2) are an important component of the plankton because this seaweed provides habitat for juvenile sea turtles. Although plankton is not a main focus of mitigation efforts, detonation would be postponed if large rafts of

Table 4-2. Predicted concentrations of explosion products in seawater, compared with permissible concentrations (Adapted from: Young, 1995a). Predicted concentrations are for the surface pool at the time of stabilization. Permissible concentrations are based on reference standards for marine life (U.S. Environmental Protection Agency, 1986; Suter and Rosen, 1988). In cases where marine life criteria have not been established, values for humans were used (Sittig, 1985).

Explosion Product	Predicted Concentration (mg/L)	Permissible Concentration (mg/L)
Carbon dioxide (CO_2)	0.00113	1.0[a]
Carbon monoxide (CO)	0.0127	0.552
Ammonia (NH_3)	0.001	0.092[b]
Ethane (C_2H_6)	0.00203	120
Propane (C_3H_8)	0.000586	120
Hydrogen cyanide (HCN)	0.000129	0.001[b] 0.036[c]
Methane (CH_4)	0.0000546	120
Methyl alcohol (CH_3OH)	0.00000446	3.60
Formaldehyde (CH_2O)	0.00000221	0.0414
Carbon (C)	0.0621	NA
Acetylene (C_2H_2)	0.00000285	73
Phosphine (PH_3)	0.00000394	0.0055
Aluminum oxide (Al_2O_3)	0.189	NA

a 1.0 mg/L produces avoidance by fish.

b Water quality criterion from U.S. Environmental Protection Agency (1986).

c Maximum acceptable toxicant concentration for fish exposed to cyanide (Suter and Rosen, 1988).

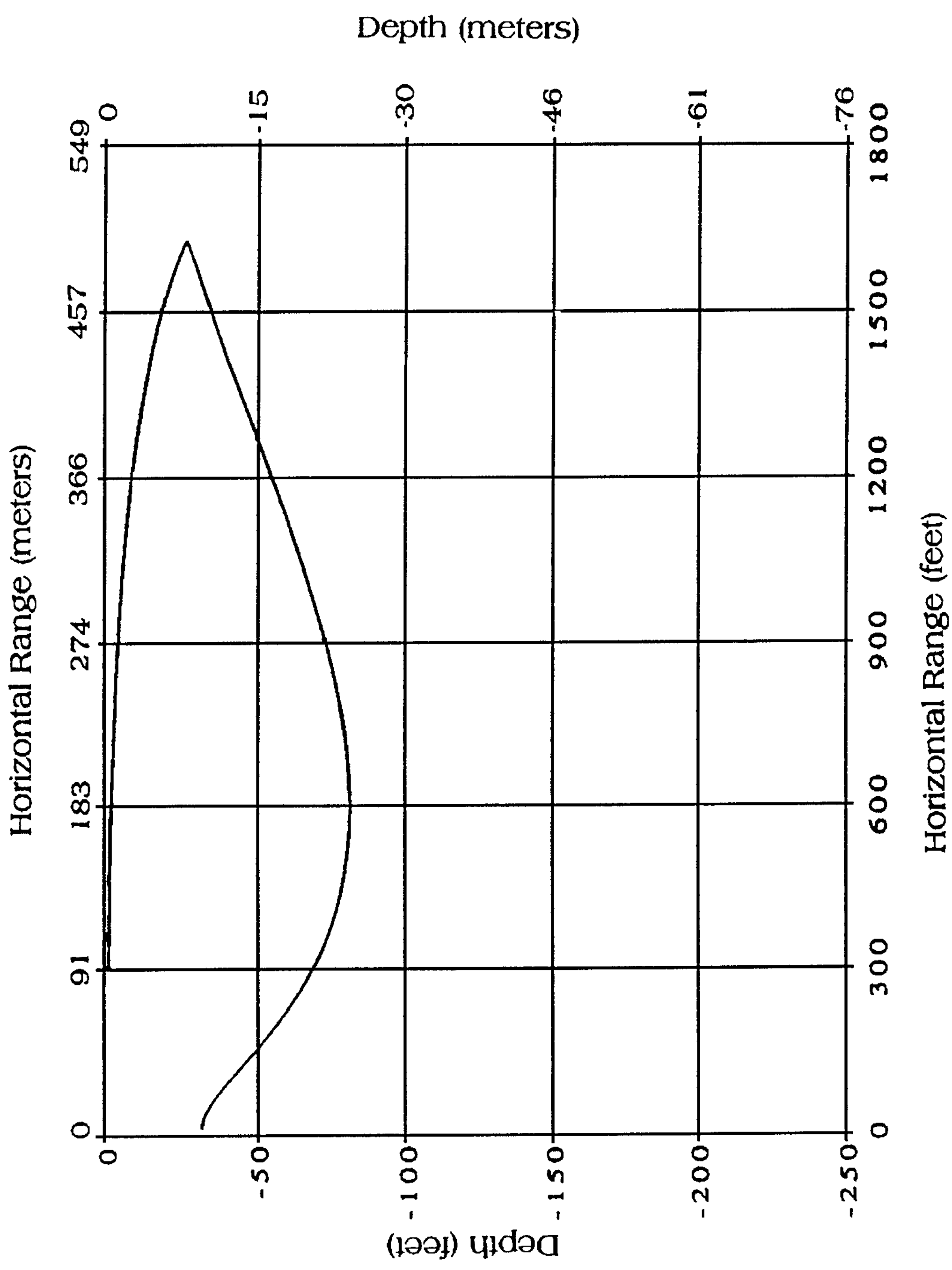


Figure 4-1. Bulk cavitation region for a 4,536-kg (10,000-lb) charge (From: Appendix D).

sargassum were present within the Safety Range, in order to protect juvenile and hatchling sea turtles (see Section 5.0).

4.2.2.2 Pelagic Fish

The proposed underwater detonations could have two main effects on pelagic (water column) fish. First, fish within a certain radius would be killed or injured by the resulting shock waves. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Second, fish at greater distances may react behaviorally to sound impulses from the blasts. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Potential impacts on demersal (bottom) fish are discussed separately under Benthos (Section 4.2.2.5).

Mortality and Injury

Effects of underwater explosions on fish have been studied extensively (Yelverton et al., 1975; O'Keeffe and Young, 1984; Young, 1991; Goertner et al., 1994). Studies have shown that the fish most vulnerable to death and injury are those with swimbladders. A swimbladder is a gas-filled organ used to control buoyancy. Most commercial and recreational fishery species are in this category. Fish without swimbladders, such as sharks and flatfish, generally are very resistant to explosions (Goertner et al., 1994). Vulnerability also depends on fish size and shape; smaller fish and those that are laterally compressed are more susceptible to injury.

Based on theoretical models and experimental evidence, Young (1991) developed equations to predict a 10% mortality range for fish (i.e., a distance beyond which at least 90% of fish would survive). **Table 4-3** lists the 10% mortality range for pelagic fish expected to occur at the Mayport and Norfolk areas. Most species could occur at both areas, so the impacts should be similar. The distances range from 22 m (73 ft) for non-swimbladder fish to over 914 m (3,000 ft) for some of the small swimbladder fish. The latter species, such as dwarf herring, round scad, Atlantic menhaden, alewife, chub mackerel, butterfish, and bluefish are the ones most likely to be injured or killed by the blasts if they are present at the site during testing.

Schooling and non-schooling fish may differ in vulnerability. Non-schooling species are usually widely dispersed, and few individuals are likely to be present at the test site. Most oceanic pelagic fish are non-schooling; exceptions are dolphinfish, tunas, and occasionally wahoo. For schooling fish, it is more likely that either several or none could be killed. Most coastal pelagic fish, including the small swimbladder species, are schooling fish. However, detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0).

It is not possible to accurately estimate the number of fish that would be within the 10% mortality range, because the abundance of fish in the open ocean is extremely variable. Monitoring following detonation of a 4,536 kg (10,000 lb) charge for the shock trial of the USS JOHN PAUL JONES revealed about 100 dead fish (Naval Air Warfare Center, 1994).

Table 4-3. Estimated 10% mortality range for pelagic fish at the Mayport and Norfolk areas. The 10% mortality range is the distance from the detonation point beyond which 90% or more of the fish would survive. Calculations are based on Young (1991), assuming a 4,536 kg (10,000 lb) charge detonated 30 m (100 ft) below the sea surface.

Common Name	Occurrence		Swim Bladder	Schooling	Fish Weight	10% Mortality Range
	Mayport	Norfolk			(lb)	(ft)
Oceanic Pelagic Fish						
Dolphin	X	X	Yes	Yes	10	2,557
Wahoo	X	X	Yes	Occasionally	20	2,337
Sailfish	X	X	Yes	No	40	2,135
White marlin	X	X	Yes	No	50	2,074
Tunas	X	X	Yes (reduced in some)	Yes	60	2,026
Swordfish	X	X	Yes	No	150	1,798
Blue marlin	X	X	Yes	No	250	1,683
Sharks	X	X	No	No	100	73
Coastal Pelagic Fish						
Dwarf herring	X	--	Yes	Yes	0.1	4,653
Round scad	X	--	Yes	Yes	0.25	4,130
Atlantic menhaden	X	X	Yes	Yes	0.5	3,774
Alewife	--	X	Yes	Yes	0.5	3,774
Chub mackerel	X	X	Yes	Yes	1	3,449
Butterfish	X	X	Yes	Yes	1.75	3,207
Bluefish	X	X	Yes	Yes	2-20	2,337-3,152
Jacks	X	X	Yes	Yes	8	2,632
Cobia	X	X	Yes	Yes	20	2,337
Atlantic mackerel	X	X	No	No	2	73
Spanish mackerel	X	X	No	Yes	2	73
Little tunny	X	X	No	Yes	9	73
King mackerel	X	X	No	Yes	15	73
Requiem sharks	X	X	No	Yes	50	73

Previous observations following explosives testing near Key West, Florida have shown "very few" floating dead fish (Department of the Navy, 1981).

Although the number of fish that would be killed or injured is not known, overall impacts on individual species are expected to be insignificant based on the relatively small area affected. The area within the 10% mortality range would represent only a small percentage of the offshore habitat at this water depth. The area within 1 nmi to either side of the 152 m (500 ft) depth contour is about 730 km^2 (213 nmi^2) at Mayport and 490 km^2 (143 nmi^2) at Norfolk. From Table 4-3, the maximum radius of the 10% mortality range is 1.42 km (4,653 ft, or 0.77 nmi). The area within this radius is 6.32 km^2 (1.84 nmi^2), which is less than 1% of the total area at Mayport and just over 1% of the total area at Norfolk. Pelagic fish species are widely distributed and are not restricted to the Mayport and Norfolk areas; therefore much less than 1% of the population is likely to be affected.

The distances listed in Table 4-3 apply to fish near the surface, where the reflected shock wave produces a region of negative pressure (see Appendix D, Section D.5 for a description of the cavitation region). Pelagic fish in deeper water or near the bottom could survive much closer to the blast. These fish would experience only the direct, positive pressure wave and reflections from the bottom. Under these conditions, there would not be much difference in survival between swimbladder and non-swimbladder species. Effects on demersal (bottom) fish are discussed separately in Section 4.2.2.5.

Behavioral Responses

Fish can hear and react to sounds (Popper and Fay, 1993). Hearing ability (frequency range and sensitivity) differs greatly among species. Fish with a swimbladder connected to the inner ear, such as herring, or other anatomical adaptations generally have the best hearing.

Effects of low-frequency sound pulses on fish have been reviewed by BBN Systems and Technologies (1993). The review included several studies of airgun blasts (Chapman and Hawkins, 1969; Dalen and Raknes, 1985; Pearson et al., 1992; Skalski et al., 1992). Such sound pulses have been shown to produce behavioral responses such as avoidance, alarm, and startle reactions, and may temporarily affect schooling behavior. The review concluded that sound pulses at received levels of 160 dB re 1 μPa (pressure) may cause subtle changes in behavior, and stronger pulses (180 dB) could cause more noticeable changes. For a 4,536 kg (10,000 lb) charge, sound pressure levels of 160 dB could extend hundreds of nautical miles from the detonation point.

Similar fish species occur at the Mayport and Norfolk areas, so the effects should be similar. Any behavioral responses to low-frequency sounds from the underwater explosions would be short term and reversible. Unlike the airgun blasts cited above, detonations during SEAWOLF shock testing would be five single events occurring at about one-week intervals. Fish behavior should return to normal within seconds or minutes after each explosion. No lasting effect on schooling behavior or catchability (for fishery species) is expected.

4.2.2.3 Marine Mammals

Two main types of potential direct impacts on marine mammals are discussed here. First, marine mammals may be killed or injured if they are present within about 1.85 km (1 nmi) of the detonation point and are not detected during pre-test monitoring. Second, marine mammals at greater distances [up to 15.7 km (8.5 nmi) for odontocetes and 23.5 km (12.7 nmi) for mysticetes] may experience auditory effects such as temporary threshold shift (TTS). At still greater distances, some marine mammals may hear the detonations and exhibit a momentary, minor behavioral response. Possible indirect impacts to marine mammals are also discussed.

Criteria for marine mammal lethality, injury, and harassment were developed through extensive literature review and modeling. Details are provided in Appendix D (for mortality and injury criteria) and Appendix E (for auditory criteria). Appendix C provides an overview of the marine mammal impact criteria used in the FEIS and explains how and why they differ from those used in the DEIS.

In addition to the main effects discussed here, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Minor increases in vessel and air traffic are not a major concern from the standpoint of marine mammal harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; and flights at approved altitudes).

Because the proposed action may result in mortality, injury, or harassment of marine mammals, the Navy submitted a request for an "incidental take" authorization from the NMFS concurrently with the release of the DEIS. The Marine Mammal Protection Act of 1972 allows the incidental (but not intentional) taking of marine mammals upon request if the taking will (1) have a negligible impact on the species or stock(s); and (2) not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. In response to the Navy's incidental take request, the NMFS published a Proposed Rule in the Federal Register on August 2, 1996 (61 FR 40377) and participated in joint public hearings to receive comments. The Proposed Rule specifies mitigation, monitoring, and reporting requirements for SEAWOLF shock testing. A Final Rule must be issued before shock testing can proceed.

In addition, because listed (endangered or threatened) species of marine mammals and sea turtles may occur at the Mayport or Norfolk areas, formal consultation with the NMFS is required under the Endangered Species Act. The DEIS served as a Biological Assessment that was submitted to the NMFS. Based on this information, the NMFS has issued a Biological Opinion (see Appendix G) taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The Biological Opinion concludes that, with the mitigation included in the proposed action, shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

The proposed action includes mitigation that would minimize risk to marine mammals (see Section 5.0). The Navy would (1) select an operationally suitable test site that poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of detectable marine mammals, turtles, large sargassum rafts or jellyfish concentrations, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation or if any marine mammals or turtles were detected in the Safety Range immediately following a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

The Safety Range radius of 3.7 km (2 nmi) and the Buffer Zone of 1.85 km (1 nmi) were developed to prevent mortality and injury of marine mammals and sea turtles. The Safety Range radius is about three times the predicted mortality range and twice the predicted injury range. The radius of the buffered Safety Range (5.6 km or 3 nmi) is about five times the predicted mortality range and three times the predicted injury range. Aerial and acoustic monitoring would extend beyond the Safety Range to ensure that no marine mammal or turtle enters the Safety Range prior to detonation (see Section 5.0).

Overview of Impact Analysis

The actual numbers of marine mammals that may be killed, injured, or harassed as a result of SEAWOLF shock testing cannot be known in advance. During the shock trial of the USS JOHN PAUL JONES, which involved detonation of two 4,536 kg (10,000 lb) charges, no marine mammal deaths or injuries were detected despite marine mammal densities that were about 3 times greater than at the Norfolk area and about 25 times greater than at the Mayport area (Naval Air Warfare Center, 1994). Similar mitigation methods that build upon this previous experience are proposed for the SEAWOLF shock testing (see Section 5.0). In addition, based on the clumped distribution of marine mammals at the Mayport and Norfolk areas as shown in Figures 3-3 and 3-4, the Navy expects to be able to select a specific test site with few, if any, marine mammals present.

However, it is necessary to estimate numbers of potentially affected animals (1) to provide a basis for comparing alternative areas in this FEIS and (2) to provide numbers for the incidental take request that was submitted to the NMFS in accordance with the Marine Mammal Protection Act. This analysis deliberately overestimates numbers of affected animals in order to provide an upper bound on potential impacts. Because the same assumptions and methods are used for both Mayport and Norfolk, the analysis is appropriate for comparing the alternative areas.

The number of marine mammals potentially killed, injured, or harassed as a result of the proposed detonations was estimated using a series of steps and assumptions:

1. Maximum ranges for mortality, injury, and harassment were defined using criteria developed in Appendices D and E. The criteria are listed in **Table 4-4** and explained later in this section. The mortality and injury criteria are based on tests conducted with terrestrial mammals, and the harassment criterion is based on temporary threshold shift (TTS) in bottlenose dolphins. The assumptions used to apply these data to all marine mammals include a margin of safety to avoid underestimating the impact range.

2. These maximum ranges were used to define concentric circles around the detonation point (**Figure 4-2**), and to calculate the area within each circle. The area of the injury range was corrected by subtracting the area of the mortality range to avoid double-counting mortality and injury. Similarly, the areas of the mortality and injury ranges were subtracted from the harassment range. Resulting areas are listed in Table 4-4.

3. Mean densities of each species were multiplied by the area of the mortality, injury, and harassment ranges to estimate the number of mammals affected "without mitigation" for a single detonation. Mean densities were taken from Section 3.2.3 and are based on aerial survey counts adjusted for submerged and undetected individuals.

4. Mitigation effectiveness was estimated for each species, taking into account the probability of detection by aerial and surface observers and passive acoustic monitoring (see Appendix B). For mortality and injury, the "without mitigation" numbers for each species were then multiplied by (1 minus mitigation effectiveness), which is the probability of not detecting that species during pre-detonation monitoring. The resulting values are the expected number of undetected animals of each species within the mortality and injury ranges.

5. For harassment, the "with mitigation" numbers were assumed to be equal to the "without mitigation" numbers, because only a small proportion of the harassment radius is within the Safety Range.

6. The mortality, injury, and harassment estimates for a single detonation were multiplied by five to account for the five detonations that would occur during SEAWOLF shock testing. Species historically present at or near each area but not seen during 1995 or 1997 aerial surveys were each assigned a value of one individual for harassment. This value is similar to those calculated for the least abundant species observed during aerial surveys. The results were totaled and then rounded up to the nearest whole number.

There are several key assumptions. First, it was assumed that marine mammal densities during shock testing would be similar to those during the 1995 or 1997 aerial surveys. Although this may or may not hold true, the aerial survey observations are the best quantitative data available (see NMFS comment letter in Appendix H). Also, other species with historical sightings or strandings from the Mayport or Norfolk areas were taken into account by assuming one individual of each of these species would experience harassment. Second, it was assumed that the mean density for a whole area (Mayport or Norfolk) can be used to predict the expected number of animals that would occur within a small test site.

Table 4-4. Impact criteria for marine mammals.

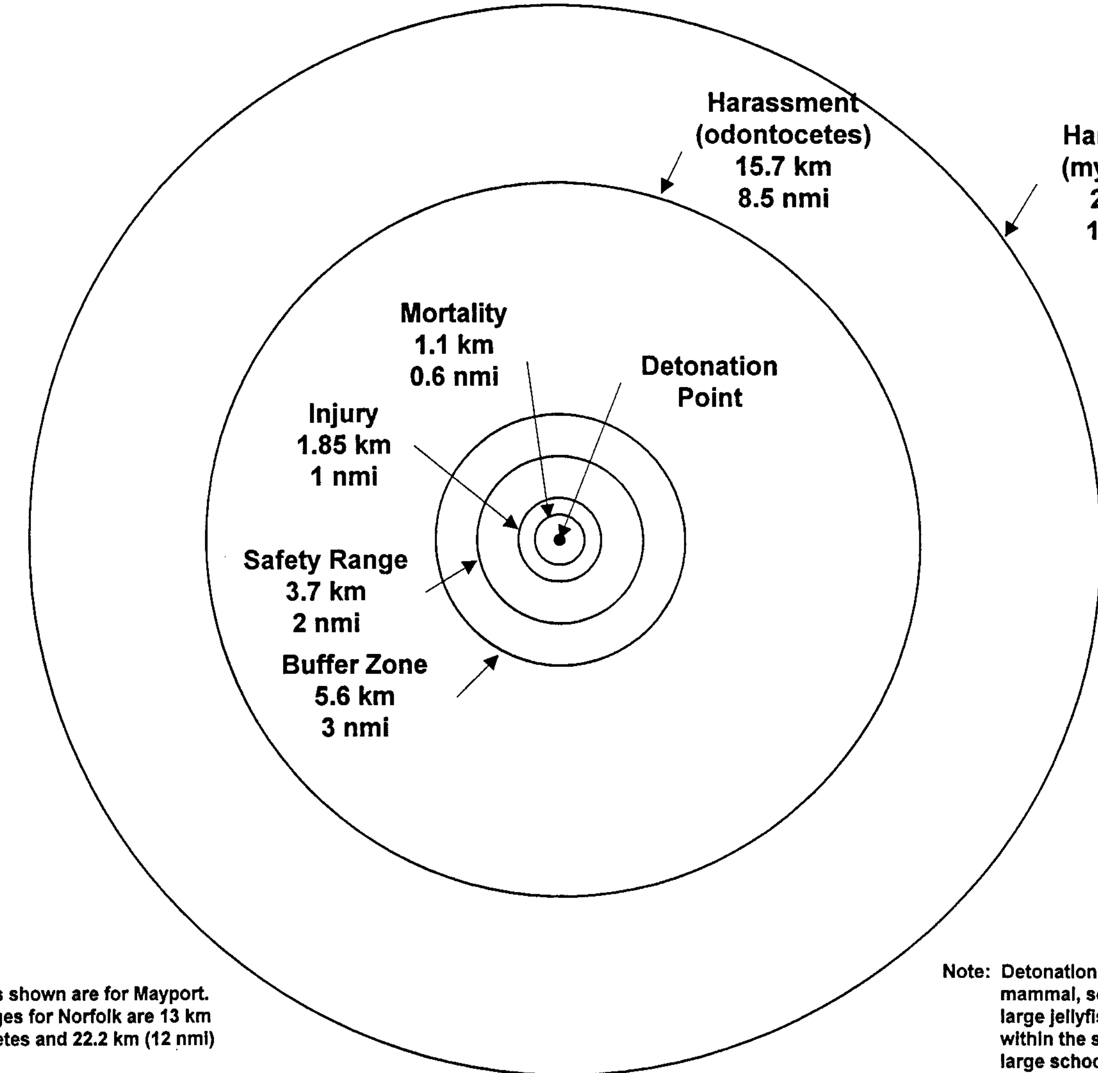
Impact Category	Specific Impact	Criterion	Predicted Maximum Range	Area for Impact Calculations [d]
Mortality	Onset of extensive lung hemorrhage (1% mortality)[a]	Impulse: 55.1 psi-msec (380 Pa-sec)	1.12 km (0.61 nmi)	3.96 km^2 (1.16 nmi^2)
Injury	50% tympanic membrane rupture[b]	Energy flux density: 1.17 in-lb/in^2 (20.44 milli-Joules/cm^2)	1.85 km (1.00 nmi)	6.85 km^2 (2.00 nmi^2)
Harassment	Temporary threshold shift (TTS)[c]	Energy: 182 dB re 1μPa^2 · sec	Mayport Odontocetes: 15.7 km (8.5 nmi)	767.60 km^2 (223.83 nmi^2)
			Mayport Mysticetes: 23.5 km (12.7 nmi)	1726.91 km^2 (503.55 nmi^2)
			Norfolk Odontocetes: 13.0 km (7.0 nmi)	517.10 km^2 (150.78 nmi^2)
			Norfolk Mysticetes: 22.2 km (12.0 nmi)	1540.63 km^2 (449.24 nmi^2)

[a] Criterion varies with animal size, with smaller animals being more vulnerable. The value given is for a very small marine mammal -- a calf dolphin (12.2 kg or 27 lb). Criteria for adult dolphins and whales would be higher and impact ranges would be lower (i.e., they would have to be closer to the detonation to be affected).

[b] Criterion is independent of animal size but varies with animal depth. The maximum range (given here) is for an animal at the bottom (152 m or 500 ft).

[c] TTS ranges for odontocetes were calculated using frequencies $\geq$100 Hz. For mysticetes, the range was calculated using frequencies $\geq$10 Hz. Separate calculations were done for Mayport and Norfolk using site-specific sound velocity profiles.

[d] The area of the mortality range has been subtracted from the area of the injury range (to avoid double-counting impacts). Similarly, the areas of the mortality and injury ranges have already been subtracted from the harassment ranges.



Note: Harassment ranges shown are for Mayport. Corresponding ranges for Norfolk are 13 km (7 nmi) for odontocetes and 22.2 km (12 nmi) for mysticetes.

Note: Detonation would be postponed if any marine mammal, sea turtle, large *sargassum* raft, or large jellyfish concentration was present within the safety range or if seabird flocks or large schools of fish were present within 1.85 km (1 nmi) of the detonation point.

Figure 4-2. Maximum horizontal ranges for mortality, injury, and acoustic harassment in relation to the safety range for mitigation efforts.

Using the mean to represent the expected density of marine mammals tends to overestimate impacts because, due to the "clumped" population distribution of marine mammals, most potential sites would have less than the mean density (**Figure 4-3**). Finally, the estimates of detectability (mitigation effectiveness) for each species are assumed to be accurate. These numbers were developed through a logical process that included literature review and consultation with and review by marine mammal experts (see Appendix B).

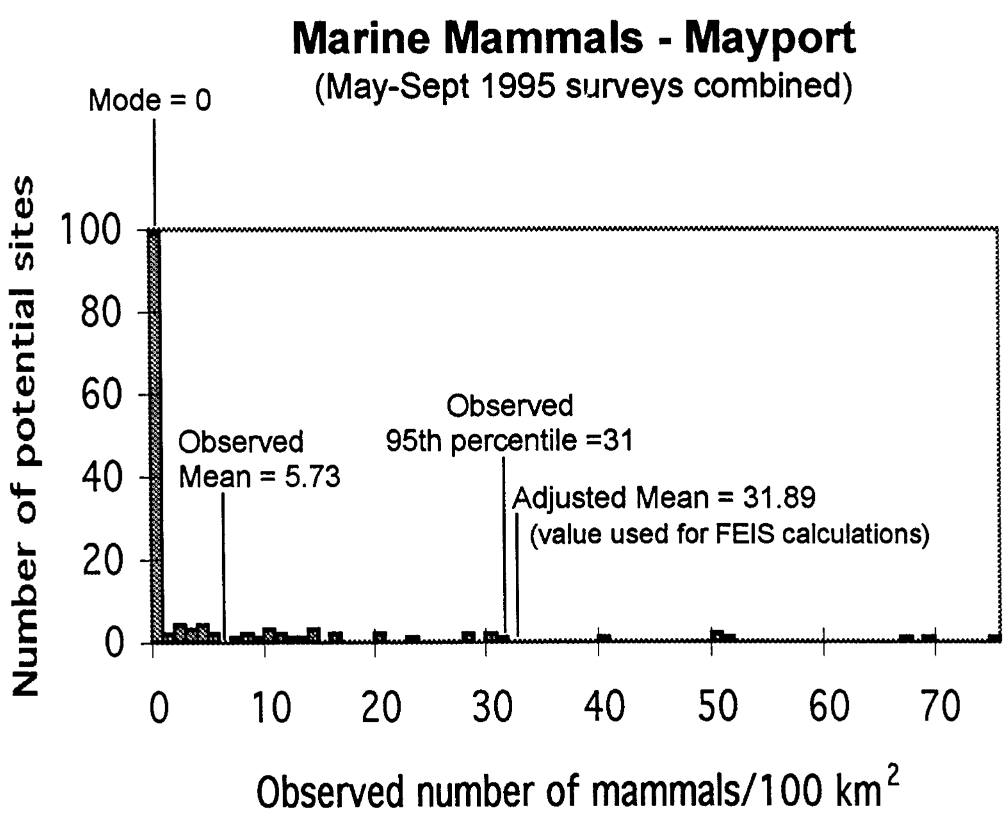
Results of the mortality and injury calculations for marine mammals are presented in **Tables 4-5 and 4-6** for Mayport (using survey data from 1995 and 1997, respectively) and **Table 4-7** for Norfolk.

Mortality and Injury

Marine mammals can be killed or injured by underwater explosions due to the response of air cavities, such as the lungs and bubbles in the intestines, to the shock wave (Yelverton et al., 1973; Hill, 1978; Goertner, 1982). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (Figure 4-1). This is a region of near total physical trauma within which no animals would be expected to survive. Based on calculations in Appendix D, the maximum horizontal extent of the cavitation region is estimated at 494 m (1,620 ft) for the proposed detonations. This region would extend from the surface to a maximum depth of about 24 m (80 ft).

A second measure of possible mortality (and the one that is used here) is the maximum range for the onset of extensive lung hemorrhage. Extensive lung hemorrhage is considered debilitating and potentially fatal; suffocation caused by lung hemorrhage is likely to be the major cause of marine mammal death from underwater shock waves, based on experiments with terrestrial mammals (Hill, 1978). Appendix D presents calculations that estimate the maximum range for the onset of extensive lung hemorrhage to marine mammals. The range varies depending on mammal weight, with the smallest mammals having the greatest range. The maximum range predicted for a small marine mammal (a calf dolphin) is 1.12 km (0.61 nmi) from the detonation point (**Figure 4-4**). *For purposes of impact analysis, it was assumed that 100% of the marine mammals within this radius would be killed, even though the probability of mortality from the onset of extensive lung hemorrhage is estimated to be only 1% at the outer edge of this range.*

Two of the measures of non-lethal injury discussed in Appendix D are slight lung hemorrhage and eardrum rupture. These are injuries from which animals would be expected to recover on their own. The maximum range predicted for the onset of slight lung hemorrhage is 1.77 km (0.96 nmi). The maximum range predicted for 50% probability of eardrum rupture varies with mammal depth in the water column. The highest range of 1.85 km (1.00 nmi), is calculated for a mammal at the bottom (Figure 4-4). The 50% eardrum rupture range at the bottom was used as the maximum range for non-lethal injury. *For purposes of impact analysis, it was assumed that 100% of marine mammals within this radius would be injured, even though the probability of eardrum rupture at the outer edge of this range is only 50% (and less in near-surface waters).*



NOTES:

1. A potential site is a group of 5 adjacent transects with an area of about 100 km^2, similar to the size of the 3 nmi radius mitigation range.

2. If a site were picked at random, then the most likely number of *visible* marine mammals would be given by the Mode, which is zero (0).

3. Because some marine mammals were not detected during surveys and to provide a margin of safety in the impact calculations, the FEIS used an Adjusted Mean Density, which is the Mean multiplied by correction factors for submerged and undetected individuals.

4. The Adjusted Mean is greater than the 95th percentile of the observed data.

5. The test site would *not* be picked at random, but rather on the basis of the lowest possible mammal and turtle densities. Therefore, the chance of picking a site with a density as high as the Adjusted Mean is probably much less than 0.05.

Figure 4-3. Statistical features of Mayport marine mammal data from 1995 aerial surveys.

Table 4-5. Estimates of potential marine mammal mortality, injury, and acoustic harassment from shock testing at the Mayport area, with and without mitigation, based on 1995 survey data. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to three decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Mayport during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for harassment.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harassment		Mortality	Injury	Harassment	Mortality	Injury	Harassment
BALEEN WHALES										
* Blue whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Bryde's whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Fin whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Humpback whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Minke whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Northern right whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Sei whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOOTHED WHALES AND DOLPHINS										
Atlantic spotted dolphin	0.115	0.199	22.277	0.93	0.008	0.014	22.277	0.042	0.072	111.385
Bottlenose dolphin	0.116	0.201	22.566	0.93	0.008	0.015	22.566	0.042	0.073	112.832
Bottlenose/Atlantic spotted dolphin	0.039	0.067	7.522	0.93	0.003	0.005	7.522	0.014	0.024	37.611
Clymene/spinner/striped dolphin	0.028	0.049	5.497	0.96	0.001	0.002	5.497	0.005	0.009	27.485
Pantropical spotted dolphin	0.342	0.591	66.252	0.93	0.025	0.043	66.252	0.124	0.214	331.262
Pilot whale	0	0	0.2	NA	0	0	0.2	0	0	1
Risso's dolphin	0.261	0.452	50.630	0.93	0.019	0.033	50.630	0.095	0.164	253.148
Rough-toothed dolphin	0	0	0.2	NA	0	0	0.2	0	0	1
Sperm whale (E)	0.006	0.010	1.157	0.81	0.001	0.002	1.157	0.006	0.010	5.786
Spinner dolphin	0.075	0.129	14.466	0.96	0.003	0.005	14.466	0.014	0.023	72.328
Unidentified dolphin	0.280	0.485	54.391	0.93	0.020	0.035	54.391	0.102	0.176	271.953

Table 4-5. (Continued).

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
* Blainville's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Clymene dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Common dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Cuvier's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Dwarf sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* False killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Fraser's dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Gervais' beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Melon-headed whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Striped dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* True's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	1.262	2.184	249.358	0.93[d]	0.088	0.153	249.358	**1** (0.442)	**1** (0.766)	**1247** (1246.789)

(E) = endangered species. NA = not applicable. *= species historically present in the region but not seen at the Mayport area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.3) for May through September 1995 at Mayport, scaled to the area within the range for mortality (3.96 km^2 or 1.16 nmi^2), injury (6.85 km^2 or 2.00 nmi^2), or acoustic harassment (767.60 km^2 or 223.83 nmi^2 for odontocetes).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

d Overall mitigation effectiveness for all species combined was calculated as 1 minus (total with mitigation/total without mitigation).

Table 4-6. Estimates of potential marine mammal mortality, injury, and acoustic harassment from shock testing at the Mayport area, with and without mitigation, based on 1997 survey data. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to three decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Mayport during 1997 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for harassment.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
BALEEN WHALES										
* Blue whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Bryde's whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Fin whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Humpback whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Minke whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Northern right whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Sei whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOOTHED WHALES AND DOLPHINS										
Atlantic spotted dolphin	0.097	0.167	18.734	0.93	0.007	0.012	18.734	0.035	0.061	93.672
Bottlenose dolphin	0.731	1.265	141.708	0.93	0.053	0.092	141.708	0.265	0.458	708.541
Bottlenose/Atlantic spotted dolphin	0.199	0.345	38.670	0.93	0.014	0.025	38.670	0.072	0.125	193.348
Clymene/spinner/striped dolphin	0.180	0.311	34.827	0.96	0.007	0.011	34.827	0.033	0.056	174.133
Pantropical spotted dolphin	0.005	0.009	0.961	0.93	<0.001	0.001	0.961	0.002	0.003	4.804
Pilot whale	0.005	0.008	0.887	0.93	<0.001	0.001	0.887	0.002	0.003	4.434
Risso's dolphin	0.322	0.557	62.448	0.93	0.023	0.040	62.448	0.117	0.202	312.238
Rough-toothed dolphin	0.016	0.028	3.122	0.93	0.001	0.002	3.122	0.006	0.010	15.612
Sperm whale (E)	0.005	0.009	0.961	0.81	0.001	0.002	0.961	0.005	0.008	4.804
Spinner dolphin	0.056	0.096	10.808	0.96	0.002	0.003	10.808	0.010	0.017	54.041
Unidentified dolphin	0.207	0.358	40.111	0.93	0.015	0.026	40.111	0.075	0.130	200.553

Table 4-6. (Continued).

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harassment		Mortality	Injury	Harassment	Mortality	Injury	Harassment
* Blainville's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Clymene dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Common dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Cuvier's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Dwarf sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* False killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Fraser's dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Gervais' beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Melon-headed whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Striped dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* True's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	1.822	3.153	357.436	0.93[d]	0.124	0.215	357.436	**1** (0.621)	**2** (1.074)	**1788** (1787.179)

(E) = endangered species. NA = not applicable. *= species historically present in the region but not seen at the Mayport area during 1997 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.3) for May through September 1997 at Mayport, scaled to the area within the range for mortality (3.96 km^2 or 1.16 nmi^2), injury (6.85 km^2 or 2.00 nmi^2), or acoustic harassment (767.60 km^2 or 223.83 nmi^2 for odontocetes).
b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).
c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).
d Overall mitigation effectiveness for all species combined was calculated as 1 minus (total with mitigation/total without mitigation).

Table 4-7. Estimates of potential marine mammal mortality, injury, and acoustic harassment from shock testing at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to three decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic harassment.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
BALEEN WHALES										
Fin whale (E)	0.229	0.397	89.278	0.89	0.025	0.043	89.278	0.125	0.216	446.391
Humpback whale (E)	0.002	0.004	0.970	0.89	<0.001	<0.001	0.970	0.001	0.002	4.852
Minke whale	0.010	0.017	3.882	0.89	0.001	0.002	3.882	0.005	0.009	19.408
Sei whale (E)	0.010	0.017	3.882	0.89	0.001	0.002	3.882	0.005	0.009	19.408
Sei or Bryde's whale	0.005	0.009	1.941	0.89	0.001	0.001	1.941	0.003	0.005	9.704
Unidentified *Balaenoptera*	0.060	0.104	23.290	0.89	0.007	0.011	23.290	0.033	0.056	116.450
Unidentified baleen whale	0.020	0.035	7.763	0.89	0.002	0.004	7.763	0.011	0.019	38.817
* Blue whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Bryde's whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Northern right whale (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOOTHED WHALES AND DOLPHINS										
Atlantic spotted dolphin	2.055	3.556	268.388	0.93	0.149	0.258	268.388	0.745	1.289	1341.938
Bottlenose dolphin	1.282	2.218	167.417	0.93	0.093	0.161	167.417	0.465	0.804	837.083
Bottlenose/Atl. Spotted dolphin	0.160	0.276	20.846	0.93	0.012	0.020	20.846	0.058	0.100	104.228
Clymene/spinner/striped dolphin	0.611	1.057	79.800	0.96	0.022	0.038	79.800	0.111	0.192	398.999
Common dolphin	0.773	1.338	100.971	0.93	0.056	0.097	100.971	0.280	0.485	504.855
Cuvier's beaked whale	0.014	0.025	1.861	0.38	0.009	0.015	1.861	0.044	0.076	9.306
Pantropical spotted dolphin	1.085	1.877	141.685	0.93	0.079	0.136	141.685	0.393	0.680	708.426
Pilot whale	3.431	5.938	448.181	0.93	0.249	0.430	448.181	1.244	2.152	2240.906
Risso's dolphin	0.297	0.514	38.760	0.93	0.022	0.037	38.760	0.108	0.186	193.799
Sperm whale (E)	0.020	0.035	2.606	0.81	0.004	0.007	2.606	0.019	0.033	13.029
Spinner dolphin	0.155	0.268	20.194	0.96	0.006	0.010	20.194	0.028	0.048	100.971
Striped dolphin	0.060	0.104	7.817	0.96	0.002	0.004	7.817	0.011	0.019	39.086
Unidentified dolphin	0.962	1.666	125.725	0.93	0.070	0.121	125.725	0.349	0.604	628.626
Unidentified small whale	0.012	0.022	1.629	0.93	0.001	0.002	1.629	0.005	0.008	8.143

Table 4-7. (Continued).

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[c] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
* Atlantic white-sided dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Blainville's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Clymene dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Dwarf sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* False killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Fraser's dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Gervais' beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Harbor porpoise	0	0	0.200	NA	0	0	0.200	0	0	1
* Killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Melon-headed whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Northern bottlenose whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy killer whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Pygmy sperm whale	0	0	0.200	NA	0	0	0.200	0	0	1
* Rough-toothed dolphin	0	0	0.200	NA	0	0	0.200	0	0	1
* Sowerby's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
* True's beaked whale	0	0	0.200	NA	0	0	0.200	0	0	1
PINNIPEDS										
* Harbor seal	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	11.252	19.473	2185.890	0.93[d]	0.808	1.399	2185.890	**5** (4.041)	**7** (6.993)	**7805** (7804.425)

(E) = endangered species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

[a] "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.3) for April through September 1995 at Norfolk, scaled to the area within the range for mortality (3.96 km^2 or 1.16 nmi^2), injury (6.85 km^2 or 2.00 nmi^2), or acoustic harassment (517.10 km^2 or 150.78 nmi^2 for odontocetes and 1540.63 km^2 or 449.24 nmi^2 for mysticetes).

[b] Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial, surface, and passive acoustic monitoring (see Appendix B).

[c] "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

[d] Overall mitigation effectiveness for all species combined was calculated as 1 minus (total with mitigation/total without mitigation).

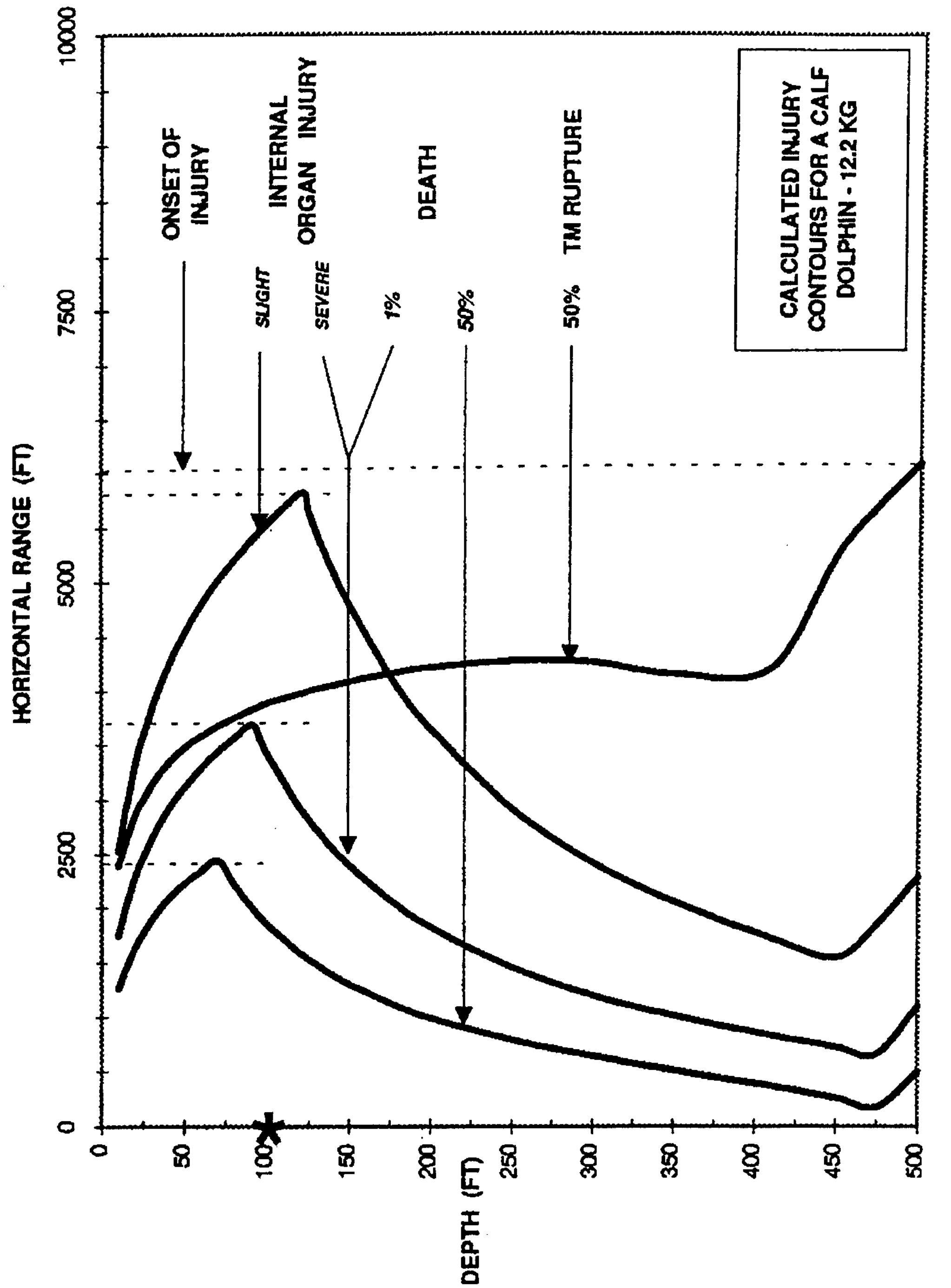


Figure 4-4. Calculated injury contours for a calf dolphin (27 lb or 12.2 kg) in relation to a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

It is recognized that some small percentage of the animals with eardrum rupture or slight lung hemorrhage could eventually die from their injuries. However, as noted above, the mortality criterion (onset of extensive lung hemorrhage) deliberately overestimates mortality by assuming 100% of animals within a radius of 1.12 km (0.61 nmi) would be killed. At this radius, the probability of eardrum rupture is 50% or less throughout most of the water column (see Figure D-8 in Appendix D); i.e., all animals within this radius are assumed to be killed even though some might not even have eardrum rupture.

Tables 4-5 and 4-6 summarize the mortality and injury calculations for the Mayport area based on 1995 and 1997 data, respectively. Based on the 1995 data, estimated maximum totals for five detonations (rounded up to the nearest whole number) are 1 mortality and 1 injury. Using the 1997 data, the totals would be 1 mortality and 2 injuries. Based on either set of calculations, it is very unlikely that one individual would be killed or injured by a single detonation. The two data sets differ somewhat with respect to species potentially affected. If the 1995 data are used, pantropical spotted dolphin and Risso's dolphin would have the highest numbers (but still much less than 1 individual). During the 1997 surveys, bottlenose dolphin and Risso's dolphin were the most abundant species and only a few pantropical spotted dolphins were seen. The relative risk to different species could vary from year to year, although the overall mortality and injury estimates, when rounded up to the nearest whole number, are similar for the two years of data.

The only endangered marine mammal species potentially killed or injured at Mayport is the sperm whale. Based on either 1995 or 1997 data, the estimated numbers for five detonations are less than 0.02 individuals for mortality and injury combined. Therefore, it is highly unlikely that any sperm whales would be killed or injured. Sperm whales produce distinctive clicked vocalizations (Jefferson et al., 1993) and are very likely to be detected (if present) using the passive acoustic monitoring system described in Section 5.0 (see Appendix B). The other endangered marine mammals (blue, fin, humpback, sei, and northern right whales) are baleen whales, which generally inhabit northern feeding grounds during the period proposed for shock testing (see Appendix B) and which were never observed off Mayport during the 1995 or 1997 aerial census efforts. Therefore, it is assumed none would be killed or injured by the proposed action.

Northern right whales are of special concern because of their highly endangered status; only about 300 individuals remain (Blaylock et al., 1995). The possibility of a right whale being present in the Mayport area during the potential test period (May through September) is remote. Northern right whales generally occur off Mayport from November/early December to April, with peak abundance between January and March (Kraus et al., 1993). Of 401 northern right whale sightings between 1950 and 1995, none occurred during May through September (Kenney, 1995). No northern right whales were seen during the April through September 1995 or May through September 1997 aerial surveys. Even if a northern right whale were present, it would almost certainly be detected by pre-detonation monitoring, as described in Section 5.0. According to recent aerial observations in the Mayport area during the calving season, northern right whales spend 15-87% of their time on the surface, with averages of 36% for single juveniles, 72% for mother/calf pairs, and 79% for surface active groups (Hain and Ellis, 1996). Therefore, during the 2.5 hours preceding detonation, a northern right whale could be on the surface for a total of 22 minutes to over 2 hours. Mean dive times are a few minutes. The probability of at least one aerial or surface observer detecting large animals which spend so much time at the surface is near 100%.

Table 4-7 summarizes the mortality and injury calculations for the Norfolk area. Estimated maximum totals for five detonations are 5 mortalities and 7 injuries. Species most likely to be affected (based on the 1995 survey data) are pilot whale, Atlantic spotted dolphin, and bottlenose dolphin.

In contrast to Mayport, several endangered whale species could be affected at the Norfolk area. However, even for the most abundant of these, the fin whale, total predicted mortalities and injuries are much less than one individual. The calculations indicate that it is highly unlikely that a humpback, sei, or sperm whale would be killed or injured.

Two other endangered species, the blue whale and the northern right whale, generally inhabit (or are migrating to) northern feeding grounds during the period proposed for shock testing and were never observed off Norfolk during the 1995 aerial census efforts; therefore, they are assumed to have no mortalities or injuries. In general, potential risk to endangered whale species would be lowest if testing occurred during July, August, or September; during 1995 aerial surveys, only one individual of an endangered species (fin whale) was seen during those months.

Tables 4.5, 4.6, and 4.7 show the mitigation effectiveness for individual species and for total marine mammals. Overall mitigation effectiveness for mortality and injury would be about 93% for both Mayport and Norfolk.

Harassment

An underwater explosion produces pressure pulses that have the potential for harassing marine mammals or damaging their hearing (Ketten, 1995; Richardson et al., 1995). An example of a pressure-time history for a 4,536 kg (10,000 lb) detonation is shown in **Figure 4-5**. Additional figures including energy vs. frequency plots for different ranges at Mayport and Norfolk are presented in Appendix E. Most of the acoustic energy from large underwater detonations is in low frequency ranges less than 500 Hz.

Harassment, as defined in the 1994 amendments to the Marine Mammal Protection Act of 1972, is "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild;" (Level A harassment) 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" (Level B harassment).

Although the 1994 amendments to the Marine Mammal Protection Act define harassment, they do not define threshold sound levels sufficient to cause it. The NMFS has not formally defined a threshold for harassment, but has cited temporary threshold shift (TTS) as an example (Federal Register 60[104]:28379-28386, 31 May 1995). TTS is a change in the threshold of hearing (the quietest sound that the animal can hear), which could temporarily

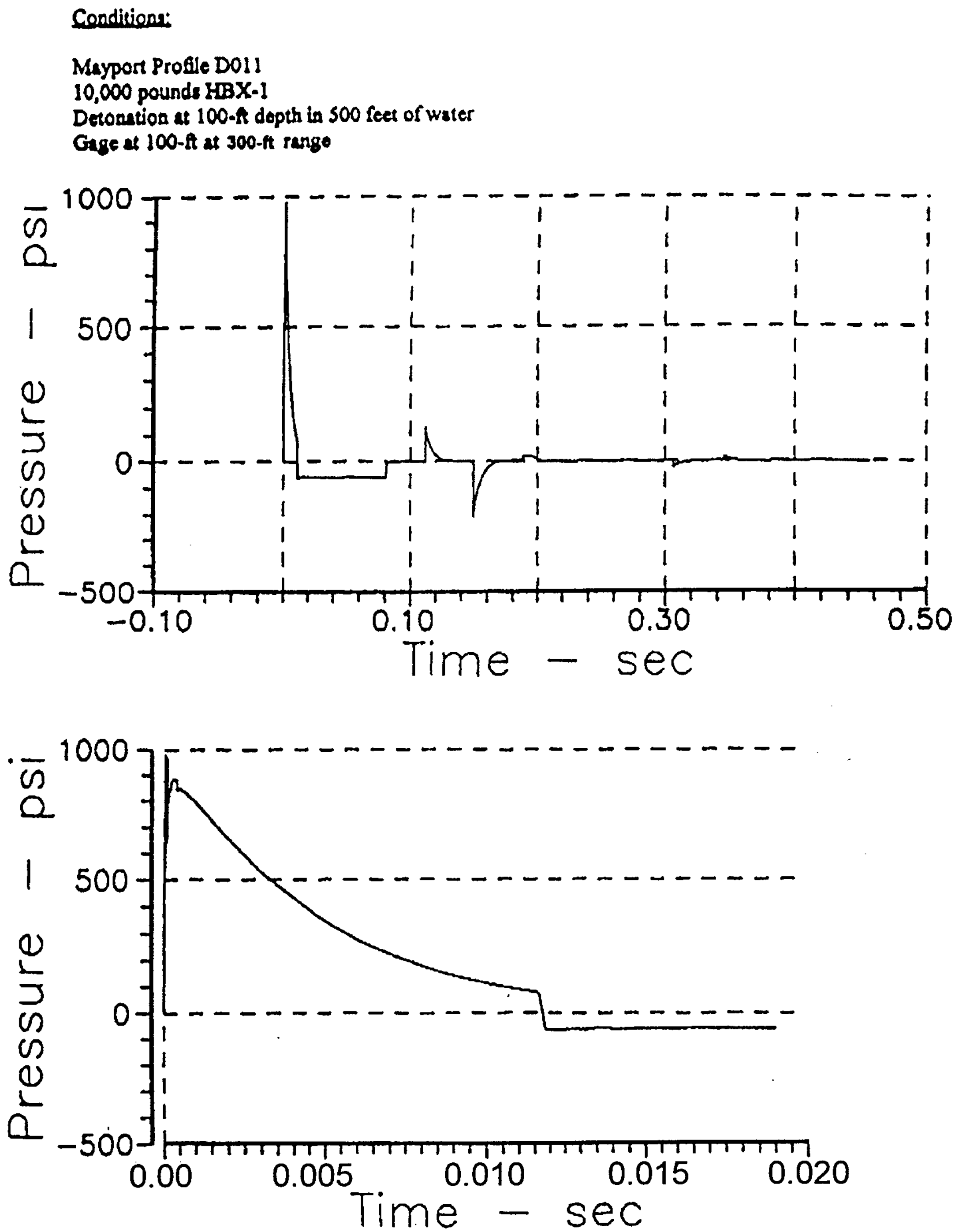


Figure 4-5. Example of a pressure-time plot for a 4,536 kg (10,000 lb) detonation.

affect an animal's ability to hear calls, echolocation sounds, and other ambient sounds. In this FEIS, TTS is used as a criterion for acoustic harassment of marine mammals.

In attempting to address the issue of Level B (behavioral) harassment, some previous environmental assessments have used a harassment criterion of 160 dB re 1 μPa. An example is the "incidental take" request for the USS JOHN PAUL JONES shock trial (Department of the Navy, 1993). This criterion was based on avoidance responses of migrating gray whales to seismic pulses (Malme et al., 1984). However, the 160 dB harassment criterion is based on a behavioral response that is of questionable biological significance in the context of a single pulse. In the case of a continuous source (e.g., industrial noise) or repeated transient sources (e.g., seismic pulses), avoidance could result in persistent changes to migratory, feeding, or breeding patterns that could affect the energetics of both individuals and populations. However, in the context of a single, brief pulse from a detonation, a momentary response causing an animal to dive or change course is not likely to be significant to either the individual or the population. Such a minor response is well within the range of normal behaviors that an animal might exhibit in response to other animals or other environmental stimuli.

The Navy believes that TTS provides a measurable basis for a harassment criterion for SEAWOLF shock testing. The Navy is using TTS as a measure of quantifiable harassment, as TTS may result in behavior reflecting an adverse reaction. Other possible forms of minor and short-term changes in immediate behavior which have no relation to any significant fear or pain cannot be reasonably measured, extrapolated, or predicted. TTS meets the definition of both Level A and Level B harassment. On a cellular level, TTS could be considered a very slight "injury" in the sense of damage to hair cells in the ear (see Appendix E). And because TTS is temporary hearing loss, it could lead to temporary "disruption of behavioral patterns" as specified in the statutory definition of Level B harassment.

The DEIS used a criterion of "acoustic discomfort" based on data from human divers. The DEIS stated that, "The most meaningful criterion would be one based on measurements of TTS resulting from exposure of marine mammals to underwater noise. Although hearing thresholds for odontocetes and pinnipeds exposed to pure tones have been measured, there are no available TTS data for any marine mammals (Richardson et al., 1995). Therefore, other methods were used to develop a criterion for acoustic discomfort. Data obtained from humans immersed in water and exposed to brief pure tones were used, assisted by human in-air data, to construct an underwater hearing-safety limit for marine mammals."

Since the release of the DEIS, new data have become available for temporary threshold shift in bottlenose dolphins (Ridgway et al., 1997). These are the first such data for any marine mammal. These experiments provide the best available basis for defining an acoustic harassment criterion for the proposed detonations. In the FEIS, "acoustic discomfort" has been replaced by TTS as a harassment criterion (see Appendix C).

In Appendix E, a dual criterion for acoustic harassment has been developed: (1) an energy-based TTS criterion of 182 dB re 1 $\mu Pa^2 \cdot sec$ derived from experiments with bottlenose dolphins (Ridgway et al., 1997); and (2) 12 psi peak pressure, cited by Ketten (1995) as associated with "a safe outer limit for the 10,000 lb charge for minimal, recoverable auditory trauma" (i.e., TTS). The harassment range is the minimum distance at which neither criterion is exceeded. Practically speaking, the 182 dB (energy) criterion was always the determining factor in the calculated ranges (Appendix E).

The 182 dB (energy) criterion was used to define estimated harassment ranges for the proposed detonations. Site-specific hydrographic data from the Mayport and Norfolk areas were used to calculate the ranges (Appendix E). Separate ranges were calculated for odontocetes and mysticetes based on their differing sensitivity to low frequencies. For odontocetes, which are "high frequency specialists," all frequencies greater than or equal to 100 Hz were included. For mysticetes, which are "low frequency specialists," all frequencies greater than or equal to 10 Hz were included. For the Mayport area, the harassment range is predicted to be 15.7 km (8.5 nmi) for odontocetes and 23.5 km (12.7 nmi) for mysticetes. Corresponding estimated harassment ranges at Norfolk are 13.0 km (7.0 nmi) for odontocetes and 22.2 km (12.0 nmi) for mysticetes. Expected numbers of marine mammals within these radii were calculated using Adjusted Mean Densities from Section 3.2.3. Because most of the harassment area would be outside the Safety Range, mitigation effectiveness was assumed to be zero (i.e., the "with mitigation" and "without mitigation" numbers were assumed to be equal).

It is considered impractical to mitigate for acoustic harassment. For example, increasing the Safety Range from 3.7 km (2 nmi) to 15.7 km (8.5 nmi) (the harassment range for odontocetes at Mayport) would increase the Safety Range area by more than 18 times. It would be logistically infeasible to monitor such a large area. Any increase in the mitigation area would reduce the effectiveness of near-field mitigation and increase the chance of killing or injuring a marine mammal or turtle.

Because the harassment range is much larger than the mortality or injury range, more individuals and more species could be affected. Therefore, species historically present at or near each area but not seen during 1995 or 1997 aerial surveys were taken into account in these calculations. This includes, for example, species such as the dwarf and pygmy sperm whales (*Kogia* spp.) which appear frequently in stranding reports from the southeastern U.S. but are rarely seen at sea. Each species was assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations. This value is similar to the values calculated for the least abundant species observed during the aerial surveys. The results were totaled and then rounded up to the nearest whole number.

Tables 4-5, 4-6, and 4-7 summarize the results of the acoustic harassment (TTS) calculations for the Mayport and Norfolk areas. Based on 1995 data for both areas, estimated maximum totals are 1,247 at Mayport and 7,805 for Norfolk. If the 1997 Mayport data are used, the Mayport total would be higher (1,788 animals) but still only about one-quarter of the Norfolk estimate. Species most likely to be affected at Mayport are bottlenose dolphin, Risso's dolphin, pantropical spotted dolphin, and Atlantic spotted dolphin; relative numbers vary depending on which year of data are used. The species most likely to be affected at Norfolk are pilot whale, Atlantic spotted dolphin, bottlenose dolphin, and pantropical spotted dolphin. Most species present at either area would have numerous individuals affected.

Comparison with the 160 dB Criterion. As noted above, some previous environmental assessments have used a harassment criterion of 160 dB re 1 μPa based on avoidance behavior of migrating baleen whales. The general rationale for using TTS instead of the 160 dB avoidance criterion has been discussed above. **Table 4-8** compares the two criteria as used in the incidental take request for the USS JOHN PAUL JONES shock trial (Department of the Navy, 1993) and in this FEIS. The advantages of the approach used in the FEIS are: (1) it is explicitly energy-based; (2) it derives from a standard, quantifiable auditory measurement; (3) it takes into account the way the ear works by using 1/3 octave frequency bands to approximate the bandwidth of the hearing system; (4) it was developed using a species (the bottlenose dolphin) that is common at both Mayport and Norfolk, as compared with migrating baleen whales which do not occur at Mayport and are rare at Norfolk during the proposed test period; (5) it is based on experiments with a single tone burst rather than repeated pulses; and (6) it takes into account the differing sensitivity of odontocetes and mysticetes by calculating separate ranges for them.

Behavioral Responses

At distances well beyond the estimated TTS range, marine mammals may detect the sound of the detonations and exhibit minor behavioral reactions (Richardson et al., 1995). As discussed above, avoidance reactions to seismic pulses have been documented based on a sound pressure of about 160 dB re 1 μPa, which would extend about 4,630 km (2,500 nmi) from the point of detonation. Detection and momentary, minor behavioral reactions are not considered harassment as defined above.

Research on behavioral reactions of marine mammals to impulsive noise has been summarized by Richardson et al. (1995). Although some controlled experiments have been conducted, most of the available information is anecdotal, with no data on the sound levels at the source and the receiver. Behavioral responses to sounds produced by underwater explosions and airgun arrays can include avoidance, altered patterns of surfacing and respiration, and interruptions in calling. Richardson et al. (1995) concluded that "some baleen whales show no strong behavioral reaction to noise pulses from distant explosions. They also show considerable tolerance of similar noise pulses from nonexplosive seismic exploration. However, strong seismic pulses elicit active avoidance, suggesting that explosives may sometimes do so as well." Todd et al. (1996) found that humpback whales in a coastal embayment showed little behavioral reaction to underwater detonations in terms of residency, overall movements, or general behavior, although it appears that increased entrapment rate of the whales in fishing nets may have been influenced by long-term effects of exposure to numerous detonations.

There is not as much information available on the behavioral responses of toothed whales and dolphins (Richardson et al., 1995). Avoidance and/or interruptions in calling have been documented in sperm whales at great distances from airgun arrays (Bowles et al., 1994; Mate et al., 1994a). Goold (1996) documented avoidance behavior of common dolphins near airgun arrays. Small explosive charges have often been used, with mixed success, to influence movement of dolphins (e.g., "seal bombs" used during purse-seining for yellowfin tuna).

Table 4-8. Comparison of 160 dB and temporary threshold shift (TTS) as criteria for acoustic harassment.

Characteristic	Acoustic Harassment Criterion: 160 dB re 1 μPa (as used in incidental take request for USS JOHN PAUL JONES shock trial)[a]	Acoustic Harassment Criterion: TTS (182 dB re 1 $\mu Pa^2 \cdot$ sec) (as used in SEAWOLF FEIS)
Units	Pressure[b]	Energy
Frequency	Does not consider frequency	Uses 1/3 octave bands (approximate filter bandwidth of hearing system)
Species used to develop criterion	Gray whale	Bottlenose dolphin
Effect on which criterion is based	Avoidance of repeated seismic pulses	Temporary threshold shift resulting from exposure to a single 1-sec pure-tone burst
Treatment of odontocetes vs. mysticetes	Assumed odontocetes would be unlikely to be acoustically harassed due to the brevity and very low frequency of the sound[c]	Separate ranges calculated for odontocetes and mysticetes based on their differing sensitivities to low frequencies
Calculated range for 4,536 kg (10,000 lb) detonation	Approximately 37 km (20 nmi)[d]	Odontocetes: Mayport: 15.7 km (8.5 nmi) Norfolk: 13.0 km (7.0 nmi) Mysticetes: Mayport: 23.5 km (12.7 nmi) Norfolk: 22.2 km (12.0 nmi))

[a] Department of the Navy (1993).

[b] The study on which the 160 dB criterion is based (Malme et al., 1984) used average (or effective) pulse pressure as a measure of the acoustic energy of the pulse from a seismic source. It is defined as the peak level of a square-topped sine wave pulse with the same duration that would contain the same energy as the actual seismic pulse.

[c] Similarly, BBN Systems and Technologies (1993) concluded that odontocetes would be less sensitive to low-frequency pulses but did not calculate a separate range for odontocete harassment.

[d] The 160 dB range was calculated incorrectly in the USS JOHN PAUL JONES incidental take request. The actual range is approximately 4,630 km (2,500 nmi).

It is reasonable to conclude that sounds produced by each detonation during SEAWOLF shock testing could startle marine mammals or result in avoidance or other subtle behavioral changes at distances beyond the estimated harassment range discussed above. However, because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would be affected by more than one detonation. Cetaceans are highly mobile; tagging studies and repeated sightings of photoidentified individuals have shown that marine mammals can travel 100 km or more during a day (Evans, 1971, 1974; Wursig and Wursig, 1977; Mate et al., 1987, 1994b). During the 1995 and 1997 aerial surveys, most sightings were of "traveling" individuals rather than "milling," "resting," or "stationary" animals (Department of the Navy, 1995b, 1998). Further, the surveys did not show any consistent patterns of abundance from month-to-month that would indicate that marine mammals congregate in any portion of the Mayport or Norfolk area. Finally, strong Gulf Stream currents would make it unlikely for animals to remain in a particular location for a week or more. Therefore, it is unlikely that an individual animal would be experience more than a single, momentary disturbance. No significant or lasting impact on movements, migration patterns, breathing, nursing, breeding, feeding, or other normal behaviors would be expected.

Indirect Impacts

An indirect way in which marine mammals could be affected is through death and injury to prey species. However, significant impacts are unlikely because (1) the Mayport and Norfolk areas are not known marine mammal feeding grounds, and (2) only a small area would be affected and prey populations would be rapidly replenished.

Toothed whales feed primarily upon mesopelagic and benthic fish. Sperm whales, pygmy sperm whales, and dwarf sperm whales prey primarily on squid; pygmy and dwarf sperm whales also feed on fish, octopus, and crustaceans. The main prey for pilot and beaked whales includes squid and fish (e.g., mackerel). Dolphins routinely consume squid and/or fish. Killer whales prey on a variety of marine organisms, including fish, sea turtles, seabirds, pinnipeds, and other marine mammals. Among the baleen whales, humpback whales feed primarily on euphausiids and small fish (e.g., mackerel, herring).

Pelagic fish and invertebrates within the cavitation region at the time of detonation are expected to be killed or injured. However, it is unlikely that prey availability would be altered for more than a few hours. Fish and invertebrate nekton (e.g., squid) from surrounding areas would quickly repopulate the small area affected. Plankton populations would be replenished through turbulent mixing with adjacent waters and population growth of each plankton species. Given that test site selection would be based on the low abundance of marine mammals, including both toothed and baleen whales, and given that the Mayport and Norfolk areas do not represent recognized feeding grounds for marine mammals, the potential for significant indirect effects is very low.

Summary

Potential direct impacts on marine mammals have been analyzed in detail in the preceding discussion. Potentially significant direct impacts include mortality, injury, and acoustic harassment. Momentary behavioral responses and possible indirect impacts to marine mammals due to impacts on prey species have also been discussed above but are considered not significant.

Table 4-9 summarizes marine mammal calculations for the Mayport and Norfolk areas. Estimated maximum totals for five detonations are 1 mortality and 1 or 2 injuries at Mayport (depending on whether 1995 or 1997 data are used), and 5 mortalities and 7 injuries at Norfolk. For acoustic harassment (TTS), estimated maximum totals for five detonations are 1,247 or 1,788 animals at Mayport and 7,805 at Norfolk. Based on 1995 data for both areas, the potential for mortality, injury, and acoustic harassment is about 5 to 7 times lower at Mayport than at Norfolk. If 1997 Mayport data are used instead, the potential for mortality, injury, and harassment is about 3.5 to 5 times lower at Mayport than at Norfolk. Overall mitigation effectiveness for mortality and injury would be about the same at the two areas (93%).

Table 4-9. Summary and comparison of Mayport and Norfolk areas with respect to marine mammal related impacts and mitigation effectiveness. A range of potential impacts is given. Maximum values are from the last row of Tables 4-5, 4-6, and 4-7; minimum values were calculated as described in the text.

Category	Description	Mayport		Norfolk (1995 data)
		1995 data	1997 data	
Mortality	Number of individuals potentially killed from 5 detonations	0-1	0-1	0-5
Injury	Number of individuals potentially injured from 5 detonations	0-1	0-2	0-7
Harassment (TTS)	Number of individuals potentially experiencing TTS from 5 detonations	92-1,247	171-1,788	488-7,805
Overall mitigation effectiveness for mortality and injury	Percentage of individuals within Safety Range that would be detected by combination of aerial, surface, and passive acoustic monitoring	93%	93%	93%

Because of the conservative assumptions incorporated in every step of the calculations, the numbers cited above should be regarded as upper limits for potential impacts. As described in Section 5.0, the Navy proposes to select a specific test site with few, if any, marine mammals present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during the shock trial of the USS JOHN PAUL JONES, with no deaths or injuries of marine mammals detected (Naval Air Warfare Center, 1994). Detection of even one marine mammal within the Safety Range would result in postponement of detonation; therefore, the presence of marine mammals would most likely result in testing delays rather than impacts on these animals. A lower limit for potential impacts can be estimated by (1) using the lowest monthly mean density from 1995 or 1997 aerial surveys; (2) assuming that all individuals were detected during the aerial surveys (i.e., no correction for submerged or undetected animals is necessary); and (3) assuming that mitigation effectiveness would be 100% (instead of 93%) for mortality and injury. For Mayport, the resulting totals would be zero mortalities, zero injuries, and either 92 or 171 individuals harassed (using 1995 or 1997 data, respectively). For Norfolk, the minimum estimates would be zero mortalities, zero injuries, and 488 individuals harassed.

At Mayport, it is very unlikely that any endangered marine mammals would be killed or injured. Sperm whales could be present, but in very low densities, and these animals are very likely to be detected by passive acoustic monitoring (see Section 5.0 and Appendix B). Northern right whales and other endangered baleen whales are very unlikely to occur at the Mayport area during the time period proposed for shock testing (May through September) and, if present, would very likely be detected by pre-detonation monitoring. At Norfolk, the endangered fin whale is abundant enough to possibly have a mortality or injury. Endangered humpback, sei, and sperm whales could also be present at Norfolk, but in very low densities. Other endangered species are very unlikely to occur at the Norfolk area during the time period proposed for shock testing (April through September).

4.2.2.4 Sea Turtles

Two main types of potential direct impacts on sea turtles are discussed here. First, animals may be killed or injured if they are present near the detonation point and not detected during pre-test monitoring. Second, animals at greater distances may be harassed by the physical and acoustic signatures of the explosions. Possible indirect impacts to sea turtles are also discussed.

In addition to these main effects, there are several minor issues that do not require detailed analysis. Effects of chemical products of the explosions are considered negligible because the initial concentrations are not hazardous to marine life and the products are rapidly dispersed in the ocean (see Section 4.2.1.3). Minor increases in vessel and air traffic are not a major concern from the standpoint of sea turtle harassment because of built-in mitigation measures (use of shipboard observers; limited transit speed; flights at approved altitudes).

Because listed (endangered or threatened) species of sea turtles may occur at the Mayport or Norfolk areas, formal consultation with the NMFS is required under the Endangered Species Act. The DEIS served as a Biological Assessment that was submitted to the NMFS. The NMFS has issued a Biological Opinion (Appendix G) taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The Biological Opinion concludes that, with the mitigation included in the proposed action, shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

The proposed action includes mitigation that would minimize risk to sea turtles (see Section 5.0). The Navy would (1) select an operationally suitable test site which poses the least risk to the marine environment; (2) effectively monitor the site prior to each detonation to ensure that it is free of marine mammals, turtles, large sargassum rafts or jellyfish concentrations, large schools of fish, and flocks of seabirds; and (3) determine the effectiveness of the mitigation efforts by using a Marine Animal Recovery Team (MART) and aerial observers to survey the site for injured or dead animals after each detonation. Detonation would be postponed if sea turtles, large sargassum rafts (which may be inhabited by juvenile or hatchling turtles), or large jellyfish shoals (which may indicate the presence of sea turtles) were detected within the Safety Range. If post-detonation monitoring showed that marine mammals or sea turtles were killed or injured as a result of a detonation, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

Mitigation measures also include a schedule shift to avoid high turtle densities in April at Mayport. Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. The higher abundance may have been due to turtles converging on nearshore areas prior to nesting. Because there was no April survey in 1997, the high turtle numbers seen during April 1995 could not be confirmed. However, based on the 1995 data and the likely concentration of loggerheads in offshore waters prior to the nesting season, exclusion of April from the test schedule at Mayport is considered a reasonable precaution. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

Mortality and Injury

Field observations have shown that sea turtles can be killed or injured by underwater explosions (O'Keeffe and Young, 1984; Klima et al., 1988). Effects are likely to be most severe in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation" (see Figure 4-1). This is a region of near total physical trauma within which no animals would be expected to survive. Beyond the bulk cavitation region, animals could still receive serious or minor injuries depending on distance from the detonation point.

The concept of a "Safety Range" has been discussed above under Marine Mammals. The same Safety Range of 3.7 km (2 nmi) would be used for both sea turtles and marine mammals. Detonation would not occur until there are no sea turtles, or marine mammals, large sargassum rafts, or large jellyfish concentrations detected within the Safety Range.

Although the Safety Range was calculated based on estimated maximum ranges for marine mammal mortality and injury (Appendix D), it is sufficient to protect sea turtles as well. The Safety Range is nearly three times greater than the non-injury range of 1.31 km (0.71 nmi) predicted using the O'Keeffe and Young (1984) equation for sea turtles. It is identical to the predicted safe range of 3.7 km (2 nmi) calculated using an equation developed by Young (1991).

With the Safety Range in place, sea turtles may be killed or injured only if they are not detected during pre-test monitoring. To estimate how many sea turtles could be killed or injured, the same methods and assumptions were used as described above under Marine Mammals. Adjusted mean densities that account for submerged and undetected turtles were used to calculate potential impacts. These densities are about 18 individuals/100 km^2 at Norfolk and 44 individuals/100 km^2 at Mayport (lower densities of about 17 individuals/100 km^2 were observed at Mayport in 1995, but the higher 1997 numbers were used). The adjusted mean densities are much higher than the highest density ever observed during the aerial surveys. For example, at Norfolk, the highest density was 6 individuals/100 km^2 and for Mayport in 1997, the highest density ever observed was about 7 individuals/100 km^2.

There is comparatively little experimental or theoretical data upon which to base mortality and injury ranges for sea turtles (O'Keeffe and Young, 1984; Young, 1991). Therefore, the corresponding ranges for marine mammals were used. These ranges were developed based on experiments with mammals (see Appendix D), but it is reasonable to assume that sea turtle lungs and other gas-containing organs would be similarly affected by shock waves (O'Keeffe and Young, 1984). Calculations in Appendix D show that observed effects of underwater explosions on sea turtles are consistent with predictions of the Goertner (1982) lung injury model that was used to develop mortality and injury criteria for marine mammals.

Tables 4-10 and **4-11** summarize mortality and injury calculations for sea turtles at the Mayport and Norfolk areas. For five detonations "with mitigation," the maximum estimated numbers based on 1995 data are 4 mortalities and 6 injuries for both Mayport and Norfolk. If the 1997 Mayport data are used, predicted maximum numbers are 8 mortalities and 14 injuries. Loggerheads make up most of the population at both areas and are the species most likely to be killed or injured.

Both of the sea turtle species potentially killed or injured at Mayport or Norfolk are listed species (endangered or threatened). Loggerheads are threatened, whereas leatherbacks are endangered. The three other sea turtle species (green, hawksbill, and Kemp's ridley) are also endangered or threatened, but these are primarily inshore species which were not seen at either area during aerial surveys. Therefore, no mortalities or injuries of these species are expected.

Average mitigation effectiveness for mortality and injury is about 8% for both Mayport and Norfolk. Mitigation is not very effective for sea turtles because they are small, stay submerged for extended periods, do not make visual displays (like dolphins leaping and spinning, or whales blowing) and do not make sounds. Mitigation effectiveness for juvenile turtles is assumed to be equal to that for adult turtles. Although juveniles are smaller, they are often associated with sargassum mats, and the presence of large sargassum rafts would cause detonation to be postponed (see Section 5.0). Also, animals at the sea surface (such as juvenile turtles in sargassum rafts) are unlikely to be affected unless they are very close to the detonation point (see Appendix D, Section D.6).

Table 4-10. Estimates of potential sea turtle mortality, injury, and acoustic harassment from shock testing at the Mayport area, with and without mitigation, based on 1995 and 1997 surveys. Shock testing would only be conducted "with mitigation," including no testing in April at Mayport. Numbers are given to three decimal places to indicate the relative risk to species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Mayport during 1995 or 1997 surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 for mortality and injury and 1 individual for acoustic harassment.

Species	MAYPORT AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	MAYPORT AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			MAYPORT AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
USING 1995 SURVEY DATA										
Loggerhead sea turtle (T)	0.600	1.038	116.303	0.081	0.551	0.954	116.303	2.755	4.768	581.517
Leatherback sea turtle (E)	0.045	0.077	8.679	0.096	0.040	0.070	8.679	0.202	0.350	43.397
Unidentified sea turtle	0.024	0.042	4.734	0.089	0.022	0.039	4.734	0.111	0.193	23.671
* Green sea turtle (T)	0	0	0.200	NA	0	0	0.200	0	0	1
* Hawksbill sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	0.669	1.158	130.317	0.083[d]	0.614	1.062	130.317	**4** (3.069)	**6** (5.311)	**652** (651.584)
USING 1997 SURVEY DATA										
Loggerhead sea turtle (T)	1.338	2.315	259.398	0.081	1.229	2.127	259.398	6.145	10.634	1296.990
Leatherback sea turtle (E)	0.242	0.418	46.836	0.096	0.218	0.378	46.836	1.092	1.890	234.179
Unidentified sea turtle	0.149	0.257	28.822	0.089	0.135	0.234	28.822	0.677	1.172	144.110
* Green sea turtle (T)	0	0	0.200	NA	0	0	0.200	0	0	1
* Hawksbill sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	1.728	2.990	335.656	0.084[d]	1.583	2.739	335.656	**8** (7.914)	**14** (13.697)	**1679** (1678.279)

(E)=endangered species. (T)=threatened species. NA=not applicable. * =species historically present in region but not seen at Mayport during 1995 or 1997 surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.4) for May through September 1995 or 1997 at Mayport, scaled to the area within the range for mortality (3.96 km^2 or 1.16 nmi^2), injury (6.85 km^2 or 2.00 nmi^2), or acoustic harassment (767.60 km^2 or 223.83 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial and surface monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

d Overall mitigation effectiveness for all species combined was calculated as 1 minus (total with mitigation/total without mitigation).

Table 4-11. Estimates of potential sea turtle mortality, injury, and acoustic harassment from shock testing at the Norfolk area, with and without mitigation. Shock testing would only be conducted "with mitigation." Numbers are given to three decimal places to indicate the relative risk to various species; totals for five detonations are rounded up at the end of the table. Species historically present in the region but not seen at Norfolk during 1995 aerial surveys (indicated by * next to the species name) are assigned five-detonation totals of 0 individuals for mortality and injury and 1 individual for acoustic harassment.

Species	NORFOLK AREA SINGLE DETONATION WITHOUT MITIGATION[a] No. of Animals Within Specified Range			Mitigation Effectiveness[b] (Mortality and Injury Only)	NORFOLK AREA SINGLE DETONATION WITH MITIGATION[c] No. of Undetected Animals Within Specified Range			NORFOLK AREA FIVE DETONATIONS WITH MITIGATION No. of Undetected Animals Within Specified Range		
	Mortality	Injury	Harass-ment		Mortality	Injury	Harass-ment	Mortality	Injury	Harass-ment
Loggerhead sea turtle (T)	0.658	1.139	85.988	0.081	0.605	1.047	85.988	3.024	5.233	429.941
Leatherback sea turtle (E)	0.012	0.022	1.629	0.096	0.011	0.020	1.629	0.056	0.098	8.143
Unidentified sea turtle	0.041	0.071	5.330	0.089	0.037	0.064	5.330	0.186	0.322	26.649
* Green sea turtle (T)	0	0	0.200	NA	0	0	0.200	0	0	1
* Hawksbill sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
* Kemp's ridley sea turtle (E)	0	0	0.200	NA	0	0	0.200	0	0	1
TOTAL	0.712	1.231	93.547	0.082[d]	0.653	1.130	93.547	**4** (3.266)	**6** (5.652)	**468** (467.733)

(E) = endangered species. (T) = threatened species. NA = not applicable. * = species historically present in the region but not seen at the Norfolk area during 1995 aerial surveys.

a "Without mitigation" numbers are based on adjusted mean densities (see Section 3.2.4) for April through September at Norfolk scaled to the area within the range for mortality (3.96 km^2 or 1.16 nmi^2), injury (6.85 km^2 or 2.00 nmi^2), or acoustic harassment (517.10 km^2 or 150.78 nmi^2).

b Mitigation effectiveness is the probability that an individual, if present, would be detected. It takes into account aerial and surface monitoring (see Appendix B).

c "With mitigation" numbers are equal to the "without mitigation" numbers times (1 minus mitigation effectiveness).

d Overall mitigation effectiveness for all species combined was calculated as 1 minus (total with mitigation/total without mitigation).

Harassment

An underwater explosion produces pressure pulses that have the potential for harassing sea turtles or damaging their hearing. In contrast to marine mammals, little is known about the role of sound and hearing in sea turtle survival. However, it is assumed that such an exposure could lead to TTS that could temporarily disrupt turtle behavior patterns. Therefore, TTS is used here as a criterion for acoustic harassment of sea turtles.

There are no data for TTS in sea turtles. Therefore, the TTS criterion developed for odontocete marine mammals has been applied to estimate potential harassment. Ridgway et al. (1969) reported maximal sensitivity for green sea turtles occurred at 300 to 400 Hz, with a rapid decline in sensitivity for lower and higher tones. Similarly, Moein et al. (1994) reported a hearing range of about 250 to 1,000 Hz for loggerhead sea turtles, and Lenhardt (1994) stated that maximal sensitivity in sea turtles generally occurs in the range from 100 to 800 Hz. Calculated in-water hearing thresholds within the useful range appear to be high (e.g., about 160 to 200 dB re 1 µPa; Lenhardt, 1994). Based on this information, the TTS distance predicted for odontocetes using frequencies ≥100 Hz [i.e., 8.5 nmi (15.7 km) at Mayport and 7.0 nmi (13.0 km) at Norfolk] should be reasonable for sea turtles.

To estimate how many sea turtles could experience TTS, the same methods and assumptions were used as described above under Marine Mammals. Species historically present at or near each area but not seen during 1995 or 1997 aerial surveys (i.e., green, hawksbill, and Kemp's ridley turtles) were taken into account in the calculations. Each species was assigned a value of 0.2 individuals per detonation, for a total of 1 individual per 5 detonations.

Tables 4-10 and 4-11 summarize the results of the harassment calculations for sea turtles at the Mayport and Norfolk areas. For five detonations "with mitigation" and using 1995 survey data for both areas, estimated numbers of sea turtles harassed are 652 at Mayport and 468 at Norfolk. If the 1997 Mayport data are used, the numbers for Mayport would be 1,679 turtles. As noted above, loggerheads make up most of the population at both areas and are the species most likely to be affected.

Behavioral Responses

Behavioral responses could occur at distances beyond the estimated harassment range discussed above. Sea turtles are thought to be capable of hearing low frequency sounds; however, according to Ridgway et al. (1969), sensitivity falls off significantly below 200 Hz. It is assumed that sea turtles may hear the brief (<50 msec) acoustic signal created by the proposed underwater detonations. This could result in behavioral effects, such as swimming toward the surface, abrupt movements, slight retractions of the head, and limb extension during swimming (Lenhardt et al., 1983; Lenhardt, 1994).

Each detonation would be a single momentary disturbance. Because the five detonations would occur at about one-week intervals, it is very unlikely that any individual sea turtle would be affected by more than one detonation. Tagging studies have shown that sea turtles can travel many kilometers per day in the open ocean (Keinath et al., 1993), and strong Gulf Stream currents would make it unlikely for animals to remain in a particular location for a week or more. Monthly aerial surveys at both Mayport and Norfolk did not show any consistent patterns of abundance to indicate that sea turtles congregate in any particular part of either area. Therefore, it is unlikely that an individual animal would be experience more than a single, momentary disturbance. No significant or lasting impact on movements, migration patterns, breathing, nursing, breeding, feeding, or other normal behaviors would be expected.

Indirect Impacts

Two indirect ways in which sea turtles could be affected are through (1) death and injury to prey species and (2) destruction of juvenile habitat (sargassum rafts). Both impacts are unlikely to be significant at either the Mayport or Norfolk area.

Adult loggerheads feed primarily on benthic molluscs and crustaceans. It is not known whether loggerheads present at the Mayport and Norfolk areas feed there; however, even if they do, any benthic impacts of the detonations would affect only a small portion of the available benthic prey. Leatherback turtles are pelagic feeders, preferring coelenterates (jellyfish). In order to protect sea turtles, detonation would be postponed if large concentrations of jellyfish were detected within the Safety Range (see Section 5.0). Therefore, although some jellyfish may be killed during the blast, it is unlikely that prey availability would be significantly reduced. Coelenterates from surrounding areas would quickly repopulate the small area affected. Given that test site selection and scheduling would be based on the low abundance of sea turtles, and given that the Mayport and Norfolk areas do not represent recognized feeding grounds for loggerhead or leatherback sea turtles, the potential for significant indirect effects is very low.

Sargassum rafts, which may serve as habitat for loggerhead juveniles, are easily detected by aerial observers. The mitigation plan includes procedures to avoid sargassum rafts to the maximum extent possible during site selection. Pre-detonation monitoring would include aerial observations to identify any large sargassum rafts that could drift into the Safety Range prior to detonation. Finally, detonation would be postponed if any large sargassum rafts were present in the Safety Range. Therefore, no significant impacts on juvenile turtle habitat are expected.

Summary

Potential direct impacts on sea turtles have been analyzed in detail in the preceding discussion. Potentially significant direct impacts include mortality, injury, and harassment. Momentary behavioral responses and possible indirect impacts to sea turtles due to impacts on prey species have also been discussed above but are considered not significant.

Table 4-12 summarizes sea turtle calculations for the Mayport and Norfolk areas. Based on 1995 data for both areas, estimated maximum totals for five detonations are 4 dead and 6 injured turtles for either Mayport or Norfolk. If the 1997 Mayport data are used, the maximum totals would be 8 mortalities and 14 injuries, or about twice as high as at Norfolk. For harassment, based on 1995 data for both areas, estimated maximum totals for five detonations are 652 at Mayport and 468 at Norfolk. If the 1997 Mayport data are used, the estimated maximum total would be 1,679 turtles experiencing harassment. In either case, mitigation effectiveness would be about the same at either area (about 8%). Loggerheads make up most of the population at both areas and are the species most likely to be affected.

Table 4-12. Summary and comparison of Mayport and Norfolk areas with respect to sea turtle related impacts and mitigation effectiveness. A range of potential impacts is given; maximum values are from the last row of Tables 4-10 and 4-11; minimum values were estimated as described in the text.

Category	Description	Mayport		Norfolk
		1995 data	1997 data	(1995 data)
Mortality	Number of individuals potentially killed from 5 detonations	0-4	0-8	0-4
Injury	Number of individuals potentially injured from 5 detonations	0-6	0-14	0-6
Harassment (TTS)	Number of individuals potentially experiencing TTS from 5 detonations	15-652	34-1,679	0-468
Overall mitigation effectiveness for mortality and injury	Percentage of individuals within Safety Range that would be detected by combination of aerial, surface, and passive acoustic monitoring	8%	8%	8%

Because of the conservative assumptions incorporated in every step of the calculations, the numbers cited above should be regarded as upper limits for potential impacts. As described in Section 5.0, the Navy proposes to select a specific test site with few, if any, sea turtles present. The proposed mitigation methods for SEAWOLF shock testing were used successfully during the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994). Detection of even one sea turtle within the Safety Range would result in postponement of detonation; therefore, the presence of sea turtles would most likely result in testing delays rather than impacts on these animals. A lower limit for potential impacts can be estimated by (1) using the lowest monthly mean density from 1995 or 1997 aerial surveys; (2) assuming that all individuals were detected during the aerial surveys (i.e., no correction for submerged or undetected animals is necessary); and (3) assuming that mitigation effectiveness would be 100% (instead of 8%) for mortality and injury. For Mayport, the resulting totals would be zero mortalities, zero injuries, and either 15 or 34 individuals experiencing TTS (using 1995 or 1997 data, respectively). For Norfolk, the estimated minimum totals would be zero for mortality, injury, and TTS.

4.2.2.5 Benthos

Two types of potential impacts on benthic organisms are (1) direct effects of the shock wave on organisms and their seafloor habitat; and (2) indirect effects of debris deposited on the bottom. In either case, no significant impact to benthic communities is expected. This conclusion applies equally to the Mayport and Norfolk areas.

Benthic organisms are unlikely to be killed or injured by the detonations. Most of the mortalities during underwater explosions occur in near surface waters above the detonation point where the reflected shock wave creates a region of negative pressure or "bulk cavitation." Benthic organisms, in contrast, would experience only the direct, positive pressure wave and reflections from the bottom. Bottom features that develop a dense epifauna, such as artificial reefs, hard bottom areas, and shipwrecks, have been avoided through environmental mapping and establishment of buffer zones (see Section 2.2.2.2).

Experimental studies have shown that benthic invertebrates, including crabs, lobsters, and bivalves are very resistant to underwater explosions (Aplin, 1947; Chesapeake Biological Laboratory, 1948; Linton et al., 1985). Based on these studies, Young (1991) developed equations which predict a Safety Range of 22 m (73 ft) for benthic organisms exposed to a 4,536 kg (10,000 lb) charge. That is, organisms more than this distance from the detonation point would not be killed. Because the blast would be 122 m (400 ft) above the bottom, no benthic organisms are likely to be killed or injured.

Demersal (bottom dwelling) fish are unlikely to be killed or injured by the detonations. The distances listed in Table 4-3 apply to fish near the surface, where the reflected shock wave produces a region of negative pressure. Fish in deeper water or on the bottom could survive much closer to the blast. These fish would experience only the direct, positive pressure wave and reflections from the bottom. Under these conditions, there would not be much difference in survival between swimbladder and non-swimbladder species. Bottom features that attract large numbers of demersal fish, such as artificial reefs, hard bottom areas, and shipwrecks, have been avoided through environmental mapping and establishment of buffer zones (see Section 2.2.2.2).

Golden tilefish is a demersal species present at both the Mayport and Norfolk areas. A calculation of tilefish mortality contours for a 4,536 kg (10,000 lb) charge detonated at a depth of 61 m (200 ft) was made for a previous environmental assessment (Department of the Navy, 1981). For an explosion at a depth of 30 m (100 ft), the contours would move upward by 17 m (55 ft) (Young, 1995b). Only the 10% mortality contour approaches the bottom. Therefore, few if any tilefish or other bottom dwelling fish would be killed by the detonations.

Some concern has been expressed about the possible presence of deepwater grouper spawning aggregations at the Mayport area (see comment J2 in Appendix H). Although some groupers form spawning aggregations, the available information does not support the claim that spawning aggregations of any deepwater groupers could occur at the Mayport area or that these aggregations would extend well into the water column (see Section 3.2.5.2). Moreover, groupers are generally associated with hard bottom, but the seafloor at the Mayport area is predominantly soft bottom. Of the four deepwater species which may occur in the area, only the yellowedge grouper is known to occur over soft bottom; they have been documented to cohabitate with burrow-dwelling tilefish (Jones et al., 1989). However, there is no information on spawning aggregations. Even if grouper aggregations were present and extended some distance into the water column, few if any are likely to be killed based on the tilefish calculations cited above.

Similarly, the shock wave is not expected to affect the benthic habitat. Calculations based on the size and depth of the explosive charge and the total water depth indicate there would be no cratering of the seafloor (see Section 4.2.1.1).

The seafloor at both the Mayport and Norfolk areas is predominantly sand bottom. Fragments of steel charge casings that settle to the bottom would provide hard substrate for epibiota and would attract fish (Marine Resources Research Institute, 1984). The largest possible fragment from the explosion is the top plate and crossbar, which together weigh 204 kg (450 lb). Due to low oxygen levels in bottom sediments, the steel fragments would likely corrode very slowly and would not be expected to pose a toxicological hazard to benthic biota.

As explained in Section 2.2.3.4, the likelihood of a charge not detonating is remote and only in the case of extreme emergency or to safeguard human life would the Navy dispose of the charge at sea. If the charge were released, it would sink to the bottom but would not be expected to have significant adverse impacts on bottom communities. Studies of munitions dumping areas have shown no contamination from explosive materials and little or no adverse impact on benthic communities (Hoffsommer et al., 1972; Wilkniss, 1973).

4.2.2.6 Seabirds

The Navy would make every effort to prevent and/or minimize harm to seabirds that may be in the vicinity of the test site during detonation. As part of the mitigation plan, the Navy would postpone detonation if flocks of seabirds were present within the Safety Range (see Section 5.0). This would avoid any large mortality of seabirds. Monitoring following detonation of two 4,536 kg (10,000 lb) charges for the shock trial of the USS JOHN PAUL JONES in 1994 detected no deaths or injuries of seabirds (Naval Air Warfare Center, 1994).

It is possible that a few seabirds on the water surface or in the air immediately above the detonation point could be killed or stunned by the plume of water ejected into the air. This could happen if birds were attracted to surface floats at the detonation point, as observed by Stemp (1985). The radius of the plume is estimated to be 165 to 195 m (540 to 640 ft) (Young, 1995b).

At greater distances, seabirds resting or feeding at the surface could also be killed or injured by the shock wave. Most of the seabirds that could occur at either Mayport or Norfolk during April through September are surface or near-surface feeders. Safe ranges for these birds can be estimated using mortality and injury criteria developed by Yelverton et al. (1973). The calculations show that no deaths or injuries would be expected beyond a distance of 457 m (1,500 ft) (Young, 1995b). This is approximately the same as the maximum horizontal range of the bulk cavitation region shown in Figure 4-1. It is unlikely that more than a few seabirds would be affected.

Each detonation would release chemical products into the atmosphere. As described in Section 4.2.1.2, these products would disperse rapidly and would not pose a health threat to marine life, including seabirds.

The USFWS has concluded that there are no endangered or threatened bird species or critical habitat that would be adversely affected by the proposed action (see Appendix G).

4.2.3 Socioeconomic Environment

4.2.3.1 Commercial and Recreational Fisheries

The explosion shock wave may kill or injure individual fish that are targets of commercial and recreational fisheries. However, a large fish kill would not be expected during SEAWOLF shock testing because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point (see Section 5.0). Due to the large populations and wide geographic distribution of the species present near Mayport and Norfolk and the limited area affected, the explosions would not be expected to have a significant impact on fishery stocks.

Effects of explosions on fish have been discussed previously in Section 4.2.2.2. Small fish with swimbladders are the ones most likely to be killed or injured if present in surface waters within about 1,400 m (4,600 ft) of the detonation point. This category includes species such as dwarf herring, round scad, Atlantic menhaden, and chub mackerel. Some of these are commercially important species, although they are not fished within the Mayport or Norfolk areas.

The main targets of commercial and recreational fishing at both the Mayport and Norfolk areas are large oceanic pelagic species such as billfish, dolphinfish, tunas, wahoo, and sharks (see Table 3-6). Because sharks do not have a swimbladder, they are unlikely to be affected unless they are very close to the detonation point (within about 22 m or 73 ft). The other large species all have swimbladders and may be affected within a radius of about 762 m (2,500 ft) (see Section 4.2.2.2). Most of the oceanic pelagic fish are non-schooling, and large fish kills of these species are therefore unlikely. Schooling species such as dolphinfish, tunas, and (occasionally) wahoo are also unlikely to have significant numbers killed because detonation would be postponed if large schools were present within 1.85 km (1 nmi) of the detonation point.

Demersal (bottom dwelling) fish and invertebrates are unlikely to be killed or injured by the detonations, as explained in Section 4.2.2.5. Demersal fishery species are golden tilefish at both Mayport and Norfolk and summer flounder, black seabass, butterfish, hake, and squid at Norfolk only. Due to the water depth (152 m or 500 ft), the shock wave is not expected to affect these species or their habitat. Previous calculations of tilefish mortality contours for a 4,536 kg (10,000 lb) charge indicate that few if any tilefish or other bottom dwelling fish would be affected (Department of the Navy, 1981; see Section 4.2.2.5). No sediment resuspension or cratering of the seafloor is expected (see Section 4.2.1.1).

Fishing vessels would be excluded from the test site for about 18 hours during each shock test. Types of fishing most likely to be affected are surface and bottom longlining and trolling (see Table 3-6). Demersal trawling occurs only at the Norfolk area, and primarily during winter months, so shock testing is unlikely to interrupt this activity. Bottom longlining for golden tilefish occurs off both Mayport and Norfolk, but most tilefishing off Norfolk occurs from Norfolk Canyon north, an area which is excluded from testing. Surface longlining by commercial fishers and trolling by recreational anglers occur at both areas. Due to the short duration of each shock test and the advance warning provided through *Notices to Airmen and Mariners*, the temporary interruption is not expected to significantly affect commercial or recreational fisheries.

4.2.3.2 Ship Traffic

An exclusion zone of 9 km (5 nmi) radius would be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. *Notices to Airmen and Mariners* would be published in advance of each test. Traffic would be excluded from the site for a period of about 18 hours for each detonation.

Both the Mayport and Norfolk areas are well offshore, and neither is near shipping lanes. The Navy selected these areas as having a low volume of ship traffic. No significant impacts on ship traffic are expected.

4.2.3.3 Other Socioeconomic Issues

There are no ocean disposal sites within 18.5 km (10 nmi) of either the Mayport or Norfolk area. Since this is the radius within which ships would be warned to alter course, testing would not conflict with use of any ocean disposal site. There are no communications cables at the Norfolk area, and the one cable identified off Mayport is no longer in use (Department of the Navy, 1995a). There would be no impact to international telecommunications should the cable be damaged (Wargo, 1994).

5.0 MITIGATION AND MONITORING

Mitigation, as defined by the Council on Environmental Quality, includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. The proposed action includes the following mitigation measures: (1) a marine mammal and sea turtle mitigation plan to minimize the risk of impacts to these animals; (2) a schedule shift at Mayport to avoid high densities of sea turtles; (3) environmental buffer zones to avoid impacts to certain environmental features; (4) a vessel exclusion zone for operational security; and (5) measures to deal with unexploded ordnance in the unlikely event of a misfire. Because the marine mammal and sea turtle mitigation plan is the most detailed, the other measures are discussed first. Mitigation requirements specified by the NMFS Biological Opinion (see Appendix G) are indicated by <u>*italic, underlined text*</u>.

5.1 SCHEDULE SHIFT TO AVOID HIGH TURTLE DENSITIES AT MAYPORT

Based on the Navy's operational requirements, shock testing could be conducted any time between 1 April and 30 September. However, if the Mayport area is selected, there would be no testing in April, when turtle densities are highest. This mitigation measure is based on the results of aerial surveys conducted monthly between April and September 1995, as explained in Section 3.2.4. About half of all the loggerhead turtles counted during the six surveys were seen during April. Because there was no April survey in 1997, the high turtle numbers seen during April 1995 could not be confirmed. However, based on the 1995 data and the likely concentration of loggerheads in offshore waters prior to the nesting season, exclusion of April from the test schedule at Mayport is considered a reasonable precaution. A similar measure is not appropriate at the Norfolk area, where April had the lowest turtle densities and differences among the other surveys were not as great as those at Mayport.

5.2 ENVIRONMENTAL BUFFER ZONES

At both the Mayport and Norfolk areas, possible test sites were defined to meet operational depth restrictions; this being any point along the 152 m (500 ft) depth contour within 185 km (100 nmi) of a naval station support facility and a submarine repair facility. Environmental features near each area were mapped, including marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, and critical habitat for endangered or threatened species (Department of the Navy, 1995a). Buffer zones were developed to avoid impacts to these areas and associated biota. Portions of the 152 m (500 ft) depth contour were excluded as described in Section 2.2.2.2. At the Mayport area there are no marine sanctuaries, artificial reefs, hard bottom areas, shipwrecks, ocean disposal sites, or critical habitat areas. Therefore, all points along the 152 m (500 ft) depth contour are considered potential shock testing sites. At the Norfolk area, the portion of the 152 m (500 ft) depth contour passing through the proposed Norfolk Canyon Marine Sanctuary, along with a 4.6 km (2.5 nmi) buffer on either side, was excluded. The entire area north of the proposed sanctuary was eliminated due to the presence of several shipwrecks within a distance of 1.85 km (1 nmi). Four points within 1.85 km (1 nmi) identified in the SEAMAP database as potential hard bottom were excluded. All remaining points along the 152 m (500 ft) depth contour at Norfolk are considered potential shock testing sites.

5.3 VESSEL EXCLUSION ZONE

An exclusion zone of 9.3 km (5 nmi) radius would be established around the detonation point to exclude all non-test ship, submarine, and aircraft traffic. Any traffic within an 18.5 km (10 nmi) radius would be warned to alter course or would be escorted from the site. *Notices to Airmen and Mariners* would be published in advance of each test. An immediate HOLD on the test would be ordered if any unauthorized craft entered the exclusion zone and could not be contacted. The HOLD would continue until the exclusion zone was clear of unauthorized vessels. The size of the exclusion zone is necessary to ensure that commercial ships have no impact on operational security and to allow large vessels sufficient time to change course.

5.4 UNEXPLODED ORDNANCE

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all marine mammal and sea turtle mitigation measures in place as described below). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea. The possibility of disposing the explosive charge at sea is very remote. However, if disposal at sea was necessary, the charge would be disposed in a manner that would not pose a hazard to the public.

5.5 MARINE MAMMAL AND SEA TURTLE MITIGATION PLAN

A detailed marine mammal and sea turtle mitigation plan has been developed to reduce or eliminate the effects of shock testing on these animals. The plan includes the same type of mitigation and monitoring efforts that were used successfully during the shock trial of the USS JOHN PAUL JONES in 1994 off the coast of southern California where observed marine mammal population densities are about 3 times greater than at the Norfolk area and about 25 times higher than at the Mayport area (Department of the Navy, 1993). Those shock trial operations included two 4,536 kg (10,000 lb) detonations and no deaths or injuries of marine mammals were detected (Naval Air Warfare Center, 1994).

Potential areas for SEAWOLF shock testing have been evaluated in Section 2 (Alternatives) based on the Navy's operational requirements. The analysis showed that only the Mayport and Norfolk areas meet all of the Navy's operational requirements and that the two areas are rated as nearly equal. Portions of the Norfolk area were excluded based on environmental considerations (proposed Norfolk Canyon National Marine Sanctuary and shipwrecks) (see Section 5.2). The schedule for testing at Mayport was shifted to avoid high turtle densities (see Section 5.1). Finally, impact analysis in Section 4 (Environmental Consequences) was used to identify a preferred alternative area (Mayport) based on the lower density of marine mammals.

The mitigation plan would build upon these previous efforts to avoid or further reduce potential environmental impacts. It would select one primary and two secondary test sites where marine mammal and turtle abundances are the lowest, based on the results of aerial surveys to be conducted immediately prior to the first detonation. This would ensure that the final test site selected for shock testing poses the least risk to these animals. Pre-detonation monitoring would be conducted prior to each detonation to ensure that the test site is free of visually or acoustically detectable marine mammals, as well as visible turtles, large sargassum rafts or large concentrations of jellyfish (both are possible indicators of turtle presence), large schools of fish, and flocks of seabirds. Finally, post-detonation monitoring would be conducted to determine the effectiveness of the mitigation efforts, by using a Marine Animal Recovery Team (MART) and aerial observers to monitor the test site and surrounding waters for injured or dead animals after each detonation. If post-detonation monitoring showed that marine mammals or turtles were killed or injured as a result of a detonation, *or if any marine mammals or sea turtles were observed in the Safety Range immediately after a detonation*, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary. Communications with stranding network personnel would be maintained throughout the SEAWOLF shock test period.

5.5.1 Terminology

The concept of a ***Safety Range***, as presented in Section 4.2.2.3, is integral to the mitigation plan. Establishment of a 3.7 km (2 nmi) Safety Range around the detonation point has taken into consideration the estimated ranges for various levels of injury and/or mortality associated with detonation of a 4,536 kg (10,000 lb) explosive. Based on analyses presented in Appendix D, the maximum distance for injury (50% probability of eardrum rupture) to a marine mammal or turtle is 1.85 km or about 1 nmi from the detonation point. As explained in Appendix C, eardrum rupture *per se* is not necessarily a serious or life-threatening injury, but the 50% eardrum rupture criterion is widely used in the auditory safety field (Ketten, 1995) and serves as a useful index of potential injury. The 50% eardrum rupture range has been doubled to establish a 3.7 km (2 nmi) Safety Range. The probability of eardrum rupture at this distance is believed to be 10% or less.

For mitigation monitoring purposes, a 1.85 km (1 nmi) ***Buffer Zone*** has also been added to the 3.7 km (2 nmi) Safety Range to accommodate the possible movement of marine mammals and turtles towards the Safety Range. Specifically, the area encompassed within a 5.6 km (3 nmi) radius from the detonation point would be monitored in an effort to detect any marine mammals or turtles approaching the 3.7 km (2 nmi) Safety Range. As detailed below, species-specific protocols have been developed to determine when and for how long to postpone detonation if a marine mammal or turtle is detected in the Buffer Zone.

In the following sections, the term ***survey*** is used to refer to site selection activities, whereas ***monitoring*** refers to pre-detonation site clearance and post-detonation activities to locate and identify marine mammals or turtles.

5.5.2 Weather Limitations

Weather that supports the ability to sight even small marine life (e.g., sea turtles) is essential for mitigation measures to be effective. Winds, visibility, and the surface conditions of the ocean are the most critical factors affecting mitigation operations for the SEAWOLF shock test. High winds typically promote increases in wave height and "white cap" conditions, both of which limit an observer's ability to locate surfacing marine mammals and to differentiate between surfacing marine mammals and white caps.

To maximize detection of marine mammals and turtles, mitigation efforts will be conducted in sea states no greater than no. 3 on the following scale:

0 = flat calm, no waves or ripples
1 = small wavelets, few if any whitecaps
2 = whitecaps on 0 to 33% of surface; 0.3 to 0.6 m (1 to 2 ft) waves
3 = whitecaps on 33 to 50% of surface; 0.6 to 0.9 m (2 to 3 ft) waves
4 = whitecaps on greater than 50% of surface; greater than 0.9 m (3 ft) waves

Visibility is also a critical factor, not only for observation capabilities but also for safety-of-flight issues. A minimum ceiling of 305 m (1,000 ft) and 5.6 km (3 nmi) visibility must be available to support mitigation and safety-of-flight concerns.

The aerial surveys conducted at the Mayport and Norfolk areas during April through September 1995 (and at Mayport during May through September 1997) were flown at an altitude of 229 m (750 ft) by a survey team which included two observers and a data logger. During the mitigation program, sighting efficiency would be improved by (1) the reduction in altitude to 198 m (650 ft); (2) the tightening of pre-detonation aerial transect line spacing to 0.46 km (0.25 nmi) instead of 1.85 km (1 nmi); and (3) the change in aircraft to Partenavia (or equivalent) with a "belly" port allowing the addition of a third observer. The full mitigation team would consist of three observers in each aircraft, six or seven shipboard observers (five with high powered binoculars), and the Marine Mammal Acoustic Tracking System (MMATS) team. This complement of trained marine mammal and turtle observers would provide five times the visual detection capability used during the 1995 and 1997 aerial surveys and would ensure effective mitigation during the shock test.

5.5.3 Mitigation Components/Teams

The mitigation plan includes three components: (1) aerial surveys/monitoring; (2) shipboard monitoring from the operations vessel and the Marine Animal Recovery Team (MART) vessel; and (3) passive acoustic monitoring using the Marine Mammal Acoustic Tracking System (MMATS). Aerial and shipboard monitoring teams would identify and locate cetaceans and turtles on the surface, whereas the acoustic monitoring team would detect and locate calls from surfaced and submerged cetaceans. The lines of communication between the various monitoring teams are outlined in **Figure 5-1** and discussed in the following section.

The mitigation team members would be qualified, experienced professionals. Minimum qualifications for the Lead Scientist are a Bachelor's degree in biology, zoology, wildlife management, or a related field, with a minimum of 10 years experience in marine mammal field work including at least five field seasons in marine mammal/sea turtle vessel or aerial surveys. Minimum qualifications for the marine animal veterinarian are a Doctorate in Veterinary Medicine (D.V.M) with a minimum of 10 years of experience with marine mammals. The veterinarian would have ample assistance from (1) a turtle handling expert with extensive background in turtle, mammal, and seabird physiology; (2) one of the marine mammal observers with several years of experience in assisting with necropsies and

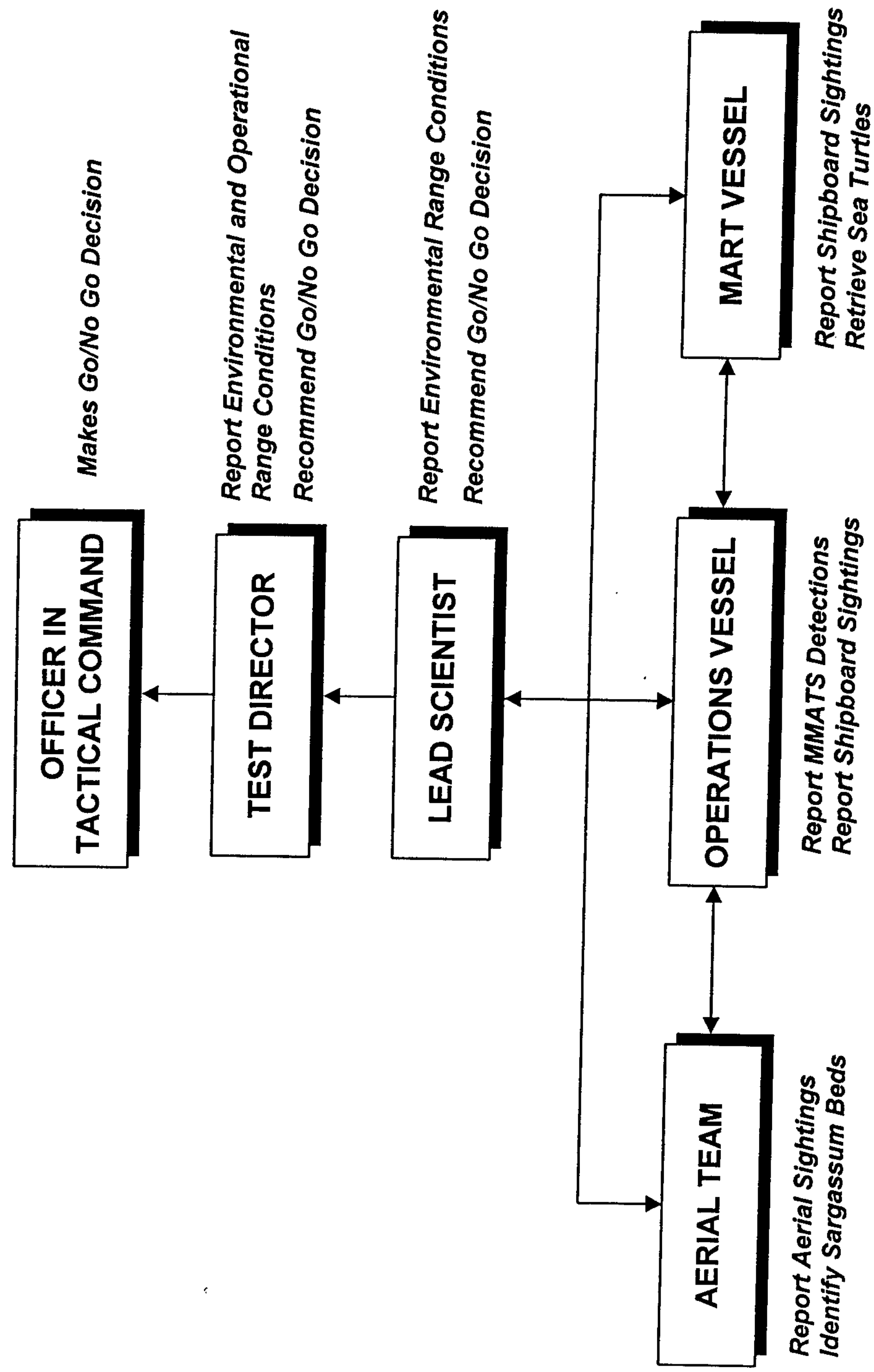


Figure 5-1. Lines of communication between the aerial monitoring team, operations vessel, and MART vessel.

pathology analysis; and (3) a marine animal collection specialist. Minimum qualifications for aerial and shipboard observers are as follows:

- Primary observer/ID specialist: Requires a minimum of five field seasons experience in marine mammal/sea turtle vessel and/or aerial surveys; at least two field seasons experience in the Atlantic Ocean or adjacent waters; at least two field seasons experience with species identification. A minimum of two primary observers would be on each visual observation platform.
- Secondary observer/data recorder: Requires a minimum of two field seasons experience in marine mammals/sea turtle vessel and/or aerial surveys or a minimum of two field seasons experience as veterinary assistant familiar with marine animal care and necropsy procedures.

5.5.3.1 Aerial Survey/Monitoring Team

The aerial team would include one aircraft with three observers aboard. Each observer would be experienced in marine mammal surveying and would be familiar with species that may occur in the area. A backup aircraft with additional observers would be available to support the shock test. The backup aircraft would relieve the primary aircraft for post-detonation monitoring. In consideration of safety-of-flight issues, only one aircraft would be allowed in the airspace over the test site at any one time (Naval Air Warfare Center, 1994). Each aircraft would have a data recorder who would be responsible for relaying the location, species, and number of animals sighted by aircraft personnel to the Lead Scientist onboard the command vessel. The Lead Scientist would be responsible for recording all sightings within the test site using the marine animal tracking and sighting program developed during the USS JOHN PAUL JONES shock trial and updated for SEAWOLF applications. The program allows immediate plotting of an animal's position relative to the detonation point. The Lead Scientist would relay this information to the Shock Test Director and the Officer in Tactical Command (OTC). The aerial monitoring team would also identify to the Lead Scientist any large accumulations of sargassum that could potentially drift into the Safety Range.

Standard transect aerial surveying methods, as developed by the NMFS (Blaylock, 1994; Hoggard, 1994; Mullin, 1994), would be used for all mitigation aerial surveys and monitoring. All site selection aerial surveys would be conducted along transects spaced 1.85 km (1 nmi) apart and flown at an altitude of 198 m (650 ft) and a speed of 110 kt. Although the 1995 aerial surveys off Norfolk and Mayport (Department of the Navy, 1995b) and additional surveys off Mayport in 1997 were flown at an altitude of 229 m (750 ft), an altitude of 198 m (650 ft) was chosen for the mitigation aerial surveys and monitoring to increase the likelihood of visual detection of sea turtles. Pre-detonation monitoring would be conducted along transects spaced at 0.46 km (0.25 nmi) to better detect adult turtles. The three aerial observers would scan a swath of sea surface that would be limited only by the effective angle of view from the aircraft's viewing ports or windows, and sea state. Based on the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994) and prior survey efforts off Mayport and Norfolk, aerial observers are expected to have good to excellent sighting capability to 0.9 km (0.5 nmi) on either side of the aircraft within the weather limitations noted previously. Observed marine mammals and turtles would be identified to species or the lowest possible taxonomic level, and their relative positions recorded. Detonations would only occur no earlier than three hours after sunrise and no later than three hours prior to sunset to ensure adequate daylight for pre- and post-detonation monitoring.

5.5.3.2 Shipboard Monitoring Teams and MART

Shipboard monitoring would be staged from surface craft participating in the shock test, including the operations vessel and the MART vessel. The Lead Scientist would be located on a third vessel, the command vessel, with the OTC. Each vessel would be outfitted with two or three sets of 25X power binoculars, depending on the vessel. The operations vessel would accommodate a Team Leader and three observers experienced in shipboard surveys and who are familiar with the marine life of the area. Two observers would monitor the test site with the vessel-mounted (i.e., installed on the bridge wing or deckhouse of the operations vessel) 25X power binoculars or hand-held binoculars. The 25X power binoculars would allow the observers to sight surfacing mammals from as far as 11.1 km (6 nmi). The third observer would rotate stations with the other two observers to allow each an opportunity to rest their eyes. The positioning of the shipboard monitoring teams would allow 360° overlapping coverage.

The operations vessel Team Leader will report all sightings locations, based on bearing and distance, to the Lead Scientist located on the command vessel. Bearing would be measured relative to the bow of the vessel using a calibrated collar at the base of the yoke of the 25X power binoculars. Distance would be measured using a calibrated reticle scale in the oculars of the binoculars. As with all aerial monitoring team sightings, the Lead Scientist would enter this information into the marine animal tracking and sighting program. The species and number of animals sighted would also be recorded. The Lead Scientist would ensure that the OTC is aware of all animals in or approaching the test site.

In addition to the operations vessel, four observers on the MART vessel would assist in pre-detonation monitoring using 25X power binoculars and hand-held binoculars. The MART vessel would also have four observers aboard with survey experience for waters of the proposed test. The MART vessel observers would follow the same monitoring rotation and reporting protocol (i.e., observer reporting to the Team Leader; Team Leader reporting to the Lead Scientist; Lead Scientist reporting to the Shock Test Director and OTC).

Other MART responsibilities during pre-detonation monitoring are as follows:

- Assist with deployment of MMATS acoustic sensors;
- Conduct supplementary pre-detonation observations for marine mammals and turtles;
- Assist the aerial monitoring team in species identifications of selected individuals or groups; and
- Investigate large patches of sargassum algae for the presence of juvenile sea turtles, and retrieve, as necessary.

The MART collection specialist would attempt to collect large turtles swimming within the test site using a large aluminum frame and net positioned from the MART vessel. All retrieved turtles would be temporarily held in a sun-protected area on the deck of the MART vessel until after the detonation. MART personnel would also tag and record any dead animals found in and near the test site prior to each detonation so that they are not counted as deaths caused by shock testing.

MART personnel would remain on station for a period of 48 hours after each detonation (and for seven days following the last detonation to allow a mortally wounded animal sufficient time to submerge and resurface) to monitor the test site and surrounding waters for injured or dead animals. If any animals are observed in the general area during the post-detonation monitoring period, the location, number, species, and behavior would be recorded. Depending upon their size, any mortally injured or dead animals would be retrieved in an attempt to determine the cause of injury or death. The MART vessel would be assisted by the aerial monitoring team for three hours per day during the two days following each detonation and for seven days following the last detonation. The aerial team would assist in the location of animals in the area and would direct the MART vessel to any sighted animals in the area that appear to be injured or dead.

5.5.3.3 Marine Mammal Acoustic Tracking System

The Marine Mammal Acoustic Tracking System (MMATS) is a portable, rapidly deployable digital signal processing system which would be used to detect and localize sources of transient acoustic signals produced by calling marine mammals. The system would consist of 10 to 15 moored acoustic receivers deployed from the operations and MART vessels. The system includes a passive sonar processing mode. The positions of transient acoustic sources are determined by time-delay-of-arrival analysis; the system is capable of localizing to within 0.46 km (0.25 nmi) of the actual position of the source. Therefore, if an animal is acoustically detected within 4.16 km (2.25 nmi) of the detonation point, it would be assumed that the animal is within the 3.7 km (2 nmi) Safety Range; under these circumstances, no detonation would occur until it is confirmed that the animal's position is outside the Safety Range. The MMATS configuration is shown in **Figure 5-2.**

The MMATS bioacousticians, currently planned to be located on the operations vessel, would monitor the frequency bandwidths between 15 Hz and 10 kHz (15 to 10,000 Hz). This frequency range covers the vast majority of calls produced by baleen and toothed whales, including the six species of endangered whales which may be found within the Mayport and Norfolk offshore areas [i.e., blue whale (*Balaenoptera musculus*): 10-30, 50-60, and 6,000-8,000 Hz; fin whale (*Balaenoptera physalus*): 20 and 1,500-2,500 Hz; humpback whale (*Megaptera novaeangliae*): 25-360, 750-1,800, and 100-4,000 Hz; northern right whale (*Eubalaena glacialis*): 160-500 and 50-500 Hz; sei whale (*Balaenoptera borealis*): 3,000 Hz; and sperm whale (*Physeter macrocephalus*): 2,000-4,000 and 10,000-16,000 Hz] (Richardson et al., 1991; Advanced Research Projects Agency, 1995).

The current version of MMATS computes and displays the spectra of up to 16 channels of acoustic data in real time. Operators identify the cetacean species by examining the spectral displays. A time difference of arrival algorithm is used to determine the location of calling animals. Operation is partly manual and partly automatic, with operator control over automatic features. Signal processing parameters are chosen to maximize the detection and localization of marine mammal calls. Analog acoustic data from 10 to 15 sensors would be

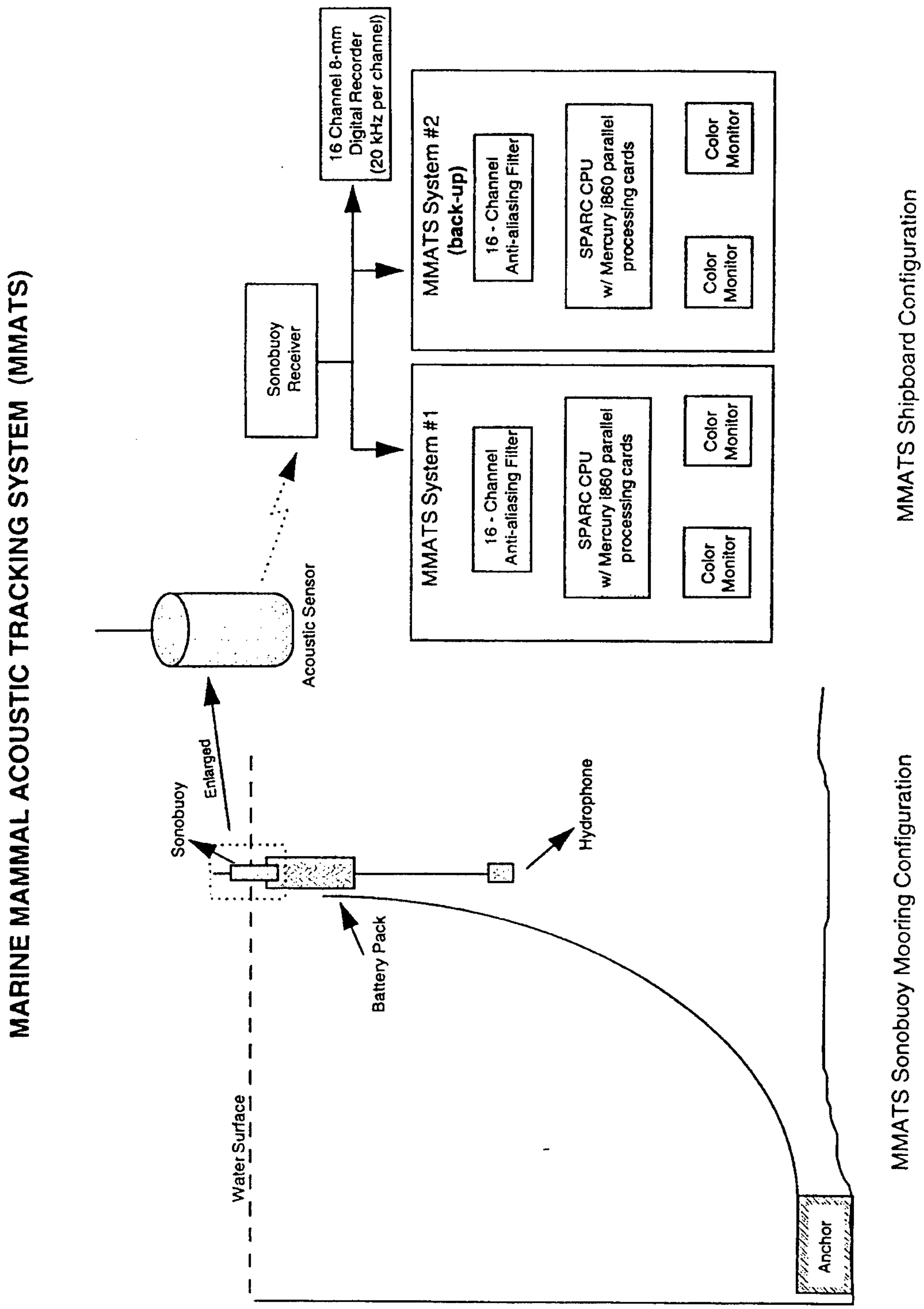


Figure 5-2. Marine Mammal Acoustic Tracking System (MMATS) sonobuoy mooring and shipboard configurations.

sampled at 25 kHz, providing a useful bandwidth of 10 kHz. Data from each sensor would be displayed in at least two frequency bands: a low band for mysticetes and a high band for odontocetes. Processing within each band includes suppression of relatively constant sounds, such as those generated by ship engines, in order to maximize the visibility of transient sounds, such as marine mammal calls. Processed data are displayed on a pair of high resolution color monitors.

MMATS has repeatedly demonstrated its effectiveness at sea during Navy tests, including the shock trial of the USS JOHN PAUL JONES (Naval Air Warfare Center, 1994). MMATS frequently has detected cetaceans, including blue, humpback, and sperm whales, that had not been seen at the surface. On several of these occasions, visual confirmation was obtained after the initial MMATS detection.

5.5.4 Mitigation Phases

The mitigation plan consists of three phases:

- Specific Test Site Selection Surveys – selecting a suitable test site, 5.6 km (3 nmi) in radius, which poses the least risk to the marine environment;
- Pre-Detonation Monitoring – effectively monitoring that site prior to each detonation in an effort to ensure that it is free of visually or acoustically detectable marine mammals, as well as visible turtles, large sargassum rafts, large jellyfish concentrations, large schools of fish, and flocks of seabirds; and
- Post-Detonation Monitoring – determining the effectiveness of the mitigation efforts, by using a Marine Animal Recovery Team (MART) and aerial observers to monitor the test site and surrounding waters for injured or dead animals after each detonation.

5.5.4.1 Test Site Selection Surveys

The purpose of the test site selection surveys is to select a site having the fewest marine mammals and turtles for the shock test. Two types of test site selection surveys would be conducted. First, aerial surveys three weeks prior to the first detonation would provide data for selection of a primary test site and two secondary test sites. Second, aerial surveys two to three days before each detonation would confirm one of these as the final test site. Site selection would be based primarily on survey data indicating the lowest relative abundance of marine mammals and sea turtles. *The Navy would also use satellite imagery of sea surface temperature, as well as other oceanographic data and aerial survey indicators such as sargassum rafts, water color changes, etc. (Hofmann and Fritts, 1982) to identify the western wall of the Gulf Stream. The final site would be within the Gulf Stream and no closer than 3.7 km (2 nmi) from its western boundary, which appears to be a seaward boundary for aggregated hatchlings and pelagic immature and adult sea turtles.*

Three Weeks Prior to Detonation

Three weeks prior to the shock test, a single aerial survey would be conducted over the selected area (i.e., Mayport or Norfolk) to identify potential test sites with the lowest density of marine mammals and turtles. The selected area would be surveyed by flying east-west transects centered on the 152 m (500 ft) depth contour and extending approximately 7.4 km

(4 nmi) to either side (**Figures 5-3 and 5-4**). From the sightings data, a single primary test site and two secondary test sites would be selected based primarily on the lowest relative abundance of marine mammals and turtles. Abundance totals would be determined initially in groups of five transects (e.g., transects 1 through 5, 2 through 6, etc.), which encompasses an area slightly larger than a potential test site. Sliding abundance totals for each transect group would then be compared to determine lowest relative abundance; transect groupings may also be enlarged (e.g., groups of 10 and/or 15) to allow greater flexibility in determining those sites with the lowest relative abundance. *Satellite imagery, aerial survey indicators, and other oceanographic data (as needed) would be examined to determine the likely position of the western wall of the Gulf Stream in relation to the potential test sites. Primary and secondary sites will be selected which have a low relative abundance of marine mammals and turtles and are likely to be at least 3.7 km (2 nmi) seaward of the western boundary of the Gulf Stream.*

Two to Three Days Prior to Detonation

An aerial survey would be conducted at the three sites two to three days prior to each detonation (i.e., 48 to 72 hr prior to setting the charge array) in order to rank the sites by scarcity of marine mammals (**Figure 5-5**). Through the comparison of data collected during this survey, the selection of the primary and two secondary test sites would be confirmed. The proposed detonation point would lie at the center of each survey area, which measures 14.8 km x 14.8 km (8 nmi by 8 nmi). Through the comparison of data collected during this survey, a final test site selection would be made by the OTC, the Test Director, and the Lead Scientist. *The most recent satellite imagery, aerial observations, and other oceanographic data (as needed) would be examined to determine the likely position of the western wall of the Gulf Stream in relation to the potential test sites. A final test site will be selected which has a low relative abundance of marine mammals and turtles and is likely to be at least 3.7 km (2 nmi) seaward of the western boundary of the Gulf Stream.*

Morning of a Test Day

As part of site selection, the shock test Lead Scientist would avoid sargassum rafts (to avoid hatchling and juvenile turtles) to the maximum extent possible. As explained above, the primary and two secondary sites would be identified three weeks prior to the first detonation. Two to three days prior to each detonation, one of these sites would be selected as the likely final test site. The Lead Scientist would have the flexibility to move the test site the morning of the test should the mitigation team find unacceptable levels of marine life in the area. The morning of the test, the Lead Scientist would confirm that weather is adequate to support mitigation, that the selected site has remained free of large rafts of sargassum and of marine life. The OTC and Lead Scientist would have the flexibility to move the test site up to the point when deployment of MMATS sonobuoys and the charge float has begun. If it is apparent the area would eventually be clear of marine life and sargassum, the OTC and the Lead Scientist may choose to remain in place until the area is clear. If sargassum rafts persist in the area and cannot be avoided, and if conditions indicate the likelihood of successful capture, the MART would attempt to collect juvenile and hatchling sea turtles from sargassum.

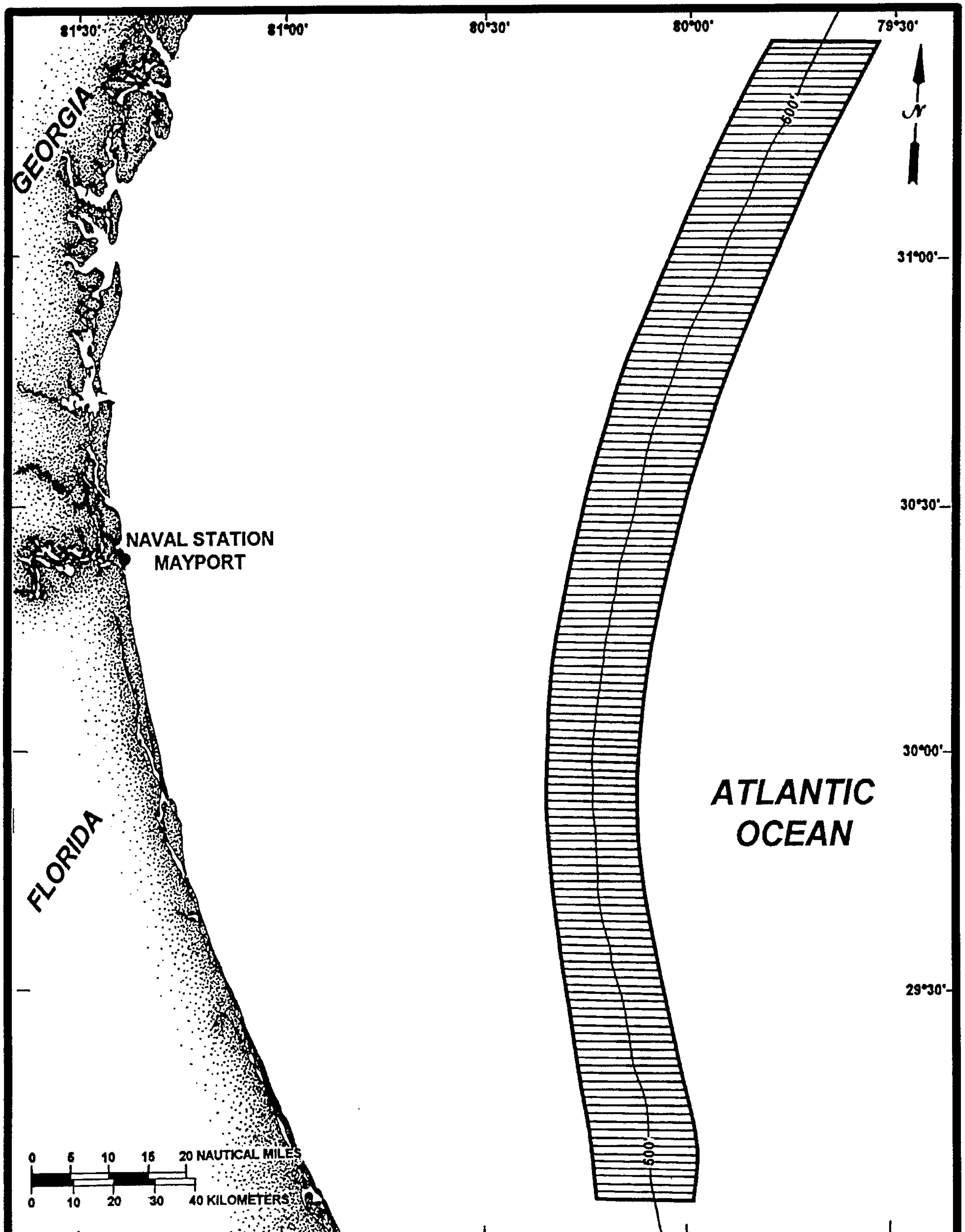


Figure 5-3. Location of aerial survey transects for test site selection three weeks prior to the shock test, if the Mayport area is selected.

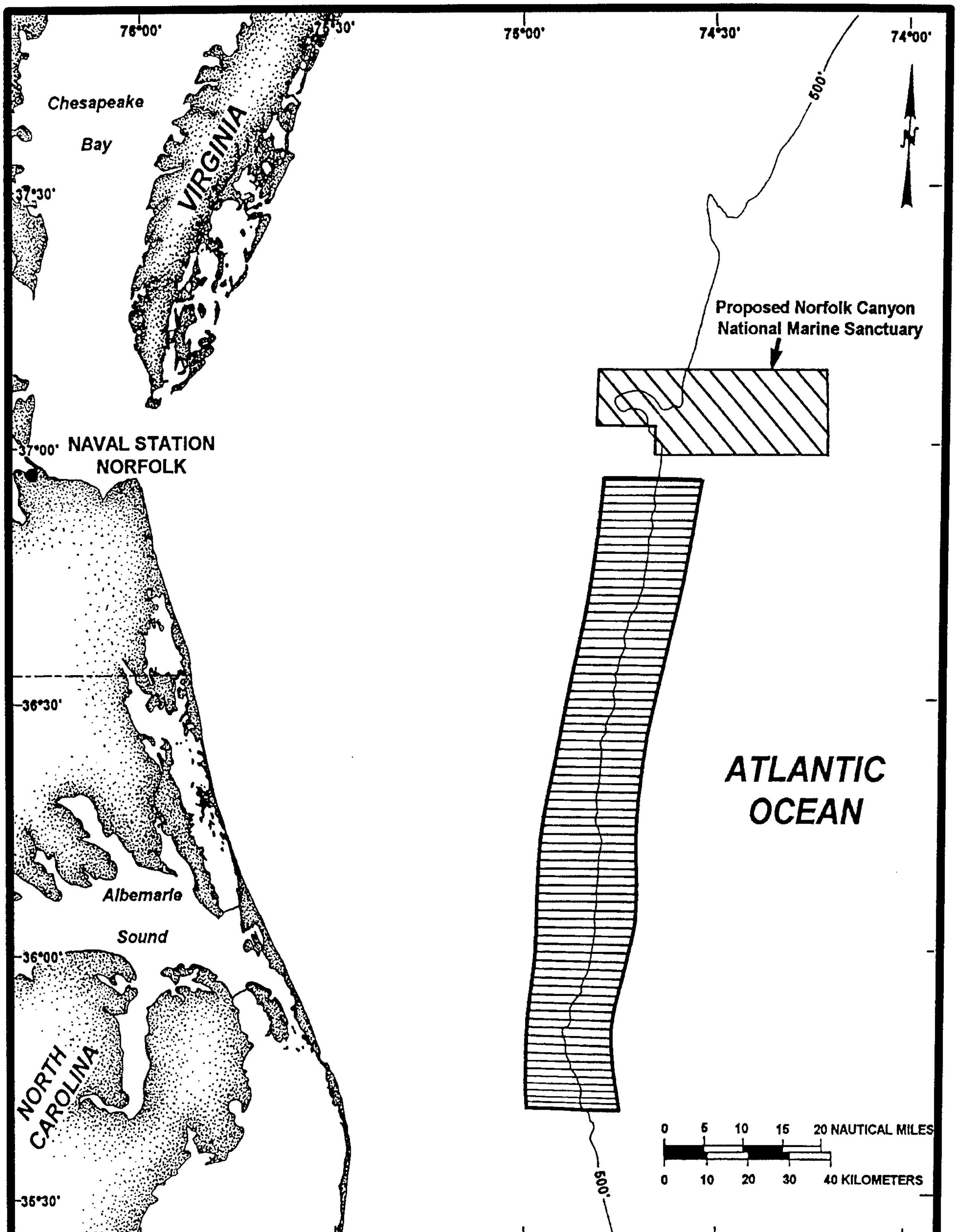


Figure 5-4. Location of aerial survey transects for test site selection three weeks prior to the shock test, if the Norfolk area is selected.

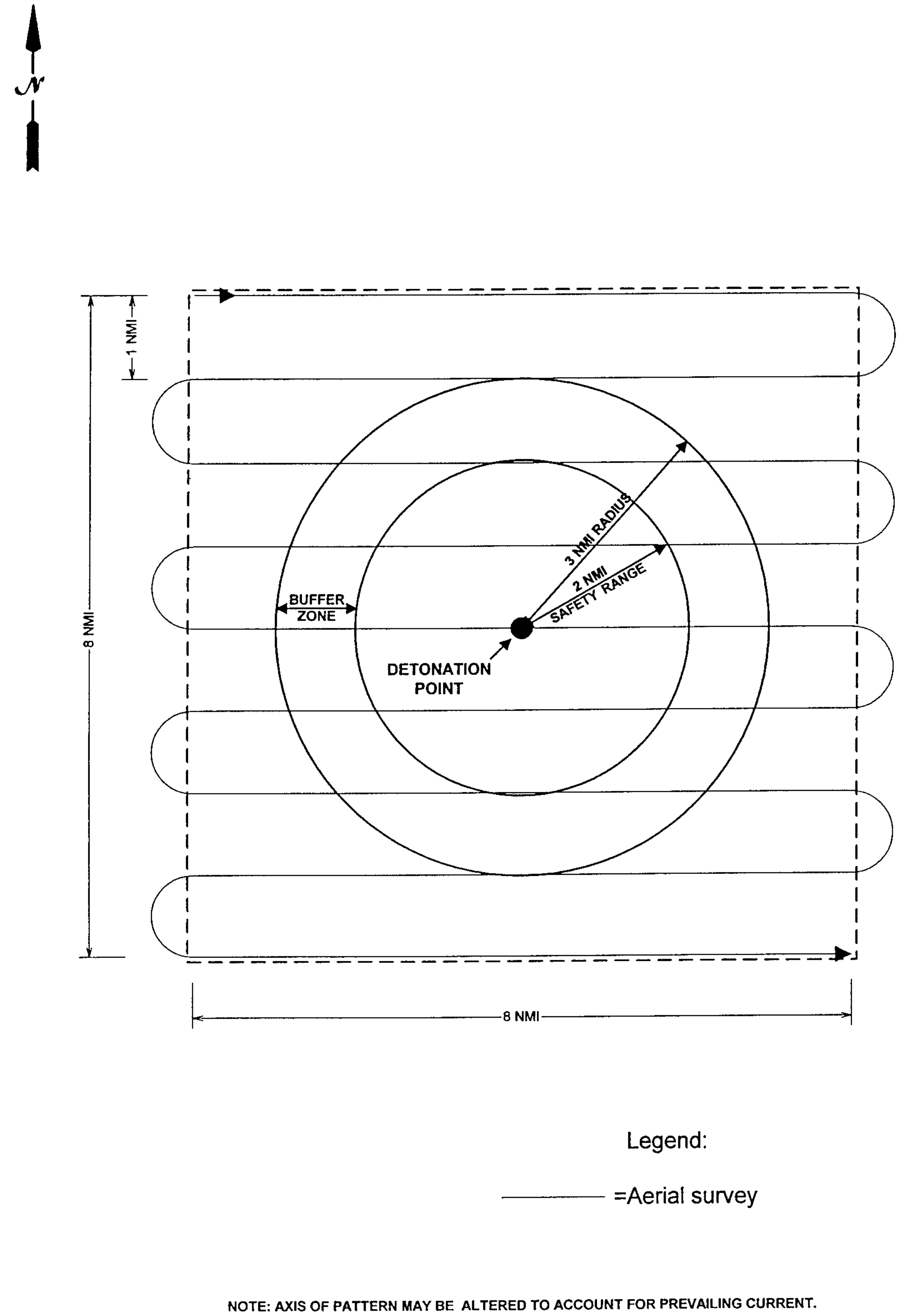


Figure 5-5. Flight plan for site selection surveys two to three days prior to detonation.

5.5.4.2 Pre-Detonation Monitoring

The purpose of pre-detonation monitoring is to ensure that marine mammals and turtles are absent from the selected test site at the time of detonation.

Six Hours Prior to Detonation

Approximately six hours prior to detonation, rigid inflatable boats from the operations vessel and MART vessel would deploy 10 to 15 passive acoustic sensors (sonobuoys) throughout the test site; the total number of sensors to be deployed would depend upon ambient acoustic propagation and noise conditions in the vicinity of the detonation point. The sensors would be anchored to the bottom during the test, and would be retrieved afterwards. A representative pattern for sensor deployment, providing complete coverage of the test site, is illustrated in **Figure 5-6**. Deployment of the acoustic sensors in this pattern is intended to provide detection and localization of marine mammal calls to a distance of approximately 14.8 km (8 nmi) from the detonation point for strong, low frequency calls common to whales and 3.9 km (2.1 nmi) for weak, high frequency calls common to dolphins. While detections can be made farther out, localization of high frequency calls is accurate to within about 0.46 km (0.25 nmi). Therefore, all calls detected at 4.16 km (2.25 nmi) or closer will be assumed to be within the Safety Range.

Two and One-half Hours Prior to Detonation

Two and one-half hours prior to detonation, aerial monitoring would be conducted within the 11.1 km x 11.1 km (6 nmi x 6 nmi) monitoring area, using a transect spacing of 0.46 km (0.25 nmi) (see **Figure 5-7**). Shipboard observers on the operations and MART vessels would also monitor the test site from positions within a 5.6 km (3 nmi) radius of the detonation point. Shipboard monitoring would focus on a 5.6 km (3 nmi) radius from the detonation point (encompassing the Safety Range and Buffer Zone). Binoculars (25X power) mounted on the flying bridge or bridge wings of the two vessels would provide full 360° overlapping coverage. Other observers would use hand-held binoculars.

Shipboard monitoring from the MART vessel would be conducted by experienced marine mammal observers. A veterinarian would coordinate the tagging of any dead animals and document any injured animals discovered during aerial or shipboard pre-detonation monitoring.

Two Hours Prior to Detonation

Two hours prior to detonation, the MMATS system would be calibrated. Two bioacousticians with extensive marine mammal call identification experience would monitor the system's receivers mounted onboard the operations vessel. All noise signals would be interpreted to identify the species and location. Call location and species data would be relayed to the Lead Scientist who would record the animal's location relative to the test site.

One Hour Prior to Detonation

One hour prior to detonation, monitoring of the area within a 5.6 km (3 nmi) radius of the detonation point would be performed (**Figure 5-8**) using a single aircraft, the MART vessel, and the operations vessel, enabling complete coverage of the test site prior to detonation.

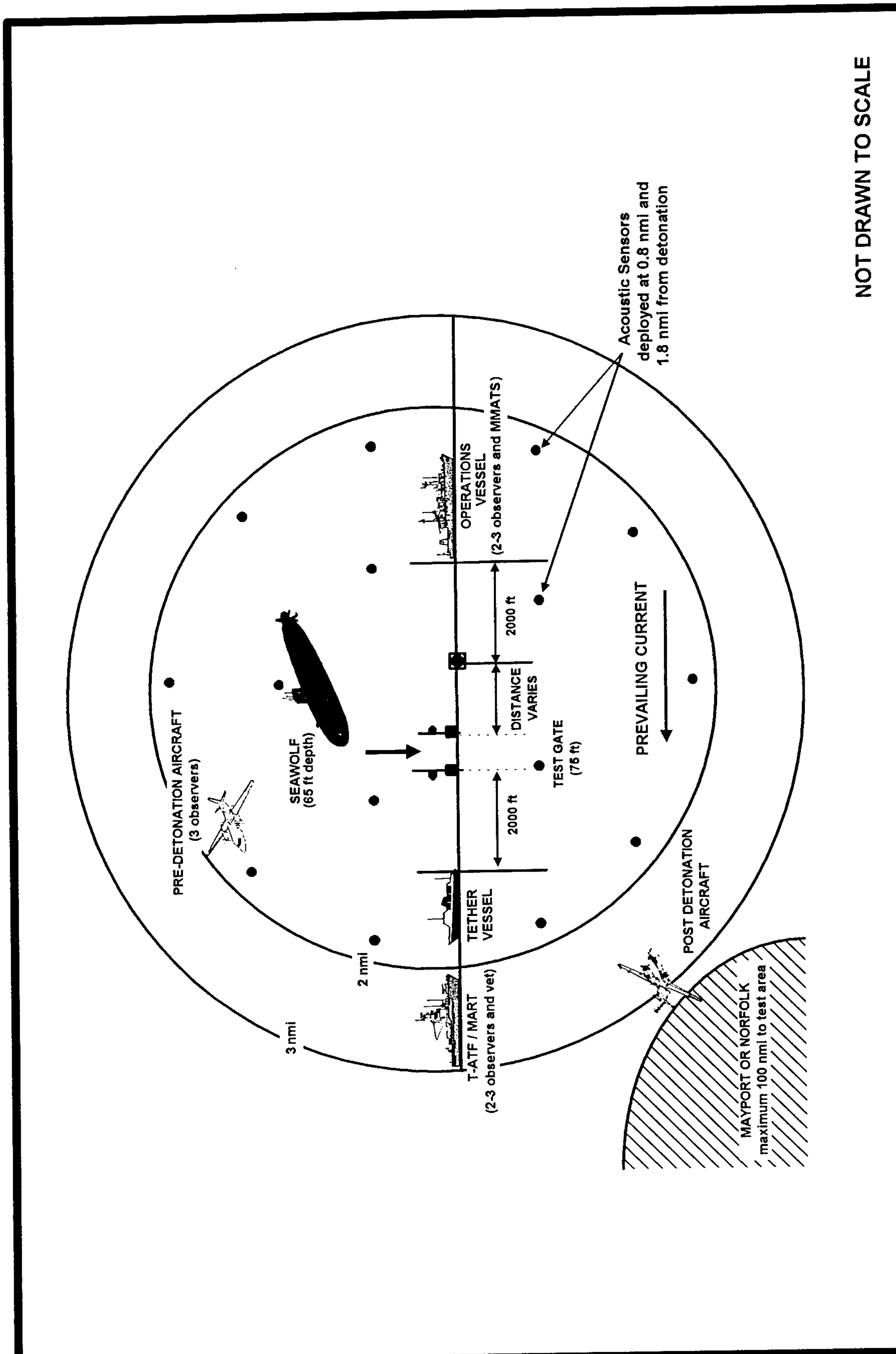


Figure 5-6. Sonobuoy deployment pattern relative to the three mile radius and the positions of the operations and MART vessels and detonation point.

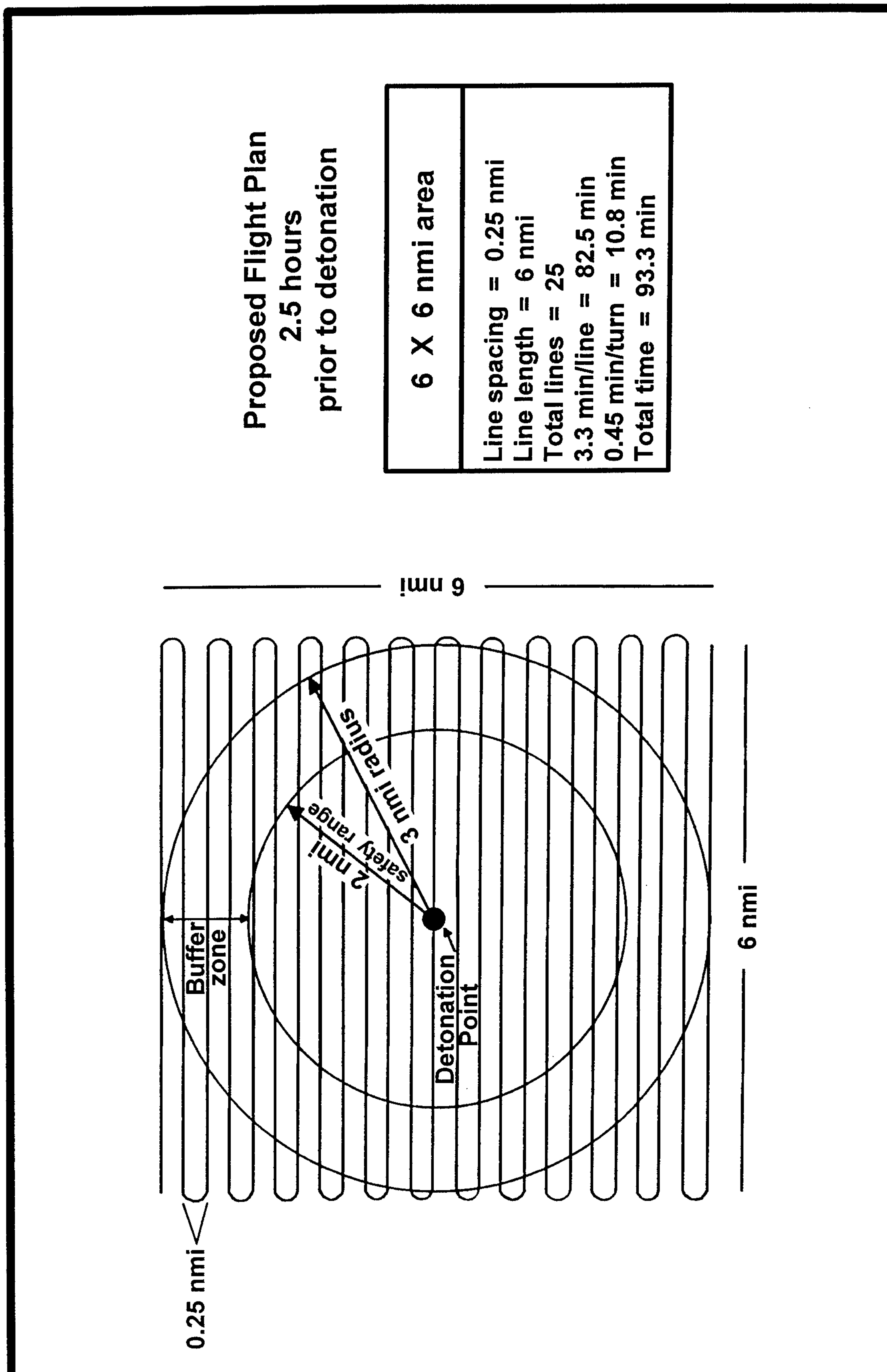


Figure 5-7. Proposed flight plan 2.5 hours prior to detonation.

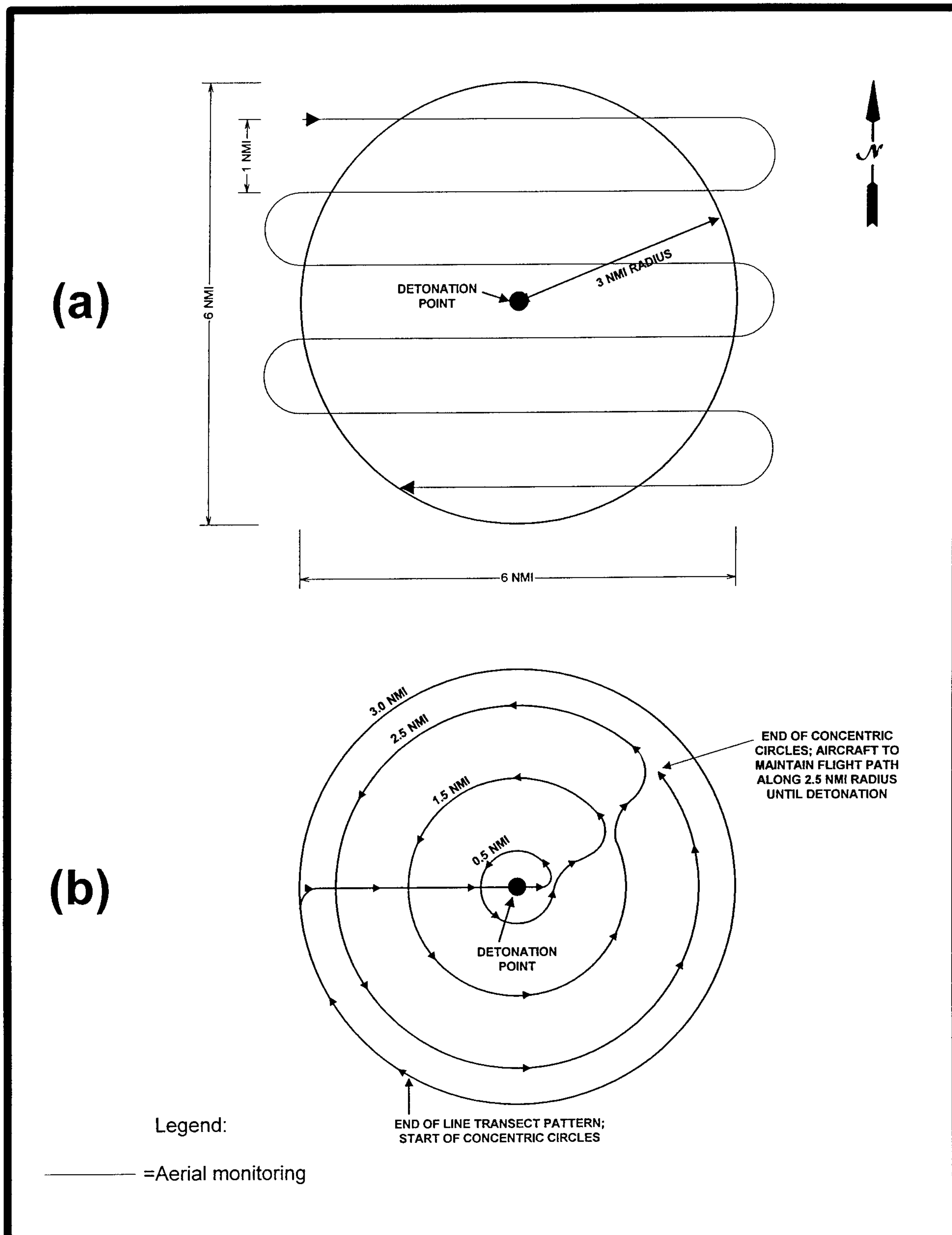


Figure 5-8. Flight plan 1.0 hour prior to detonation.

Aboard the aircraft, observers would follow a line transect pattern, followed by overflight of the detonation point and a series of three concentric circles outward from the detonation point. The axis of the pattern may be altered to account for prevailing currents in the vicinity of the test site.

As reflected in **Figure 5-8(a)**, the initial phase of monitoring would consist of the line transect pattern, where a total of six east-west transects would be completed at 1.85 km (1 nmi) intervals. Following completion of the bottom east-west transect, the aircraft would follow the 5.6 km (3 nmi) radius to a point almost directly west of the detonation point. The aircraft would then turn east towards the detonation point. After crossing the detonation point, the aircraft would continue east to the 0.9 km (0.5 nmi) radius, turn northward, and complete the radius in a counter-clockwise direction. Once the 0.9 km (0.5 nmi) radius is completed, the aircraft would move to the 2.8 and 4.6 km (1.5 and 2.5 nmi) radii to complete each concentric circle in similar fashion. Once the final concentric circle is completed along the 4.6 km (2.5 nmi) radius, the aircraft would maintain this distance until after detonation. **Figure 5-6** illustrates the general position of all operational and mitigation assets during the pre-detonation period.

Flight lines [i.e., transects and concentric circles shown in **Figure 5-8(a)** and **5-8(b)**] are designed to search for marine mammals and turtles which may be present within 5.6 km (3 nmi) of the detonation point or that may swim into the Safety Range immediately prior to the detonation. While the initial east-west flight transects are intended to ensure that no marine mammals or sea turtles are present within the Buffer Zone or Safety Range, the overflight along the concentric circles is designed to further ensure that no mammals or turtles have entered the Buffer Zone or Safety Range during completion of the line transects. At a flight speed of 110 kt, completion of six line transects and five turns would require a total of less than 30 minutes (i.e., 3.3 min/transect; 1.7 min/turn). Completion of the concentric circles would require an additional 21 minutes. As noted previously, the aircraft would complete the 4.6 km (2.5 nmi) radius as the last of the concentric circles, holding that distance from the detonation point until detonation. This would assure effective monitoring of the Buffer Zone by the aerial team immediately prior to detonation. A summary of the distances and estimated travel times for each aerial monitoring component is provided in **Table 5-1.**

To account for marine mammals or sea turtles that may enter into the Buffer Zone and move toward the Safety Range during the time when the aircraft is flying its transects, shipboard observers and the MMATS team would monitor the 5.6 km (3 nmi) radius test site. Shipboard observers would place emphasis on the portions of the test site that the aircraft has already monitored, while MMATS personnel would continue to monitor the entire test site.

Table 5-1. Distances and time required for completion of the aerial monitoring one hour prior to detonation.

Survey Component	Distance		Time Required (min)
	nmi	km	
Line Transects			
6 transects	36.0	66.6	19.8
5 turns	15.7	29.1	8.6
Total line transects	51.7	95.7	28.4
Concentric Circles			
To 0.5 nmi circle	6.0	11.1	3.3
0.5 nmi circle	3.14	5.81	1.7
From 0.5 nmi circle to 1.5 nmi circle	1.5	2.78	0.9
1.5 nmi circle	9.4	17.41	5.2
From 1.5 nmi circle to 2.5 nmi circle	1.5	2.78	0.8
2.5 nmi circle	15.7	29.1	8.6
Total concentric circles	37.24	68.98	20.5
TOTAL	**88.94 nmi**	**164.68 km**	**48.9 min**

Go/No-Go Decision Process

The Lead Scientist will have the authority to declare the range fouled and recommend a "hold detonation" until monitoring indicates that the Safety Range is and will remain clear of animals prior to the detonation. There are a series of checks in the schedule including those at 3 minutes, and 1 minute prior to detonation in addition to periodic updates during the 2.5 hour pre-detonation monitoring period. The Lead Scientist also will have the authority to declare a fouled range anytime in the 1 minute prior to detonation, which would result in a "hold detonation" command by the OTC, unless personal safety or an operational emergency dictates detonating the charge.

Immediately prior to detonation and upon request of the OTC, the MART vessel would stand by at a distance of 3.7 km (2 nmi) from the detonation point. Detonation would be postponed if:

(1) Any marine mammals or sea turtles are *visually* detected within the Safety Range [i.e., within 3.7 km (2 nmi) of the detonation point]. The "hold detonation" would continue until the marine mammal or sea turtle that caused the postponement is confirmed to be outside of the Safety Range.

(2) Any marine mammals are *acoustically* detected within 4.16 km (2.25 nmi) of the detonation point [it would be assumed that the animal is within the 3.7 km (2 nmi) Safety Range]. The "hold detonation" would continue until the marine mammal that caused the postponement is confirmed to be outside of the Safety Range.

(3) *Any listed marine mammal is detected within the Buffer Zone and subsequently cannot be detected. Sighting and acoustic teams would search the area for 2.5 hours (approximately three times the typical large whale dive duration) before assuming the animal has left the Buffer Zone.*

(4) *Any northern right whale is detected within the Buffer Zone. The shot would not occur until the animal is positively reacquired outside the Buffer Zone and at least one additional aerial monitoring of the Safety Range and Buffer Zone shows that no other right whales are present.*

(5) Large sargassum rafts are observed within the Safety Range [i.e., within 3.7 km (2 nmi) of the detonation point]. The "hold detonation" would continue until the sargassum rafts that caused the postponement are confirmed to be outside of the Safety Range;

(6) Large concentrations of jellyfish are observed within the Safety Range [i.e., within 3.7 km (2 nmi) of the detonation point]. The "hold detonation" would continue until the jellyfish concentrations that caused the postponement are confirmed to be outside of the Safety Range.

(7) Flocks of seabirds or large schools of fish are observed in the water within 1.85 km (1 nmi) of the detonation point. The "hold detonation" would continue until the seabird flocks or large fish schools are confirmed to be more than 1.85 km (1 nmi) from the detonation point.

Detonation would also be postponed under certain conditions if a sea turtle or non-listed marine mammal were detected within the Buffer Zone [i.e., from 3.7 km to 5.6 km (2 to 3 nmi) of the detonation point]. The Lead Scientist would plot and record sighting and acoustic (MMATS) position and bearing for all marine animals detected. The output of the computer program would depict animal sightings relative to the charge, and concentric circles indicating the Safety Range and Buffer Zone. Detonation would be postponed if it is determined that a marine mammal or turtle detected in the Buffer Zone is moving toward and could enter the Safety Range prior to detonation. If any marine mammal or turtle cannot be reacquired after an initial detection in the Buffer Zone, a protocol based upon conservative assumptions of dive times would be applied to predict the exit of the animal from the Buffer Zone.

In the event of a postponement, pre-detonation monitoring would continue as long as weather and daylight hours allow. Aerial monitoring is limited by fuel and the on-station time of the monitoring aircraft, which is approximately 3 to 6 hours depending on the exact location of the test site. Unless marine mammal or turtle detections persisted in the Safety Range for several hours, detonation would not be canceled for the day, only delayed until animals are clear of the Safety Range. If animals remain in the test site (i.e., for several hours) then the detonation would likely be postponed for the day.

5.5.4.3 Post-Detonation Monitoring

Post-detonation monitoring would be conducted by the MART vessel for a period of 48 hours after each detonation where a subsequent shot is planned. The MART vessel would be assisted by the aerial mitigation team for up to three hours per day during the same 48 hours. After the last detonation, post-test mitigation would continue for seven days.

Aerial and shipboard monitoring are intended to locate and identify any dead or injured animals. Any marine mammals or turtles killed by a blast would likely suffer lung rupture, which would cause them to float to the surface immediately due to air in the blood stream. If an animal were mortally wounded, but the lungs not ruptured, time until it floats to the surface is likely to be two to five days depending on animal size and water depth. The MART would document any marine mammals or turtles that were killed or injured as a result of the shock test and, if practicable, recover and examine any dead animals. The behavior of any animals observed by the MART and the aerial team would be documented.

If all detonations are conducted at the same site, the mitigation effort for each subsequent shot would also serve as post-detonation mitigation for each previous detonation. If detonations are conducted at more than one site, the extended post-detonation monitoring following the last test would provide some additional coverage of each site. Over the planned 33 days from the first detonation until the final post-detonation day, the mitigation team would be on-site in either surface vessels or aircraft for 19 days.

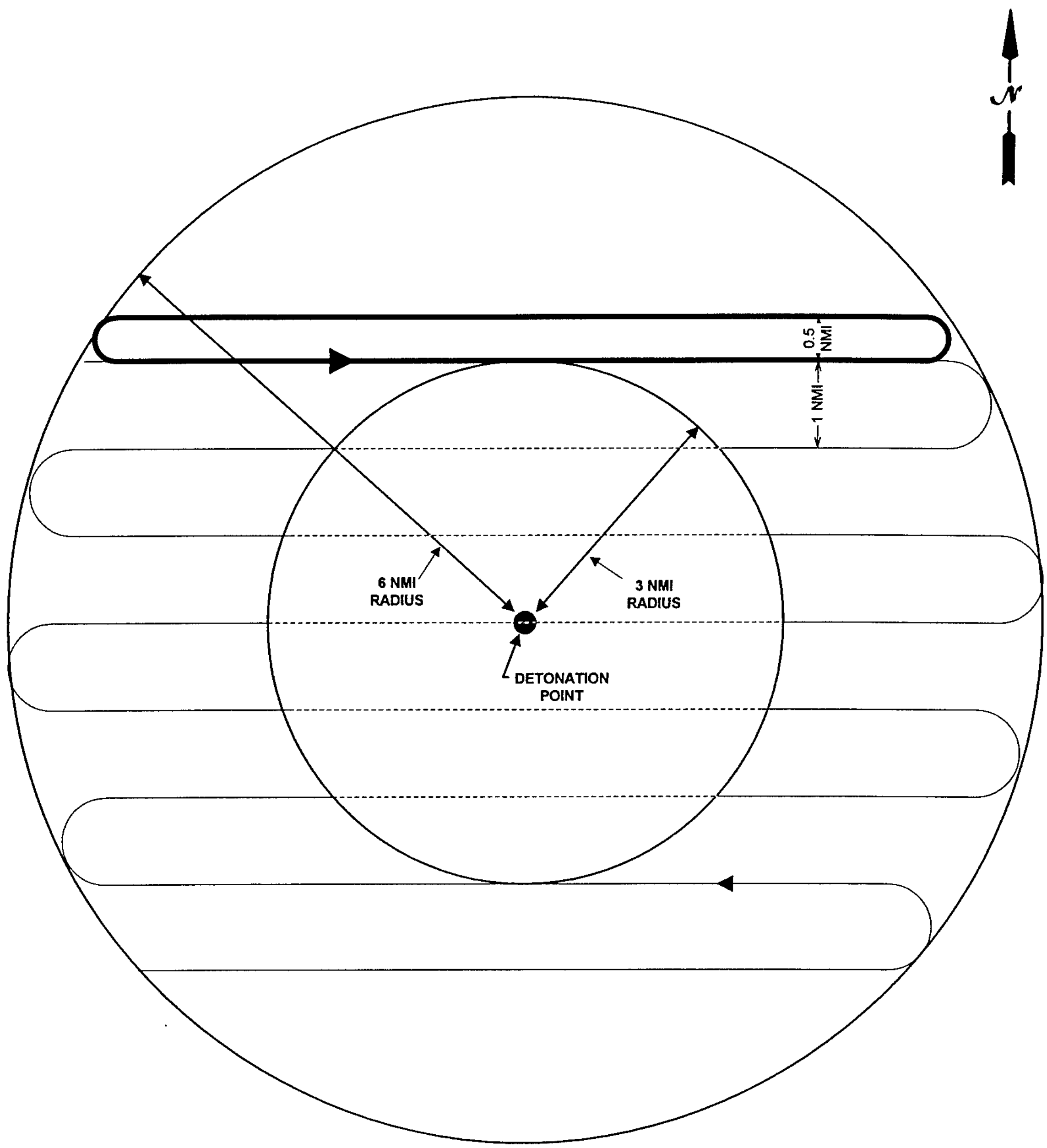
Immediately Following Detonation

The aerial team, located on a second aircraft, would monitor the area of the test [5.6 km (3 nmi) radius] immediately following the detonation (**Figure 5-9**) and report any sightings of dead or injured marine mammals or turtles to the MART. After completing this initial monitoring of the test site, the aerial team would survey an 11.1 km (6 nmi) radius area from the detonation point, starting at the upcurrent end and continuing downcurrent. Aerial monitoring, with transects spaced 1.85 km (1 nmi) apart, would continue downcurrent for three hours after the detonation, or until sighting conditions are unsuitable (e.g., due to nightfall).

The MART vessel would move to the detonation point immediately following the detonation to search for dead fish or turtles, and then proceed to the downcurrent boundary of the 5.6 km (3 nmi) radius to search for any animals that have drifted with the current. Once at this position, the MART vessel would commence an 11.1 km (6 nmi) long racetrack pattern, centered 5.6 km (3 nmi) downcurrent of the detonation point (**Figure 5-9**) for one hour, intercepting any dead or injured marine animals drifting with the current. After one hour, the MART vessel would reposition an additional 3.7 km (2 nmi) downcurrent of the detonation point and commence the same racetrack pattern for another hour. The MART vessel would continue to reposition in this manner until nightfall. The MART would immediately break away from the racetrack pattern to investigate any sightings of potentially injured or dead marine animals reported by the aerial monitoring team.

Post-Detonation Days 1 and 2

Monitoring by the aerial team and the MART would continue on post-detonation days 1 and 2 to detect any potentially injured or dead animals moving in the predominant direction and speed of the Gulf Stream (**Figure 5-10**). Drogues or lighted buoys deployed by the MART vessel would determine current attributes. Satellite imagery may also be used to further refine current speed and direction estimates. The aerial team would monitor for at least three hours each day, surveying transects 22.2 km (12 nmi) in length spaced 1.85 km (1 nmi) apart. Aerial transects would correspond to the position of the MART vessel and move progressively downcurrent.



Legend:

- ——— =Aerial monitoring (6 nmi)
- ------ =Aerial monitoring (3 nmi)
- ▬▬ =Marine Animal Recovery Team (MART) vessel monitoring

Figure 5-9. Flight and MART vessel plan immediately following detonation.

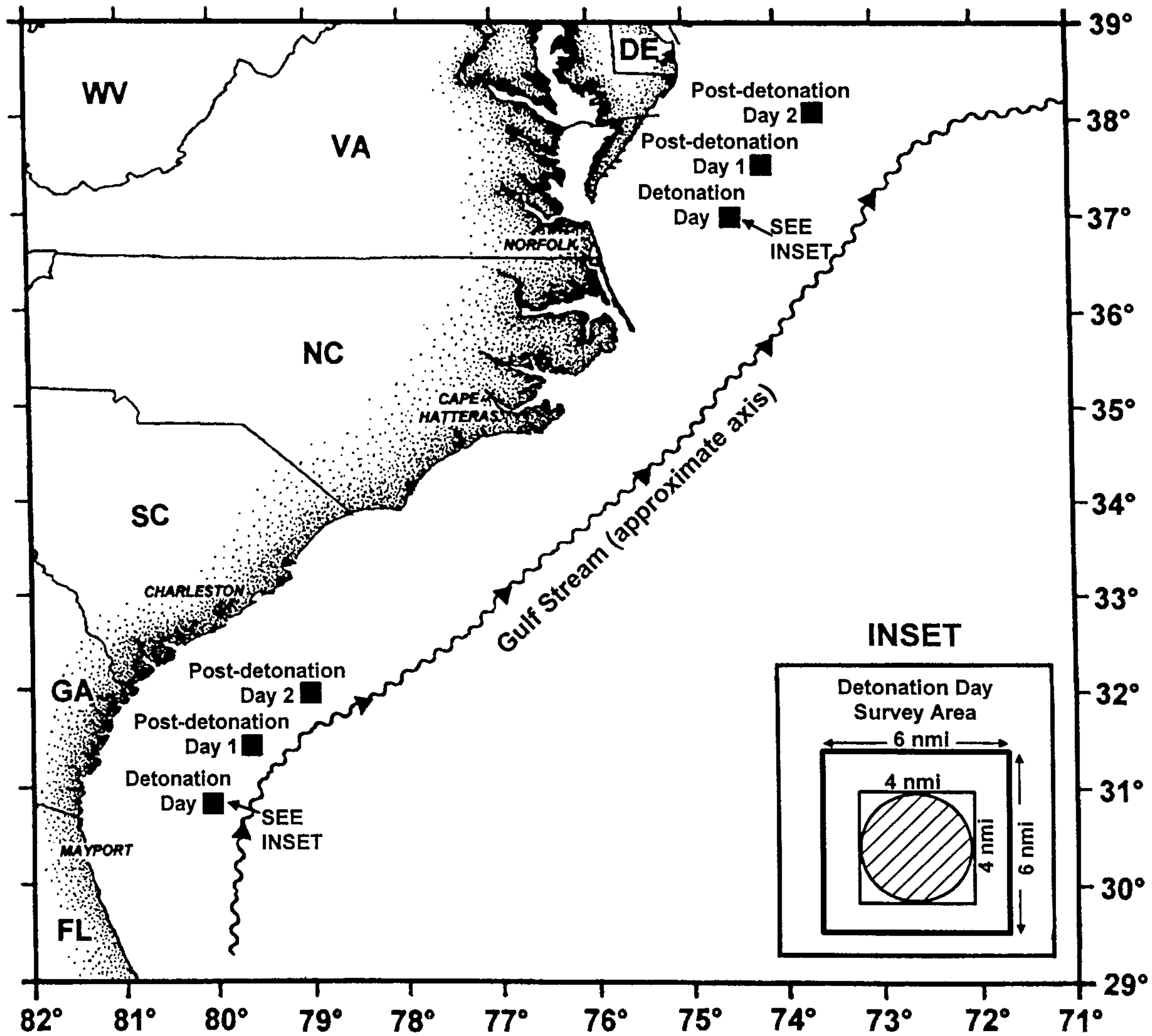


Figure 5-10. Projected location of post-detonation monitoring immediately following detonation and on post-detonation days 1 and 2.

As its first task on post-detonation days 1 and 2, the aerial team supporting the MART would return to the detonation point to observe and document the behavior of any animals in the area, after which they would move downcurrent to continue their observations. The MART vessel would continue the 11.1 km (6 nmi) long racetrack pattern throughout the day, moving 3.7 km (2 nmi) downcurrent each hour. The MART would immediately break away from the racetrack pattern to investigate any sightings of potentially injured or dead marine animals reported by the aerial monitoring team. At the end of post-detonation day 1, the MART would deploy another drogue or lighted buoy to determine current direction and speed. The area to be monitored on post-detonation day 2 would be determined based on the results of the drift (**Figure 5-10**).

In total, the MART would continuously monitor the area around the detonation site and areas downcurrent for at least 24 of the 48 hours following each detonation, covering approximately 444 km (240 nmi), based on two post-detonation monitoring days and an average vessel speed of 10 kt. The aerial team is expected to monitor as much as 1,833 km (990 nmi) during the same 48 hour period, based on a maximum of nine hours on station (i.e., three hours immediately after detonation, three hours each on post-detonation days 1 and 2) and an average air speed of 110 kt. If the post-detonation monitoring determines that injurious or lethal takes have occurred, a review and change of test procedures and monitoring methods would be made as necessary. A table listing the post-detonation MART action plan is shown in **Figure 5-11**.

After the Last Detonation

Following the last detonation, monitoring by the aerial team and the MART would continue for seven days to detect any potentially injured or dead animals moving in the predominant direction and speed of the Gulf Stream. For the first two days following the final detonation, the MART and the aerial team would monitor the detonation area in the same manner as for previous detonations. Over the next five days, the aerial team would monitor the entire area encompassing all of the detonation sites for three hours each day, weather permitting. The exact design of this final aerial monitoring effort will depend on where the detonations have taken place and the predominant direction of the current. Monitoring will start at the detonation site that is farthest upcurrent and continue past the site that is farthest downcurrent. The monitoring will consist of 14.8 km (8 nmi) transect legs spaced 1.85 km (1 nmi) apart. The aerial team will be able to monitor 795 km^2 (232 nmi^2) per day. The frequency with which any particular area is monitored during this five-day period will depend on the spacing of the detonation sites. All sightings of marine mammals and sea turtles will be included in the report to the NMFS. The locations of any dead marine mammal or sea turtle will be reported to the appropriate stranding network coordinator.

5.5.5 Coordination with Marine Animal Stranding Network(s)

The NMFS coordinates regional stranding networks along the northeast (Maine to Virginia) and southeast (North Carolina to Texas, Puerto Rico, and the U.S. Virgin Islands) coasts to collect and disseminate information about marine mammal strandings. The Lead Scientist would contact the designated coordinator of the appropriate stranding network prior to the beginning of the shock test and again after each detonation and report any observations of injured or killed marine mammals or turtles that cannot be recovered by the MART.

Post-Detonation MART Action Plan

A. Deploy current meter
B. Search for injured/dead cetaceans and sea turtles

Dead cetacean

1. Note location and species.
2. Determine if animal can be lifted onto vessel.
   - 3a. If lifting is possible, recover carcass, perform complete necropsy, preserve tissues, send tissues to AFIP.
   - 3b. If lifting is not possible, call Kellie Chouest out to location as platform for on-site necropsy, position animal on aft work bay, conduct full necropsy, preserve tissues, send tissues to AFIP.

Injured cetacean

1. Note location and species.
2. Observe behavior to determine if injury appears to be mortal (observable serious injury, completely still at surface, etc).
   - 3a. If injury appears mortal, determine if animal can be lifted onto vessel (<12' length) to be placed in dolphin box.
     - 4a. If lifting is possible, recover animal, determine if injury is mortal.
       - 5a. If injury is mortal, chemically euthanize, perform complete necropsy, preserve tissues, send tissues to AFIP.
       - 5b. If injury does not appear mortal, stabilize animal in sling/stretcher/wet box, attempt to coordinate aerial transport assistance to appropriate care facility.
     - 4b. If lifting is not possible and safe circumstances predominate, secure animal by encircling with nets (using RHIBs).
       - 6a. If injury is mortal, chemically euthanize, perform necropsy, preserve tissues, re-release carcass, notify stranding network, send tissues to AFIP
       - 6b. If injury cannot be determined to be mortal, continue to observe behavior, note identifying marks, photograph if possible, notify marine mammal stranding network.
     - 4c. If lifting is not possible and animal cannot be safely encircled by nets, call Kellie Chouest out to location to recover animal.
       - 7a. If injury is mortal, go to 6a.
       - 7b. If injury is not mortal, go to 5b.
   - 3b. If injury does not appear mortal, continue to observe behavior, note identifying marks, photograph if possible, notify marine mammal stranding network

Dead turtle

1. Note location and species.
2. Determine if environmental conditions will permit collection.
   - 3a. If recovery is possible, lift animal onto vessel, perform complete necropsy, preserve tissues, send tissues to AFIP.
   - 3b. If recovery is not possible, tag animal, notify turtle stranding network.

Injured turtle

1. Note location and species.
2. Determine if environmental conditions will permit recovery.
   - 3a. If recovery is possible, recover animal.
     - 4. Determine if injury is mortal.
       - 5a. If injury is mortal, chemically euthanize, perform complete necropsy, preserve tissues, send tissues to AFIP.
       - 5b. If injury is not mortal, stabilize animal.
         - 6a. If animal can be stabilized and appears to have recovered, tag and release (note release location).
         - 6b. If animal continues to require treatment:
           - 7a. If shot day, transfer animal to operations vessel for immediate return to port; notify appropriate care facility.
           - 7b. If post-detonation day, continue to stabilize animal onboard MART vessel, transfer to appropriate care facility upon returning to port.
   - 3b. If recovery is not possible, observe behavior, note identifying marks, photograph if possible, notify turtle stranding network.

Figure 5-11. Post-Detonation MART Action Plan.

Communications with stranding network personnel would be maintained throughout the SEAWOLF shock test period.

A brief description of plans to coordinate with the stranding networks is provided below. Protocols have been established in coordination with the NMFS Southeast Fisheries Science Center (SEFSC) to recover stranded animals, and collect and analyze critical tissues to determine the cause of death. The necropsy protocols will be published in the Newsletter of the Southeast U.S. Marine Mammal Stranding Network. A description of the turtle necropsy protocol will be published in the Marine Turtle Newsletter. The stranding networks have personnel trained to conduct marine mammal and sea turtle necropsies. The tissue samples should be forwarded to the Armed Forces Institute of Pathology (AFIP).

5.5.5.1 Post-Detonation MART Action Plan

The post-detonation MART Action Plan is provided as **Figure 5-11**.

5.5.5.2 Marine Mammal Stranding Network Protocol

Marine mammals that cannot be recovered by the MART would be tagged. This information would be relayed to the Lead Scientist or Mitigation Team Leader. The Lead Scientist would contact the NMFS-SEFSC marine mammal stranding network coordinator, currently Blair Mase. The coordinator would contact the appropriate stranding network representative (based on the animal's possible point of landfall given the prevailing current). Each network has qualified technicians who have been trained at NMFS-sponsored workshops in correct necropsy and preservation techniques, using the National Stranding Format and NMFS Collection Protocol. A Marine Mammal Stranding Report would be completed by the technician and forwarded to the coordinator. Tissues would be forwarded to the AFIP for analysis. The AFIP would attempt to provide the MART veterinarian a preliminary report on their findings prior to subsequent detonations. AFIP results would be incorporated into subsequent shot day protocols, as possible. Specific information about the stranding would be relayed from the coordinator to the Lead Scientist for inclusion in reports.

5.5.5.3 Sea Turtle Stranding Network Protocol

Sea turtles that cannot be recovered would be tagged and the information relayed from the MART to the Lead Scientist and Mitigation Team Leader. The Lead Scientist would contact the NMFS-SEFSC turtle stranding network coordinator, currently Wendy Teas. The Southeast U.S. turtle stranding network is coordinated on a statewide basis with volunteers reporting to a statewide coordinator. The coordinator would alert statewide coordinators to the possibility of a tagged turtle stranding, and request that they inform her if/when that happens. During this time of year, numerous turtles strand due to various causes; necropsies on stranded turtles are normally carried out only on those that are fresh enough for viable tissue collection. Data regarding any collected tagged strandings would be relayed from the coordinator to the Lead Scientist for inclusion in reports.

6.0 CUMULATIVE IMPACTS

Cumulative impacts are those resulting from the incremental effects of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of which agency or person undertakes them. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over time.

As described in the Environmental Consequences section, the main impacts of the proposed shock testing would include release of chemical products into the ocean and atmosphere; deposition of metal fragments on the seafloor; mortality and injury of plankton and fish near the detonation point; possible mortality, injury, and acoustic discomfort of marine mammals and sea turtles; and possible interruption of commercial and recreational fishing activity in the test area. Because of the short-term nature of the proposed action and the minor and localized nature of the impacts, there would not be any incremental or synergistic impact on present or reasonably foreseeable future uses of either the Mayport or Norfolk area.

Shock testing would not be expected to result in accumulation of explosion products in the water column or atmosphere. Both the Mayport and Norfolk areas are in deep, oceanic waters where the explosion products would be rapidly dispersed and mixed. Gases released into the atmosphere would also be rapidly dispersed and mixed. As stated in Sections 4.2.1.1 and 4.2.2.5, metal fragments from the explosions would accumulate on the seafloor but would not be expected to produce adverse impacts; they would provide a substrate for growth of epibiota and attract fish.

The Navy is currently designing the New Attack Submarine (NSSN). The Navy's Live Fire Test and Evaluation Plan for the NSSN includes a ship shock test in 2005. The technical and operational requirements to shock test the NSSN would be similar to SEAWOLF and therefore, both the Mayport and Norfolk areas may be considered as potential shock test areas in the future. Other than the shock testing of the NSSN, there are no ongoing, planned, or reasonably foreseeable Navy actions that could have similar impacts on the marine environment at either the Mayport or Norfolk area. No other shock testing has been proposed for either area during this time period. The petroleum industry has proposed offshore drilling at a location south of the Norfolk area (DOI, MMS, 1990), but the proposal has been postponed indefinitely (Oil and Gas Journal, 7 August 1995, p. 34). Commercial and recreational fishing at both Mayport and Norfolk targets some of the same fish species that may be killed or injured by the proposed action; however, no cumulative impact on fisheries is expected because the fish species are abundant and widely distributed.

Pursuant to its authority and responsibilities under the Endangered Species Act, the NMFS has issued a Biological Opinion (Appendix G) taking into account the cumulative impacts of all activities potentially affecting listed marine mammal and turtle populations. The Biological Opinion concludes that shock testing is not likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat.

7.0 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Unavoidable impacts of the proposed shock testing include release of chemical products into the ocean and atmosphere, deposition of metal fragments on the seafloor, mortality and injury of plankton and fish near the detonation point, possible acoustic discomfort of marine mammals and sea turtles, and possible interruption of commercial and recreational fishing activity in or near the test site.

Underwater explosions would release chemical products into the ocean and atmosphere and deposit metal fragments on the seafloor. Due to the low initial concentrations and rapid dispersion of the chemical products, they would pose no hazard to marine or human life. The metal fragments would not be expected to produce adverse impacts; they should provide a substrate for growth of epibiota and attract fish.

Fish near the detonation point would be killed or injured. A large fish kill would not be expected because detonation would be postponed if large schools of fish were observed within 1.85 km (1 nmi) of the detonation point. No impact on fish populations, including commercial and recreational species, is expected because the fish found at the Mayport and Norfolk areas are abundant and widely distributed. Plankton and other small marine life would also be affected but would be rapidly replenished through population growth and mixing with adjacent waters.

Most potential impacts to marine mammals and sea turtles would be avoidable due to the mitigation procedures described in Section 5.0. Because detonations would not occur if any marine mammals or turtles were detected within the safety range, mortality or injury is unlikely. However, because no method of detection can be 100% effective, some marine mammals and/or sea turtles could be killed or injured if present within the safety range. Also, marine mammals or turtles up to several nautical miles beyond the safety range could experience temporary threshold shift (reversible hearing loss) due to the acoustic characteristics of the detonations. Animals many nautical miles away could be momentarily disturbed or startled. However, no lasting impacts on marine mammals or turtles beyond the safety range is expected.

Fishing vessels and other ship traffic would be excluded from the test site before, during, and after each shock test. Due to the short duration of the tests and advance warning through *Notices to Airmen and Mariners*, the interruption is not expected to significantly affect commercial or recreational fisheries or other ship traffic.

8.0 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

Shock testing would require expenditure of energy in the form of fuel consumed by vessels and aircraft. Fuel would be used by the SEAWOLF submarine, which is the platform to be shock tested, by ships associated with placing the test array and detonating the charge, and by ships and aircraft involved in mitigation and clearing the site. Because the shock test site would be located near required Navy facilities, energy consumed by vessels and aircraft would be conserved by minimizing transit distances and keeping the time at sea to a minimum.

9.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Shock testing would result in commitments of labor and capital along with use of non-renewable materials. Fuel used by vessels and aircraft during shock testing, as well as non-recyclable materials used for engine maintenance, are irretrievable resources. Mitigation will minimize the effects of the proposed action on the marine environment, and no irreversible or irretrievable commitment of marine resources is expected.

10.0 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed action will allow the Navy to assess the survivability of the SEAWOLF submarine in accordance with 10 USC 2366. Shock test operations will have no significant long-term impacts on the environment. Shock testing of the SEAWOLF is being proposed as a short-term action that includes five detonations between 1 April (1 May for the Mayport area) and 30 September 2000. Short-term commitments of labor and capital along with use of non-renewable materials for machine power and maintenance would result from the proposed activities. No long-term commitments of resources would be required. The location of the test site in offshore waters will minimize biological effects because productivity is expected to be lower than in nearshore waters. Mitigation monitoring using visual and passive acoustic surveillance techniques will minimize the effects of the proposed action on marine resources and improve knowledge of the marine environment in the area. The only long-term effect from the operations will be a limited distribution of small steel fragments from the charge container on the seafloor. Although the fragments could slightly enhance benthic productivity by increasing available substrate for the attachment of marine invertebrates, this effect is considered insignificant. All other effects would be temporary in nature; individual marine organisms may be killed or injured as a result of underwater detonations, but there should be no lasting impact on population levels of any species. Therefore, the activities should have no significant adverse or beneficial long-term impacts on the maintenance and enhancement of long-term biological productivity.

11.0 RELATIONSHIP WITH FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

11.1 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) of 1969, as amended, contains policy and guidance to ensure that potential impacts from proposed federal actions are assessed using a systematic and interdisciplinary approach. This FEIS has been prepared in accordance with Section 102(2)(c) of NEPA, the Council on Environmental Quality (CEQ) regulations on implementing NEPA procedures (40 CFR 1500-1508), and Department of the Navy regulations on implementing NEPA procedures (32 CFR 775).

11.2 EXECUTIVE ORDER 12114

Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions," requires analysis of environmental impacts of Federal agency actions that could significantly affect the global commons, the environment of a foreign nation, or impacts on protected global resources. Executive Order 12114 is based on independent authority but furthers the purpose of NEPA. Because the proposed action could result in environmental impacts outside of U.S. territorial seas, this FEIS has been prepared in accordance with Executive Order 12114. Impact discussions in this FEIS (Section 4.0, Environmental Consequences) are divided into separate subsections to distinguish between those operations that are evaluated under NEPA and those that are evaluated under Executive Order 12114.

11.3 EXECUTIVE ORDER 12898

Consistent with Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," it is the Navy's policy to identify and address disproportionately high and adverse human health or environmental effects on members of minority and low-income populations. Shock testing and associated mitigation operations would occur well offshore and would result in minor and/or temporary impacts to the environment at the test site with no significant direct or indirect impacts on the human population. Chemical byproducts of the detonations would be rapidly dispersed at the test site (Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality. Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or sport fishery stocks, fishing activities (including subsistence fishing), or the coastal fishing industry (Section 4.1.3). Existing and temporary facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide all services in support of shock testing, and no significant direct or indirect impacts on the local economy are expected (Section 4.1.3). The shore-based operations and transit of ships and aircraft from shore support facilities to the test site are of the same type routinely conducted by the Navy and would not involve any unusual or extraordinary activities which could have impacts on coastal resources or the coastal economy. Therefore, the proposed action would not have any adverse impacts on the human population and would not have a disproportionately high effect on any minority or low-income group.

11.4 ENDANGERED SPECIES ACT

The Endangered Species Act of 1973, as amended, empowers the Secretary of the Interior to establish a listing of endangered and threatened species and critical habitats designated for protection. The Act prohibits jeopardizing endangered and threatened species or adversely modifying critical habitats essential to their survival. Section 7 of the Act requires consultation with the NMFS and the USFWS to determine whether any endangered or threatened species under their jurisdiction may be affected by the proposed action. Copies of the Department of the Navy, NMFS, and USFWS informal consultation letters written prior to preparation of the DEIS are provided in Appendix G. No formal consultation with the USFWS was required because the USFWS determined that there are no endangered and threatened species or critical habitats under its jurisdiction that could be affected by the proposed action (i.e., the Navy and USFWS have already completed their responsibilities under the Endangered Species Act for species under USFWS jurisdiction). However, formal consultation with the NMFS was required. The DEIS served as a Biological Assessment which the Navy submitted to the NMFS to initiate formal consultation. Formal consultation was completed when the NMFS issued a Biological Opinion (presented in Appendix G of the FEIS).

11.5 MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act of 1972, as amended, establishes a national policy designed to protect and conserve marine mammals and their habitats. This policy is established to prevent the reduction of population stocks beyond the point at which they cease to be a functioning element in the ecosystem, or the reduction of species below their optimum sustainable population.

Section 101(a)(5) of the Marine Mammal Protection Act directs the Secretary of the Department of Commerce to allow, upon request, the incidental (but not intentional) taking of marine mammals by U.S. citizens who engage in a specified activity (exclusive of commercial fishing) within a specified geographical region if certain findings are made and regulations are issued. Permission may be granted by the Secretary for the incidental take of marine mammals if the taking will (1) have a negligible impact on the species or stock(s); and (2) not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. Regulations must be issued setting forth the permissible methods of taking and the requirements for monitoring and reporting such taking.

Concurrently with the release of the DEIS, the Navy submitted an incidental small take application to the NMFS. Based on this application, the NMFS published a Proposed Rule on August 2, 1996 (61 FR 40377) and participated in joint public hearings as described in Section 1.0. The Proposed Rule specifies take limits as well as mitigation, monitoring, and reporting requirements for SEAWOLF shock testing. A Final Rule must be issued before shock testing can proceed.

11.6 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The Marine Protection, Research and Sanctuaries Act of 1972 (Ocean Dumping Act), as amended, makes it illegal for any person to transport material from the U.S. for the purpose of dumping it into ocean waters. The term "dumping" as defined under the Act does not include the intentional placement of any device in ocean waters for a purpose other than disposal. In the case of the proposed action, the explosive charge would be transported for the purposes of detonating the charge and conducting the shock test. After each detonation, the test array would be recovered and floats and floating debris would be removed. Thus, shock testing would not involve transporting material for the purpose of dumping it into ocean waters, and the proposed action would not require an ocean dumping permit.

The probability of a charge not detonating during a test is remote. Should a charge fail to explode, the Navy would attempt to identify the problem and detonate the charge (with all mitigation measures, Section 5.0). If these attempts failed, the Navy would recover the explosive and disarm it. Only in case of an extreme emergency or to safeguard human life would the Navy dispose of the charge at sea.

11.7 COASTAL ZONE MANAGEMENT ACT

The Coastal Zone Management Act of 1972, as amended, provides for the effective management, beneficial use, protection, and development of the U.S. coastal zone. The Act enables individual states to develop and implement regulatory guidelines to ensure appropriate protection and compatibility of uses within their coastal zones. The shore-based operations and transit of ships and aircraft from shore support facilities to the test site would have no effects on coastal resources. Shore facility operations and ship and aircraft transits are of the same type routinely conducted by the Navy and would not involve any unusual or extraordinary activities. As the shock testing itself would occur well outside state waters and coastal zones, it would not directly or indirectly affect coastal resources of any state. Chemical byproducts of the detonations would be rapidly dispersed at the test site (Sections 4.2.1.2 and 4.2.1.3) and therefore would not affect coastal water quality or air quality. Due to the small area affected and the short duration of shock testing, the proposed action would not have significant impacts on commercial or sport fishery stocks, fishing activities, or the coastal fishing industry (Section 4.1.3). Existing and temporary facilities at Naval Station Mayport and Naval Submarine Base Kings Bay or Naval Station Norfolk would provide all services in support of shock testing, and no significant direct or indirect impacts on the local economy are expected (Section 4.1.3). The coastal tourist industry would not be affected by floating debris or dead fish; what little floating debris may result from the detonations would be removed, and any fish killed or injured by the explosions would be expected to drift to the northeast with the Gulf Stream and would not reach coastal waters (Section 4.1.3).

In conclusion, shock testing would not have any impact on the resources or uses of the coastal zone. Therefore, no formal consistency determination under Section 307 of the Coastal Zone Management Act is required from any state.

11.8 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act of 1918 (MBTA), as amended, regulates the taking, killing, and possession of migratory birds within U.S. territory. The MBTA applies to migratory birds as defined in the terms of conventions between the U.S. and Great Britain, Mexico, Japan, and the Union of Soviet Socialist Republics. Many of the seabird species that could occur at the Mayport or Norfolk areas are migratory birds as defined in the act. No taking or killing of migratory birds would result from those portions of the proposed action taking place within U.S. territory at shore support facilities or during transit of ships and aircraft to the test site. While the MBTA does not apply, the Navy will make every effort to prevent and/or minimize harm to migratory seabirds that may be in the vicinity of the test site during detonation. The mitigation plan set out in Section 5.0 of the FEIS includes a provision for postponing detonations if flocks of birds are present within the safety range.

12.0 LIST OF PREPARERS

DEPARTMENT OF THE NAVY

- William R. Sloger. Engineer-in-Charge. M.S. Environmental Studies, M.E. Structural Engineering; B.S. Civil Engineering. 6 years relevant experience.
- Steve Schulze. Project purpose and need. B.S. Ocean Engineering. 11 years relevant experience.
- Phil Barfield. Operational requirements. B.S. Mechanical Engineering. 14 years relevant experience.
- James Craig. Appendix D. B.S. Physics. 30 years relevant experience.
- Christian Hearn. Appendix D. B.S. Mechanical Engineering. 7 years relevant experience.
- David A. Helweg. Appendix E. Ph.D. Psychology (cognitive science track), M.A. Psychology (marine mammalogy track), B.A. Neuroscience. 12 years relevant experience.
- Joel B. Gaspin. Appendix E. B.A. Physics. 30 years relevant experience.
- Jean A. Goertner. Appendix E. B.S. Mathematics and Chemistry. 40 years relevant experience.
- Will Knoll. Appendix F. B.S. Chemistry, M.E.A. 11 years relevant experience.

CONTINENTAL SHELF ASSOCIATES, INC.

- Richard M. Hammer. Project Manager. Ph.D. Marine Biology; M.S. Oceanography; B.S. Fisheries and Wildlife. 27 years relevant experience.
- Neal W. Phillips. Impact assessment and FEIS editor. Ph.D. Ecology; M.S. Marine Studies; B.A. Biological Sciences. 15 years relevant experience.
- Brian J. Balcom. Impact assessment, mitigation, biological assessment for marine mammals and turtles. M.S. Marine Biology; B.S. Biology. 18 years relevant experience.
- David B. Snyder. Literature review and description of existing environment. M.S. Marine Biology and Ichthyology; B.S. Zoology. 17 years relevant experience.
- Stephen T. Viada. Aerial surveys, literature review, and species descriptions for marine mammals and sea turtles. M.S. Biological Oceanography; B.S. Zoology. 17 years relevant experience.

TRACOR SYSTEMS TECHNOLOGIES

- Greg Bryant. Mitigation and monitoring. B.S. Marine Engineering. 3 years relevant experience.
- Bibi N. Vosbeck. Mitigation and monitoring. B.S. Geology, M.S. Environmental Sciences. 3 years relevant experience.

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APPENDIX A

DISTRIBUTION LIST FOR THE FINAL ENVIRONMENTAL IMPACT STATEMENT

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Alexandria, Virginia

Larry Coar
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Aircraft Division Detachment
Trumbo Point Annex
Key West, Florida

Commander
MRJ Technology Solutions
Attn: Jim Wysor
Building 3187 MS-3
Naval Air Station
Patuxent River, Maryland

Commander
Naval Base Norfolk
Norfolk, Virginia

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CSL N8A
Norfolk, Virginia

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Norfolk, Virginia

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Naval Sea Systems Command
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Naval Facilities Engineering Command
San Diego, California

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Naval Station
Norfolk, Virginia

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Code N4
Naval Station Mayport
Mayport, Florida

Commanding Officer
Attn: Richard Shockley
NCCOSC RDT&E Div
San Diego, California

Commanding Officer
Naval Submarine Base Kings Bay
Facilities & Engineering Directorate
Kings Bay, Georgia

COMNAVBASE Jacksonville
Attn: Environmental Management Department
Code N3 Box 102
Naval Air Station
Jacksonville, Florida

Dr. Dennis Conlon
Chief Oceanographer PMW-182
Space and Naval Warfare Systems Command
Arlington, Virginia

Council on Environmental Quality
Washington, DC

Paul D. Coverdell
United States Senator
Washington, DC

Defense Technical Information Center
DTIC Customer Service Help Desk (DTIC-BLS)
Ft. Belvoir, Virginia

Department of Energy
Dave Harris\L-205
Lawrence Livermore National Lab
Livermore, California

Desiree Dimauro
Commandant G-ECZ-1
U.S. Coast Guard Headquarters
Washington, DC

Barry S. Drucker
U.S. Department of the Interior
Minerals Management Service
Office of International Activities and Marine
Minerals (INTERMAR)
Herndon, Virginia

Marguerite Duffy
Environmental Protection Agency
Washington, DC

David L. Evans
Deputy Assistant Administrator for Fisheries
National Marine Fisheries Service
Silver Springs, Maryland

Dagmar Fertl
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
New Orleans, Louisiana

Congresswoman Tillie K. Fowler
Fourth District, Florida
Jacksonville, Florida

Marie Ferdman
Code 007
Naval Surface Warfare Center
Carderock Division
Bethesda, Maryland

Tracy Gill
National Oceanic and Atmospheric Administration
Silver Spring, Maryland

Dr. Robert Gisiner
Biological Science and Technology Program
Office of Naval Research, Code 335
Arlington, Virginia

James Haluska
Code: 2032JH
Environmental Protection Specialist
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Maurice Hill
Minerals Management Service
Camarillo, California

Ken Hollingshead
National Marine Fisheries Service
Office of Protected Resources
Silver Spring, Maryland

Ron Hudson
Naval Air Weapons Station
Environmental Div. - Code 833210E
Pt. Mugu, California

Robert F. Jones
Regional Environment Coordinator
COMSUBGRU TWO
Groton, Connecticut

Capt. F. Klein
NAVDEPNOAA
Washington, DC

Jack Lewis
Minerals Management Service
Herndon, Virginia

Andreas Mager, Jr.
National Marine Fisheries Service
St. Petersburg, Florida

Chris Mantceros
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Gloucester, Massachusetts

Marine Mammal Commission
Washington, DC

Maxine Milbourn
LANTDIV NAVFAC
Norfolk, Virginia

National Marine Fisheries Service
Director, Office of Protected Resources
Marine Mammals Division
Silver Spring, Maryland

National Marine Fisheries Service
Attn: Coleen Coogan
Southeast Regional Office
St. Petersburg, Florida

Naval Submarine Base Kings Bay
Public Affairs Office
Kings Bay, Georgia

Doug Nester
U.S. Army Corps of Engineers
Mobile District
Mobile, Alabama

Clyde Nishimura
Naval Research Laboratory
Code 7420
Washington, DC

Captain Bob Parlet
Commanding Officer
Fleet Area Control & Surveillance Facility
Naval Air Station
Jacksonville, Florida

Mark O. Pierson
Minerals Management Service
Pacific OCS Region
Camarillo, California

Program Executive Office
Attn: LCDR D. Falk
Code PMA264C2
Patuxent River, Maryland

Rodger Pugliese
South Atlantic Fishery Management Council
Charleston, South Carolina

Andrew Rich
Fort Matanzas National Monument
St. Augustine, Florida

Sam Ridgway, DVM, Ph.D.
SPAWARSYSCEN, Code 511
San Diego, California

Trish Riley
U.S. Geological Service
Reston, Virginia

LCDR R.J. Rogers, R.N.
NLO
Winfrith Technology Centre
Winfrith Newburgh
Dorchester Dorset, United Kingdom

Karen Salvini
National Marine Fisheries Service
Silver Spring, Maryland

Randy Schneider
Norfolk Canyon National Marine Sanctuary
National Oceanic and Atmospheric Administration
Sanctuaries and Reserves Division
Office of Ocean and Coastal Resource Management
Silver Spring, Maryland

Dr. Joe Schrodt
HQ AFTAC/TTR
Patrick AFB, Florida

Wayne Van Scoyoc
Environmental Manager
PMO450T4E
New Attack Submarine Program
A.F. Meyer & Associates, Inc.
McLean, Virginia

Jan M. Sechrist
Marine Mammal Commission
Washington, DC

Merrily Severance
Naval Facilities Engineering Command
Alexandria, Virginia

Ted Sledzinski
SPAWARSYSCEN, Code 721
San Diego, California

Scott Smullen
National Marine Fisheries Service – PAO
Silver Spring, Maryland

Alex Stone
Project Manager
Naval Air Warfare Center
Code 8320003
Point Mugu, California

Sal Testeverde
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Gloucester, Massachusetts

Robert Thrun
Naval Surface Warfare Center
Indian Head Division (Code 460)
Silver Spring, Maryland

John R. Twiss, Jr.
Executive Director
Marine Mammal Commission
Washington, DC

Shaari Unger
NUWC
Division Keyport
Code 043
Keyport, Washington

U.S. Coast Guard
Office of Law Enforcement & Defense Ops
Washington, DC

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National Marine Fisheries Service
Southeast Regional Office
St. Petersburg, Florida

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National Oceanic and Atmospheric Administration
Washington, DC

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Washington, DC

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Washington, DC

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Director, Office of Federal Activities
Washington, DC

U.S. Environmental Protection Agency
Administrator, Region III
Philadelphia, Pennsylvania

U.S. Environmental Protection Agency
Administrator, Region IV
Atlanta, Georgia

U.S. Fish & Wildlife Service
Environmental Coordination Branch
Department of the Interior
Washington, DC

Jerry Wallmeyer
COMNAVBASE Jacksonville
Code N3, Box 102
NAS Jacksonville
Jacksonville, Florida

STATE AGENCIES

Henry Ansley
Georgia Department of Natural Resources
Coastal Resources Division
Brunswick, Georgia

Commonwealth of Virginia
Marine Resources Commission
Newport News, Virginia

Mark Delaplaine
Federal Consistency Supervisor
California Coastal Commission
San Francisco, California

Tom Feldey
Department of Environmental Quality
Richmond, Virginia

Duane Harris
Director
Department of Natural Resources
Coastal Resources Division
Brunswick, Georgia

Tom Hopkins
Office of the Secretary of Natural Resources
Richmond, Virginia

John R. Marling
Director
Office of Environmental Impact Review
Division of Intergovernmental Coordination
Virginia Department of Environmental Quality
Richmond, Virginia

Ron Michaels
Georgia Department of Natural Resources
Coastal Resources Division
Brunswick, Georgia

Harold Rehels, Director
Environmental Protection Division
Atlanta, Georgia

Roger N. Schecter
Director
Department of Environment, Health, & Natural Resources
Division of Coastal Management
Raleigh, North Carolina

Susan Shipman, Chief
Marine Fisheries Section
Georgia Department of Natural Resources
Brunswick, Georgia

State of Florida
Department of Community Affairs
Florida State Clearinghouse
Tallahassee, Florida

State of Florida
Department of Environmental Protection
Marjory Stoneman Douglas Building
Tallahassee, Florida

Suzanne P. Tarr
Florida Department of Environmental Protection
Florida Marine Research Institute
St. Petersburg, Florida

Traycie West
Virginia Department of Environmental Quality
Virginia Beach, Virginia

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Norfolk, Virginia

Mayor, City of Jacksonville
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Jacksonville, Florida

Dana Morton
City of Jacksonville
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St. Marys, Georgia

OTHER INTERESTED PARTIES

Gary Aldridge
In Defense of Animals
Shepherdstown, West Virginia

Peter Allan
Short Hills, New Jersey

Applied Ordnance Technology
Patuxent River Office
Attn: Dana Hall
Lexington Park, Maryland

Stephania Ascoli
Norfolk, Virginia

Nancy Azzam
American Cetacean Society
Golden Valley, Minnesota

BBN Corp.
Attn: Cola Atkinson
Arlington, Virginia

Marianie Balolong
Jacksonville University
Marine Science Department
Jacksonville, Florida

Susan Barco
Virginia Marine Science Museum
Virginia Beach, Virginia

Peter Barnett
VITRO Corporation
Section ESA12
Silverdale, Washington

Michael Bean
Chairman, Wildlife Program
Environmental Defense Fund
Washington, DC

Elizabeth Becker
Ogden Environmental
Santa Barbara, California

Jonah Bernier
Westport, Connecticut

Reverend Thomas P. Borland
Hodges Boulevard Presbyterian Church
Jacksonville, Florida

Greg Bryant
Vitro Corporation
Arlington, Virginia

Jim Burton
South Carolina Association for Marine Mammal Protection
Myrtle Beach, South Carolina

Cynthia Caldwell
EDAW
Niceville, Florida

Raymond C. Cavanagh
Vienna, Virginia

Ed Cherian
SAIC
Arlington, Virginia

David Clark
National Wildlife Federation
Chevy Chase, Maryland

Janet Clark
Science Applications International Corporation
San Diego, California

Jennifer Coates
Society for Animal Protective Legislation
Washington, DC

Cousteau Society
Attn: Clark Merriam
Chesapeake, Virginia

Christopher Croft
Defenders of Wildlife
Washington, DC

Mike D'Amico
Atlantic Biodiversity Center
Nassau, Delaware

Russell DeConti
Center for Coastal Studies
Provincetown, Massachusetts

Robert Deegan
Sierra Club
Virginia Beach, Virginia

Cathi Delisle
Mystic Mammalife Aquarium
Mystic, Connecticut

Adele Douglass
American Humane Association
Washington, DC

Muriel Ducloy
People for the Ethical Treatment of Animals
Norfolk, Virginia

Mary Duffy
Amelia Island Sea Turtle Watch, Inc.
Fernandina Beach, Florida

Dynamic Systems
c/o Alex Stone
Alexandria, Virginia

David S. Favre
Animal Legal Defense Fund
Detroit, Michigan

Larry Febrick
ETTCO
Seekonk, Massachusetts

Bridgette Fitzgerald
Bloomington, Indiana

Ari Friedlaender
Biological Sciences
University of NC at Wilmington
Wilmington, North Carolina

Tom Fryer
SRS Technologies
Washington Operations
Arlington, Virginia

Kathryn S. Fuller
President
World Wildlife Fund
Washington, DC

William W. Furr, Jr.
First Coast Fishing Club
Jacksonville Beach, Florida

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Cahn Wishod and Lamb
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Survivability Dept.
Arlington, Virginia

Quent Gillard
EDAW
Huntsville, Alabama

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Silver Spring, Maryland

Jeff Goodyear
Victoria, B.C. Canada

John C. Goold
University of Wales Bangor
School of Ocean Sciences
Menai Bridge
Gwynedd, United Kingdom

Charles Greene
Santa Barbara, California

Shane Guan
Grice Marine Biological Laboratory
University of Charleston
Charleston, South Carolina

Frances R. Guarnieri
Flagler County Sea Turtle Patrols
Palm Coast, Florida

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Delex Systems
Vienna, Virginia

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President
National Wildlife Federation
Washington, DC

Jannine Hamilton
Atlanta, Georgia

Katherine A. Hanly
Environmental Investigation Agency
Washington, DC

Morton H. Hanson
Beaches Sea Turtle Patrol, Inc.
Atlantic Beach, Florida

Donna Hart
International Wildlife Coalition
Elsberry, Missouri

Donna Hart
Marine Mammal Protection Coalition
Washington, DC

Jan Hartke
EarthKind USA
Washington, DC

Barbara Heffernan
Anheuser Busch
Washington, DC

Annie Ho
ICF
Fairfax, Virginia

Jason Holstine
Arlington, Virginia

Peter Hopford
Royal College of Defense Studies
London, United Kingdom

John Hotes
Ponte Vedra Beach, Florida

Penny Hudson
Madison, Alabama

Eric Isom
EG&G, WASC
Arlington, Virginia

Suzanne Iudicello
Vice President
Center for Marine Conservation
Washington, DC

Bruce Jaildagian
Ocean Advocates
New Smyrna Beach, Florida

Keith James
Norfolk, Virginia

Cecil J. Jenkins
Norfolk, Virginia

Carmelita Amelia Danzey (Jones)
c/o Curley Fields
Tallahassee, Florida

Susan Jordon
Manhatten Beach, California

E. Kalakauskis
Jacksonville Offshore Sport Fishing Club
Jacksonville, Florida

Ken Kasher
Jacksonville Beach, Florida

David Kastak
Long Marine Laboratory
Santa Cruz, California

Violet Kelly
Norfolk, Virginia

Dr. Darlene Ketten
Harvard Medical School
Boston, Massachusetts

Patricia Kilianski
Neptune Beach, Florida

Robert Krasko
Groundwater and Environmental Management Services (GEMS)
Neptune Beach, Florida

Lisa Lange
People for the Ethical Treatment of Animals
Norfolk, Virginia

Garry Leape
Greenpeace USA
Washington, DC

Cynthia Lebrun-Yaffe
Council for Compassionate Governance
Bethesda, Maryland

Tracy Leepart
Jacksonville University
Marine Science Department
Jacksonville, Florida

Jennifer Lewis
MSPCA
Boston, Massachusetts

Beth E. Libert
Volusia County Turtle Patrol, Inc.
Ponce Inlet, Florida

Ginger Liemohn
Huntsville, Alabama

Joanne Lowenstein-Whaley
Marineland, Inc.
Marineland, Florida

Sue Ellen Lowry
Sierra Club Legal Defense Fund
Washington, DC

Dr. Charles Malme
Engineering and Science Services
Hingham, Massachusetts

David A. Mann
University of Maryland
Department of Zoology
College Park, Maryland

Marine Acoustics
Attn: Dick Gallota
Arlington, Virginia

Marye K. Marshall
Volusia Sea Turtle Society
New Smyrna Beach, Florida

Dr. Marianne B. McEuen
Orange Park, Florida

Jamie McKee
SAIC
Shalimar, Florida

Clark Lee Merriam
The Cousteau Society
Chesapeake, Virginia

Tom Moliterno
International Fund for Animal Welfare
Yarmouth Port, Massachusetts

Priscilla Monti
WVEC-TV
Norfolk, Virginia

Dr. Sue Moore
SAIC Maritime Services Division
San Diego, California

Natural Resources Defense Council
Office Administrator
Washington, DC

Michael Newcomer
Montara, California

Sharon Newkirk
Port Angeles, Washington

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Jacksonville Beach, Florida

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Dolphin Project
Coconut Grove, Florida

Kata O'Connell
Humane Society International
West Hartford, Connecticut

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Neptune Beach, Florida

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Marine Science Department
Jacksonville, Florida

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Narragansett Bay Campus
Narragansett, Rhode Island

Mark Pfarrer
EG&G
Arlington, Virginia

Paul Pielmeier
ADI Technology Corp.
Arlington, Virginia

Susie Pike
University of California, San Diego
IGPP 0225
La Jolla, California

Elizabeth Pomfret
E. Falmouth, Massachusetts

Mike Posey
Norfolk, Virginia

R.E. Wright Co.
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Virginia Beach, Virginia

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St. Augustine, Florida

Tracy Reiman
People for the Ethical Treatment of Animals
Norfolk, Virginia

W. John Richardson
LGL Limited
King City, Ontario
Canada

Samantha Richman
Jacksonville University
Marine Science Department
Jacksonville, Florida

Nathaniel Riggins
President, Titustown Civic League
Norfolk, Virginia

Reverend Rene Robert
Diocese of St. Augustine Pax Christi
St. Augustine, Florida

Sarah Robinson
Environmental Services Inc.
Jacksonville, Florida

Dr. Naomi A. Rose
The Humane Society of the United States
Washington, DC

William Rossiter
Cetacean Society International
Ridgefield, Connecticut

C. Ruckdeschel
The Cumberland Island Museum
St. Marys, Georgia

Dr. Theodor C. Sauer
Battelle Memorial Institute
Duxbury, Massachusetts

Alice Scanlan
Virginia Marine Science Museum
Virginia Beach, Virginia

Allison Schaefers
Camden County Tribune
St. Marys, Georgia

Peter M. Scheifele, Director
Marine Education Programs/Bioacoustic Research
National Undersea Research Center
University of Connecticut
Avery Point Campus
Groton, Connecticut

Jim Sching
Jamesville, Maryland

D. J. Schubert
Fund for Animals
Silver Spring, Maryland

Sheila Sedberry
Jacksonville, Florida

Marie L.M. Sheen
Amelia Island Turtle Watch
Fernandina Beach, Florida

Maris Siden-Stecker
Seaside, California

SIO Library Mono
Scripps Inst of Oceanography
La Jolla, California

Jane M. Smith
Hodges Boulevard Presbyterian Church
Jacksonville, Florida

Tracey Snyder
Virginia Beach, Virginia

Pam Snyder
Virginia Beach, Virginia

Belkys Sosa
GCI
Silver Spring, Maryland

Brandon L. Southall
c/o Schusterman Project
Long Marine Laboratory UCSC
Santa Cruz, California

Sandy Stan
Ponte Vedra Turtle Patrol
Ponte Vedra Beach, Florida

Evelyn D. Stauber
St. Johns Wildlife Care
St. Augustine, Florida

Tony Stokes
Great Barrier Reef
Marine Park Authority
Townsville Old 4810
Australia

Richard Stradling
Daily Press
Newport News, Virginia

Richard Max Strahan
c/o Conservation Research Group
Boston College Law School
Newton, Massachusetts

Kim Strate
Jacksonville Offshore Sport Fishing Club
Atlantic Beach, Florida

Ron Summers
Atlantic Beach, Florida

Carrie Suter
Jacksonville University
Marine Science Department
Jacksonville, Florida

Betsy Swart
Friends of Animals
Washington, DC

Edward S. Syrjala
Centerville, Massachusetts

Tams Consultants, Inc.
Attn: Janet O'Neil
Arlington, Virginia

Ray Tarpley
Dept of Veterinary Anatomy & Public Health
College of Veterinary Medicine
Texas A&M University
College Station, Texas

Shirley Taylor
Chair, Sierra Club
National Marine Committee
Tallahassee, Florida

The Beaches Leader
Jacksonville Beach, Florida

The Florida Times Union
Jacksonville, Florida

The Southeast Georgia Newspapers
Kings Bay Advertisor
Kingsland, Georgia

The Virginian Pilot & Ledger Star
Norfolk, Virginia

The Washington Post
Washington, DC

Dr. Peter Tyack
Biology Dept
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

University of Southhampton
Attn: Mrs. P. Simpson
Head of Information Services
National Oceanographic Library
Southhampton, United Kingdom

Alan Walten
Environmental Law Offices
Oakland, California

Ronald R. Watson
Hanns Park
Jacksonville, Florida

Roger Weeder
WTLV - TV12
Jacksonville, Florida

Debbie Weiner
ASPCA
Washington, DC

Terri A. Whanger
Norfolk, Virginia

Lloyd Lee Wilson
Virginia Beach, Virginia

Pamela A. Wilson
Jacksonville, Florida

Richard E. Wilson
U.S. Navy, Retired
Wavemasters Society
Jacksonville, Florida

Peter Wood
Norfolk, Virginia

John H. Wright
Hopkins, Minnesota

Sharon Young
International Wildlife Coalition
Bourne, Massachusetts

George A. Young
Environmental Effects Consultants
Wheaton, Maryland

Ernest J. Young
Manassas, Virginia

APPENDIX B

MARINE MAMMALS, TURTLES, AND BIRDS

CONTENTS

APPENDIX B
MARINE MAMMALS, TURTLES, AND BIRDS

B.1 MARINE MAMMALS

B.1.1 Species Descriptions of Listed Marine Mammals

Based on a review of historical sighting records, six species of listed marine mammals may occur at the Mayport or Norfolk areas. These include five baleen whales (blue whale, fin whale, humpback whale, northern right whale, and sei whale) and one toothed whale (sperm whale).

Blue whales (*Balaenoptera musculus*) range from the Arctic to at least mid-latitudes including the waters of the Gulf of Mexico. This species is pelagic, primarily found feeding north of the Gulf of St. Lawrence during spring and summer. It is considered as a very occasional species in waters off the eastern U.S. (Blaylock et al., 1995). Limited migration has been documented south to subtropical waters during fall and winter. This species feeds on krill and copepods, the abundance of which most likely controls migration in and out of polar areas. Mating and calving occurs in late fall and winter. Gestation lasts 10 to 11 months. Calves are born every 2 to 3 years. Blue whales are usually seen solitary or in groups of 2 or 3 individuals. Existing data are insufficient for stock differentiation and population estimates in the Atlantic (Blaylock et al., 1995).

Fin whales (*Balaenoptera physalus*) range from the Arctic to the Greater Antilles, including the Gulf of Mexico. They are usually found inshore of the 2,000-m (6,562-ft) contour. This species occurs widely in the middle Atlantic throughout the year, with concentrations from Cape Cod north in summer and from Cape Cod south in winter. This species is frequently found along the New England coast from spring to fall in areas of fish concentration. It is thought that fin whales migrate north nearshore along the coast during spring and south offshore during winter. This species feeds on krill, planktonic crustaceans, and schooling fish such as herring and capelin. It is believed that fin whales breed in the middle Atlantic, with mating and calving occurring from November to March. Gestation lasts about 1 year and calves are suckled for 7 months. Fin whales off the eastern U.S. to Canada constitute a single stock (Blaylock et al., 1995). The minimum population estimate for this species in the western Atlantic was 1,704 individuals, based on a 1991-92 shipboard survey (Blaylock et al., 1995).

Humpback whales (*Megaptera novaeangliae*) range from the Arctic to the West Indies, including the Gulf of Mexico. They are found in middle Atlantic shallow coastal waters during spring and in waters around Cape Cod to Iceland during late spring to fall. During summer there are at least five geographically distinct feeding aggregations in the northern Atlantic. Generally, their distribution has been largely correlated to prey species and abundance (Blaylock et al., 1995). It is thought that migration south to the Caribbean occurs during fall. This species feeds largely on euphausiids and small fish such as herring, capelin, and sand lance. Calving and breeding occurs in the Caribbean from January to March. Gestation lasts 10 months and calves are suckled for about 11 months. Critical habitats have been identified in the western Gulf of Maine and the Great South Channel (Massachusetts). The minimum population estimate for the North Atlantic range of the humpback whale is 4,865 individuals (Blaylock et al., 1995).

Northern right whales (*Eubalaena glacialis*) range from Iceland to eastern Florida, with occasional sightings in the Gulf of Mexico. This is the rarest of the world's baleen whales, with a current North Atlantic population between 325 and 350 individuals (Kraus et al., 1993). Coastal waters of the southeastern United States (off Georgia and northeast Florida) are important wintering and calving grounds for northern right whales, while the waters around Cape Cod and Great South Channel are used for feeding, nursery, and mating during summer (Kraus et al., 1988; Schaeff et al., 1993). From June to September, most animals are found feeding north of Cape Cod. Northern right whale mating probably occurs during late summer; gestation lasts 12 to 16 months, and calves are suckled for about one year (Knowlton and Kraus, 1989). Southward migration occurs offshore from mid-October to early January, although northern right whales may arrive off the Florida coast as early as November and may stay into late March (Kraus et al., 1993). Migration northward along the coast of Florida takes place between early January and late March. Coastal waters off the Carolinas may represent a migratory corridor for this species (Winn et al., 1986; Kraus et al., 1993). It has been suggested that during the spring migration, northern right whales typically transit offshore North Carolina in shallow water immediately adjacent to the coast; fall migrations may occur further offshore in this region (Department of the Interior, Minerals Management Service, 1990). This species usually occurs shoreward of the 200-m (656-ft) contour line. Preferred water depths during recent surveys off the Florida coast range from 3 to 73 m (10 to 240 ft), with a mean of 12.6 m (41.3 ft) (Kraus et al., 1993).

Designated critical habitat for the northern right whale includes portions of Cape Cod Bay and Stellwagen Bank and the Great South Channel (off Massachusetts) and waters adjacent to the coasts of Georgia and northeast Florida (Federal Register 59(106):28793-28808). The southernmost critical habitat (**Figure B-1**) encompasses "waters between 31°15'N (i.e., near the mouth of Altamaha River, Georgia) and 30°15'N (i.e., near Jacksonville, Florida) from the shoreline out to 15 nautical miles offshore, and the waters between 30°15'N and 28°00'N (i.e., near Sebastian Inlet, Florida) from the shoreline out to 5 nautical miles."

Sei whales (*Balaenoptera borealis*) range from south of the Arctic to northeast Venezuela, including the Gulf of Mexico. This species is considered to be pelagic and widely distributed from below polar seas to the Caribbean. It is believed that the following three main stocks occur:
1) Newfoundland/Labrador; 2) Nova Scotia; and 3) Caribbean/Gulf of Mexico. The Nova Scotia stock migrates along the coast, with occurrence south of Cape Cod in winter and from Cape Cod north to the Arctic in summer. This species feeds on copepods, krill, and small schooling fish such as anchovies, sauries, and mackerel. Peak pairing is reported to be from November to February in temperate waters. Gestation lasts 1 year and calves are born in February in warmer waters. Calves are suckled for 6 months. Large numbers concentrate in feeding grounds but usually travel in groups of 2 to 5 individuals. Existing data are insufficient for obtaining estimates of population size in the Atlantic (Blaylock et al., 1995).

Sperm whales (*Physeter macrocephalus*) range from the Davis Straits to Venezuela, including the Gulf of Mexico. This species is pelagic, occurring along the continental shelf edge and slope, continuing into mid-ocean areas; it is occasionally found on the shelf. Sperm whales generally feed on mesopelagic (open ocean environment between 150 and 1,000 m [492 and 3,281 ft] depth) squid along the 1,000-m (3,281-ft) contour. North-south migratory routes observed through middle Atlantic areas are always inhabited. Females, calves, and juveniles remain south of 40°N to 42°N latitude throughout the year while mature males range to higher latitudes (68°N) during summer. This species is most abundant during spring. Mating season is prolonged, extending from late winter through early summer. Calves are born once every 3 to 6 years. Calving occurs between May and September in the northern hemisphere. Large, old males are solitary, while females, calves, and juveniles form "breeding schools" with 4 to 150 individuals. Young males form segregated bachelor groups, or "schools", of up to 50 individuals. The sperm whales which occur along the eastern U.S. represent only a fraction of the total stock. The nature of linkages of this habitat with others is unknown. Their minimum population estimate is 226 individuals (Blaylock et al., 1995).

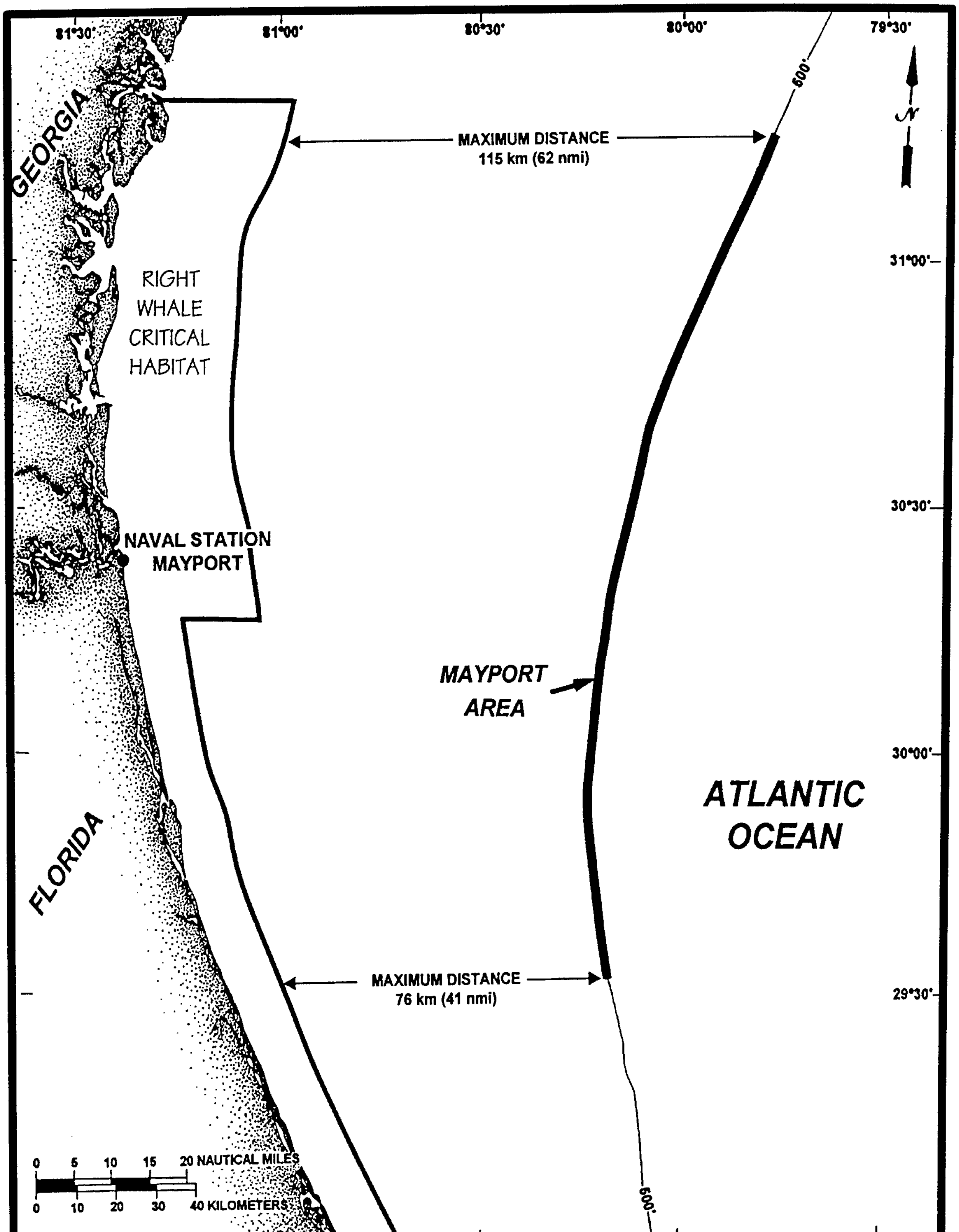


Figure B-1. Location of the northern right whale critical habitat in relation to the Mayport area.

B.1.2 Species Descriptions of Nonlisted Marine Mammals

Nonlisted marine mammals that may occur at the Mayport or Norfolk area include both baleen whales and toothed whales. This includes two nonlisted baleen whale species: minke whale and Bryde's whale. Both are rorquals (Family Balaenopteridae). In addition, 26 nonlisted toothed whale species may occur, including beaked whales (Superfamily Ziphioidea), pygmy and dwarf sperm whales (Superfamily Physeteroidea), dolphins (Family Delphinidae) and porpoises (Family Phocoenidae).

B.1.2.1 Baleen Whales

Minke whales (*Balaenoptera acutorostrata*) have a widespread distribution in polar, temperate, and tropical waters. There are four recognized minke whale populations in the North Atlantic. Minke whales off the U.S. eastern seaboard are considered part of the Canadian East Coast population which covers the area from the eastern half of the Davis Strait out to 45°W and south to the Gulf of Mexico (Blaylock et al., 1995).

Along the U.S. east coast, the minke whale is the third most common large whale in the region (Cetacean and Turtle Assessment Program [CETAP], 1982). Blaylock et al. (1995) noted a strong seasonal component to minke whale distribution, with widespread and common occurrence of this species off the eastern coast of the U.S. in spring and summer. Minke whales are observed north of Cape Cod in summer, commonly in nearshore waters of the Gulf of Maine and Bay of Fundy. Migrations occur northward during spring and southward in fall. It is believed that this species spends winter offshore of south Florida and the Lesser Antilles. Mitchell (1991) suggested a possible winter distribution in the West Indies and the mid-ocean south and east of Bermuda. Lee (1985a) indicated that minke whales may winter off the North Carolina coast, but are absent during other seasons. Manomet Bird Observatory (1989) recorded rare sightings of this species in summer, autumn, and winter (i.e., 2 to 5 individuals/100 transects) on the shelf north of Cape Hatteras. Sightings typically occur nearshore or within the 200-m (656-ft) contour. Like most other baleen whales, minke whales typically occupy the shelf proper, rather than the shelf edge (Blaylock et al., 1995). Preferred prey include herring, cod, salmon, capelin, squid, and shrimp (Leatherwood et al., 1976). Pairing is normally observed during October to March, coincident with calving. Gestation is about 10 to 11 months; nursing lasts for less than 6 months. It is believed that this species is more solitary though large groups have been observed. The minimum population estimate of minke whales in the eastern U.S./Canadian population is unknown (Blaylock et al., 1995). Minke whale abundance data acquired by shipboard surveys conducted during 1991-92 estimated 2,053 individuals (Blaylock et al., 1995).

Bryde's whales (*Balaenoptera edeni*) range from off the southeastern United States including the Gulf of Mexico, to the southern Caribbean Sea and Brazil (Leatherwood and Reeves, 1983). This species is found primarily in tropical and subtropical waters, and seldom occurs above 40°N except in warm-water (above 20°C [68°F]) projections northward. Bryde's whales are not thought to undergo long migrations. Some northward movements during summer and southward movements during winter have been observed and suggest pursuit of prey. This species typically inhabits nearshore waters and feeds on schooling fish such as sardines, mackerel, anchovies, and herrings. Bryde's whales are relatively uncommon. Information from South African waters suggests they breed year round.

B.1.2.2 Toothed Whales and Dolphins

Beaked Whales. There are six species of beaked whales which occur in the Mayport and Norfolk areas (Leatherwood et al., 1976; Blaylock et al., 1995), including Blainville's beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), Gervais' beaked whale (*M. europaeus*), Northern bottlenose whale (*Hyperoodon ampullatus*), Sowerby's beaked whale

(*M. bidens*), and True's beaked whale (*M. mirus*). The members of the genus *Mesoplodon* are difficult to identify to the species level at sea. Therefore, much of the available characterization for these species is to genus level only. Similarly, the elusive nature of *Mesoplodon* spp. has, to date, prevented the acquisition of sufficient data to determine specific population trends (Blaylock et al., 1995). Beaked whales are currently classified as a "strategic stock" by the National Marine Fisheries Service (NMFS) (Blaylock et al., 1995).

Blainville's beaked whales (*Mesoplodon densirostris*) range from Nova Scotia to Florida and the Bahamas, including waters of the Gulf of Mexico. This species is considered pelagic, inhabiting very deep waters. It is widely but sparsely distributed throughout tropical and warm temperate waters up to 45°N latitude in the western Atlantic due to the presence of the Gulf Stream (Leatherwood et al., 1976). Data suggest that Blainville's beaked whales feed on squid and live in family groups of 3 to 6 individuals. Little is known about the life history of this species.

Cuvier's beaked whales (*Ziphius cavirostris*) range from Massachusetts to the West Indies, including waters of the Gulf of Mexico. Stock structure in the northwestern Atlantic is unknown (Blaylock et al., 1995). As with other beaked whales, it is believed that this species inhabits pelagic waters and exhibits a wide distribution. Migration to higher latitudes during summer has been suggested. This species feeds primarily on squid and deep water fish, but is also known to eat crab and starfish. No marked breeding season is evident. It is believed that calving occurs year-round. Cuvier's beaked whales form family groups of about 15 individuals. Little is known about the life history of this species. Sightings from CETAP (1982) surveys indicate the presence of Cuvier's beaked whales over the shelf break throughout the middle Atlantic region, with highest sightings recorded for late spring and summer.

Gervais' beaked whales (*Mesoplodon europaeus*) are considered pelagic, and strandings have been reported from the Middle Atlantic Bight to Florida into the Caribbean and the Gulf of Mexico (Blaylock et al., 1995). Data suggest that the preferred prey of this species is squid.

Northern bottlenose whales (*Hyperoodon ampullatus*) are found only in temperate to arctic waters of the North Atlantic. They follow a relatively well-defined migratory pattern, and are found at low latitudes only during winter (Leatherwood and Reeves, 1983). They are deep divers and appear to feed primarily on squid and fish (Leatherwood and Reeves, 1983; Jefferson et al., 1993). They are characterized as extremely uncommon or rare in the northern Atlantic, and current data are insufficient to determine population size (Blaylock et al., 1995).

Sowerby's beaked whales (*Mesoplodon bidens*) are known only from temperate to subarctic waters of the North Atlantic, and data suggest that they are more common in European than American waters (Leatherwood and Reeves, 1983). As with other *Mesoplodon* spp., little is known of their life history (Blaylock et al., 1995).

True's beaked whales (*Mesoplodon mirus*) are a temperate water species that has been reported from Cape Breton Island, Nova Scotia to the Bahamas (Leatherwood et al., 1976). It is suggested that these whales are pelagic due to their infrequent stranding record. It is believed that True's beaked whales feed on squid as well as a variety of fish. As with other *Mesoplodon* spp., little is known about their life history.

Dwarf and Pygmy Sperm Whales. The pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia simus*) appear to be distributed worldwide in temperate to tropical waters along the continental shelf edge and continental slope (Blaylock et al., 1995). As in the case of beaked whales, pygmy sperm whales and dwarf sperm whales are difficult to distinguish and are typically categorized as *Kogia* spp. There is no information on Atlantic stock differentiation and population size for these species (Blaylock et al., 1995). However, results cited by Hansen and Blaylock (1994) for a 1992 survey in the South Atlantic indicated a *Kogia* spp. population (i.e., *K. breviceps*, and dwarf sperm whales [*K. simus*]) of 420 individuals. Estimates of abundance were derived from 1992 winter observations using line-transect techniques between Cape Hatteras, North Carolina and Miami, Florida. *Kogia* are rarely seen alive at sea, but they are among the most frequently stranded small whales in some areas (Jefferson et al., 1993), including the southeastern U.S.

Dolphins and Porpoises. The family Delphinidae is taxonomically diverse and includes dolphins, killer whales, false killer whales, pygmy killer whales, Risso's dolphins (or grampus), pilot whales, and melon-headed whales. In addition, one member of the family Phocoenidae, the harbor porpoise, may be present in the Norfolk area.

Atlantic spotted dolphins (*Stenella frontalis*) range from New Jersey to Venezuela, including waters of the Gulf of Mexico. This species is found in warm temperate and tropical waters. The Atlantic spotted dolphin inhabits the continental shelf and slope, though southern populations occasionally come into shallow coastal waters. Favored prey include herrings, anchovies, and carangid fish. Mating has been observed in July, with calves born offshore. Atlantic spotted dolphins often occur in groups of up to 50 individuals. Stock structure in the western North Atlantic is unknown. The minimum population estimate of 4,896 individuals was determined by the NMFS (in Blaylock et al., 1995).

Atlantic white-sided dolphins (*Lagenorhynchus acutus*) are found in temperate and sub-polar waters of the North Atlantic, and appear to prefer deep waters of the outer continental shelf and slope. This species ranges from central West Greenland to Chesapeake Bay. Population estimates from aerial surveys between Cape Hatteras, North Carolina and Nova Scotia (Canada) from 1978 to 1982 (CETAP, 1982) was 28,600 individuals. Minimum population estimates based on 1991-92 shipboard survey abundance data was 12,540 individuals (Blaylock et al., 1995).

Bottlenose dolphins (*Tursiops truncatus*) in the western Atlantic range from Nova Scotia to Venezuela, as well as the waters of the Gulf of Mexico (Hansen and Blaylock, 1994). This species is distributed worldwide in temperate and tropical inshore waters. Middle Atlantic populations are represented by a hematologically and morphologically distinct offshore stock and coastal stock (Duffield et al., 1983; Duffield, 1986; Hersh and Duffield, 1990; Hansen and Blaylock, 1994). Aerial survey results reported by CETAP (1982) and Kenney (1990) indicated the offshore stock extends along the entire shelf break from Georges Bank to Cape Hatteras during spring and summer. During fall, this distribution compressed towards the south, with fewer sightings in winter. According to Kenney (1990), the offshore stock is concentrated along the shelf break, extending beyond the shelf edge in lower concentrations. Peak average estimated abundance for the offshore stock occurred during fall and was estimated to be 7,696 individuals (Hansen and Blaylock, 1994). No abundance estimates are available for the offshore stock south of Cape Hatteras (Blaylock et al., 1995). Recent research has indicated that there are a variety of stock structures possible within the coastal Atlantic bottlenose dolphin population both north and south of Cape Hatteras. Blaylock and Hoggard (1994), reporting results from the Southeast Cetacean Aerial Survey (SECAS) study (i.e., continental shelf waters; Cape Hatteras, North Carolina to mid-Florida; Gulf of Mexico waters), developed abundance estimates for the shallow, warm water Atlantic bottlenose dolphin ecotype. The offshore distribution of coastal bottlenose dolphins south of Cape Hatteras has not been described. Blaylock and Hoggard (1994) noted, however, the possibility for coexistence of the coastal and offshore stocks inhabiting the edge of the outer continental shelf and slope waters south of Cape Hatteras. Bottlenose dolphins feed on shrimp and fish. Mating and calving occur from February to May in Florida waters. The calving interval is 2 to 3 years. They are found in groups of up to several hundred individuals with group sizes increasing with distance from shore.

Clymene dolphins (*Stenella clymene*) are widely distributed in subtropical and tropical waters of the Atlantic where they occur in the same geographic areas as *S. longirostris*. It is believed that this species lives over the deeper waters off the continental shelf (Blaylock et al., 1995). Little is known about its life history, and data on stock differentiation and population estimates in the Atlantic are not available (Blaylock et al., 1995).

Common dolphins (*Delphinus delphis*) range from Newfoundland and Nova Scotia to northern South America. They are distributed in worldwide temperate, tropical, and subtropical offshore waters on the continental slope, shelf, and shelf edge (Blaylock et al., 1995). According to Kenney and Winn (1987), CETAP (1982) results indicated the temporal presence of saddleback dolphins off the northeast U.S. coast in fall and winter, a trend which is the reverse of that exhibited by *Stenella* spp. and most other cetacean taxa, indicative of possible resource partitioning. The species is less common south of Cape Hatteras (Blaylock et al., 1995). Kenney and Winn (1987) also noted the possible co-occurrence of common dolphins with Atlantic spotted dolphins (*Stenella frontalis*). Common dolphins feed on epipelagic and mesopelagic fish, squid, and demersal fish (Kenney and Winn, 1987). Breeding is seasonal. Gestation lasts 10 to 11 months, with calves born in spring and fall. The minimum population estimate of 3,321 individuals was determined by the NMFS (in Blaylock et al., 1995).

Fraser's dolphins (*Lagenodelphis hosei*) are distributed worldwide in tropical waters. This species appears to be largely oceanic, with preferred prey including shrimp, fish, and squid. Fraser's dolphins are found in groups of up to 500 individuals. Little is known about the life history of this species. There is no information on stock differentiation and population size in the Atlantic (Blaylock et al., 1995).

False killer whales (*Pseudorca crassidens*) range from Maryland to Venezuela, including Gulf of Mexico waters. This species is distributed worldwide in tropical and temperate waters. False killer whales are generally considered to be oceanic but individuals have been observed in cool, nearshore waters. This species feeds on squid and fish. It is believed that mating occurs year round, with a gestation period of about 15 months. False killer whales are found in large groups composed of smaller family groups of 4 to 6 individuals. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

Killer whales (*Orcinus orca*) are characterized as uncommon or rare in waters of the western Atlantic. They are distributed from the Arctic pack ice to the Lesser Antilles, including waters of the Gulf of Mexico. Migration is thought to occur in association with changes in food abundance. Killer whales feed on squid, fish, sea turtles, seabirds, and other marine mammals. It is believed that mating occurs throughout the year, with gestation requiring about 1 year. Killer whales are found in groups ranging from a few to 25 to 30 individuals, where social structure and territoriality may be important. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

Melon-headed whales (*Peponocephala electra*) are distributed worldwide in tropical to sub-tropical waters (Blaylock et al., 1995). Melon-headed whales are highly social, and are known to occur in pods of 100 to 500 animals. They are often seen swimming with dolphin species and are known to feed on squid and small fish. There is some evidence to indicate a calving peak in July and August, but this evidence is inconclusive (Jefferson et al., 1993). There is no information on stock differentiation and population estimates in the Atlantic (Blaylock et al., 1995).

Pygmy killer whales (*Feresa attenuata*) range from North Carolina to the Lesser Antilles, as well as Gulf of Mexico waters. This species is distributed worldwide in tropical and warm temperate waters. Preferred prey includes small fish. Nocturnal feeding has been noted for this species. It is believed that calving occurs in spring. This species is typically found in groups of 10 individuals. Little is known about the life history of this species. Stock definition and population estimates in the Atlantic are unknown (Blaylock et al., 1995).

Short-finned pilot whales (*Globicephala macrorhynchus*) occur in the western Atlantic from New Jersey to Venezuela, as well as in waters of the Gulf of Mexico. This species is found worldwide in warm temperate and tropical waters. Sightings of pilot whales typically occur seaward of the continental shelf edge and within waters of the Gulf Stream (Blaylock et al., 1995). Little is known about migration. Preferred prey items include squid and fish. It is believed that this species has an extended breeding and calving season in warm waters. Short-finned pilot whales have been observed chasing and feeding on schools of tuna. There is no information on stock differentiation for the Atlantic population. Estimated abundance of pilot whales between Miami, Florida and Cape Hatteras, North Carolina, derived from a 1992 shipboard survey, was 749 individuals (Blaylock et al., 1995).

Long-finned pilot whales (*Globicephala melaena*) are distributed from Iceland to North Carolina. They are commonly found in both oceanic and certain coastal waters of the North Atlantic (Jefferson et al., 1993). The stock structure of the North Atlantic population is currently unknown (Blaylock et al., 1995).

Pantropical spotted dolphins (*Stenella attenuata*) range from Massachusetts to the Lesser Antilles, including waters of the eastern Gulf of Mexico. They are distributed worldwide in subtropical and tropical oceans. They appear to prefer waters of the continental slope (Blaylock et al., 1995). It is believed that this species feeds on squid, fish, and shrimp. This species is often found in association with schools of tuna. Pantropical spotted dolphins occur in groups of 5 to 30 individuals. Little is known about the life history of this species and no information exists on stock differentiation and current population estimates for the Atlantic population (Blaylock et al., 1995).

Risso's dolphins (*Grampus griseus*) range from eastern Newfoundland to the Lesser Antilles and Gulf of Mexico. This species is distributed worldwide in tropical to temperate waters. It is believed that Risso's dolphins undergo north-south, summer-winter migrations. Off the northeast U.S. coast, Risso's dolphins are distributed along the shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and fall (CETAP, 1982; Payne et al., 1984). In winter, this species ranges further offshore (Blaylock et al., 1995). Typically, this species occupies the continental shelf edge year-round. This species feeds mainly on squid. Risso's dolphins are found in groups of 3 to 30 individuals, although groups of up to several hundred individuals have been reported. Total numbers of Risso's dolphins off the eastern U.S. coast are unknown. CETAP (1982) survey results indicated a population estimate of 4,980 individuals. Current data are insufficient to determine stock differentiation and population trends in the Atlantic. This species is considered a "strategic stock" under the Marine Mammal Protection Act (Blaylock et al., 1995).

Rough-toothed dolphins (*Steno bredanensis*) are distributed worldwide in tropical to warm temperate waters (Blaylock et al., 1995). Within the western Atlantic they range from Virginia and North Carolina to northeastern South America, including eastern and northwestern Gulf of Mexico waters (Leatherwood and Reeves, 1983). This species is pelagic and usually found seaward of the continental slope edge. Little is known about the life history of this species and no information exists on stock differentiation and population levels in the Atlantic (Blaylock et al., 1995).

Spinner dolphins (*Stenella longirostris*) range from North Carolina to southern Brazil, including Gulf of Mexico waters. Though presumably an offshore, deep-water species, they occur in both oceanic and coastal tropical waters (Blaylock et al., 1995). Two reproductive peaks in spring and fall have been suggested. Stock structure and population estimates of spinner dolphins in the western North Atlantic is unknown (Blaylock et al., 1995).

Striped dolphins (*Stenella coeruleoalba*) range from Nova Scotia to the Lesser Antilles, including the Gulf of Mexico. These dolphins are distributed worldwide in temperate and tropical waters. This species is considered to be found along the continental slope from the Gulf of Mexico to Georges Bank. Migratory patterns are uncertain. There is no information on stock differentiation and population size in the Atlantic (Blaylock et al., 1995).

Harbor porpoises (*Phocoena phocoena*) are found in cool temperate and subpolar waters of the Northern Hemisphere. They are typically found in shallow water, most often nearshore, although occasionally travel over deeper offshore waters (Jefferson et al., 1993). During summer, harbor porpoises are concentrated in Canada and the northern Gulf of Maine. During fall and spring, they are widely distributed from Maine to North Carolina (Blaylock et al., 1995). The minimum population estimate was 40,345 individuals (Blaylock et al., 1995).

B.1.2.3 Pinnipeds

Harbor seals (*Phoca vitulina*) are widely distributed from temperate to polar regions of the Northern Hemisphere. Along the eastern U.S. they are found from the Canadian Arctic to the mid-Atlantic (Jefferson et al., 1993). At sea, they are mainly found in coastal waters of the continental shelf and slope.

B.1.3 Summary of 1995 and 1997 Aerial Surveys

Between April and September 1995, six aerial surveys of the Mayport and Norfolk areas were completed to estimate the density of marine mammals and sea turtles. Five additional surveys were flown at the Mayport area from May through September 1997. Survey data were used to support development of the EIS and associated permit requests. Detailed methods and results are presented in the survey reports (Department of the Navy, 1995b, 1998). An overview is presented in the following sections.

B.1.3.1 Survey Locations and Dates

The two areas lie along the 152 m (500 ft) depth contour within a 185 km (100 nmi) radius of naval facilities at Mayport, Florida and Norfolk, Virginia (**Figures B-2** and **B-3**). Along the Atlantic coast in these areas, this bathymetric contour represents the continental shelf edge (Abernathy, 1989).

Within the Norfolk survey area, the northern limit was established just south of the proposed Norfolk Canyon National Marine Sanctuary [National Oceanic and Atmospheric Administration (NOAA), 1990]. The sanctuary and the area to the north were excluded due to environmental concerns with the sanctuary waters and the presence of a number of shipwrecks. The survey area thus extended from latitude 36°56.00'N to 35°41.00'N. All survey flights were staged from the Elizabeth City-Pasquotank County Municipal Airport, Elizabeth City, North Carolina.

The Mayport survey area extended from latitude 31°25.00'N to 29°01.00'N. All survey flights were staged from the Glynco-Taj Jetport in Brunswick, Georgia.

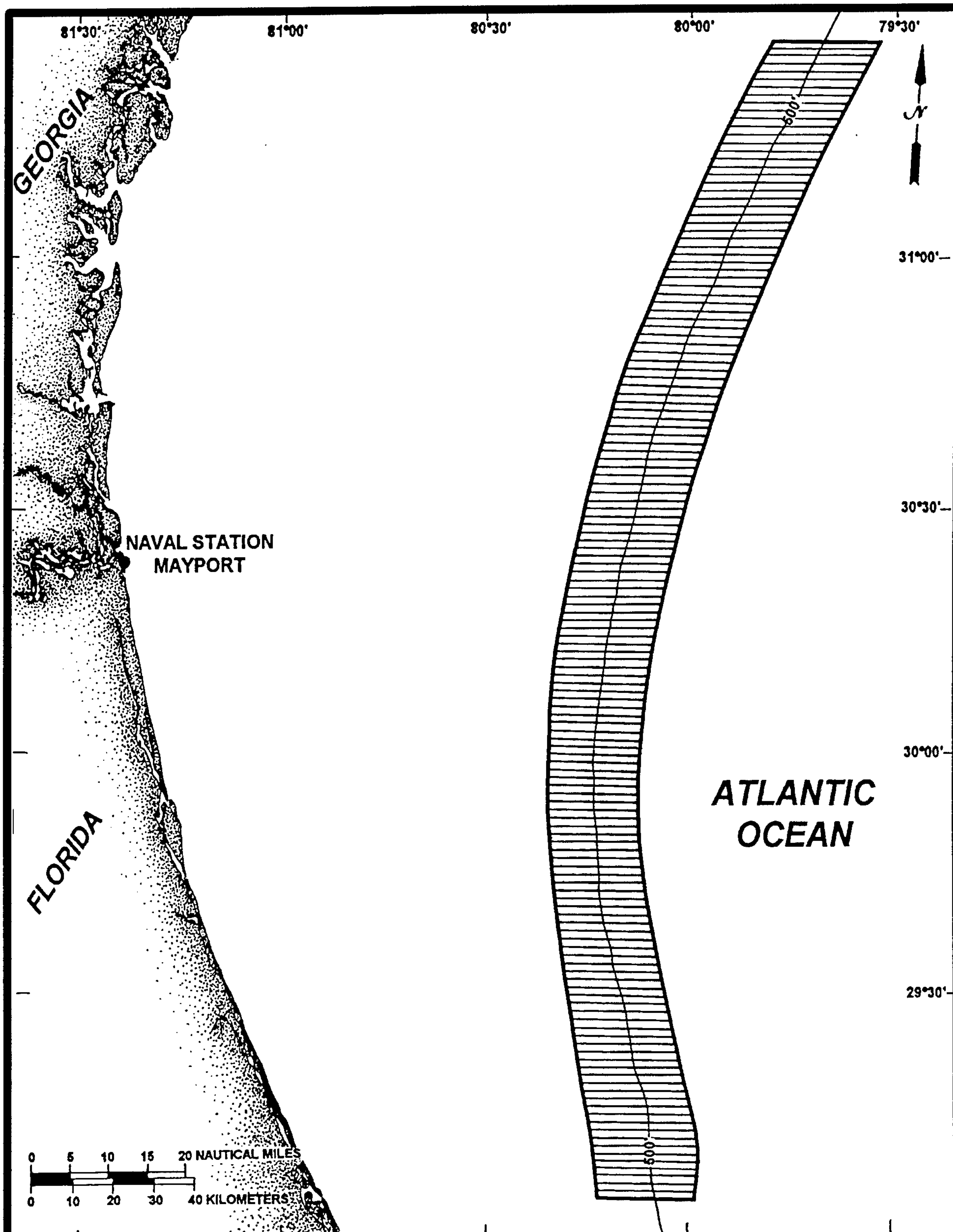


Figure B-2. Location of Mayport aerial survey area showing transects relative to the 152 m (500 ft) depth contour.

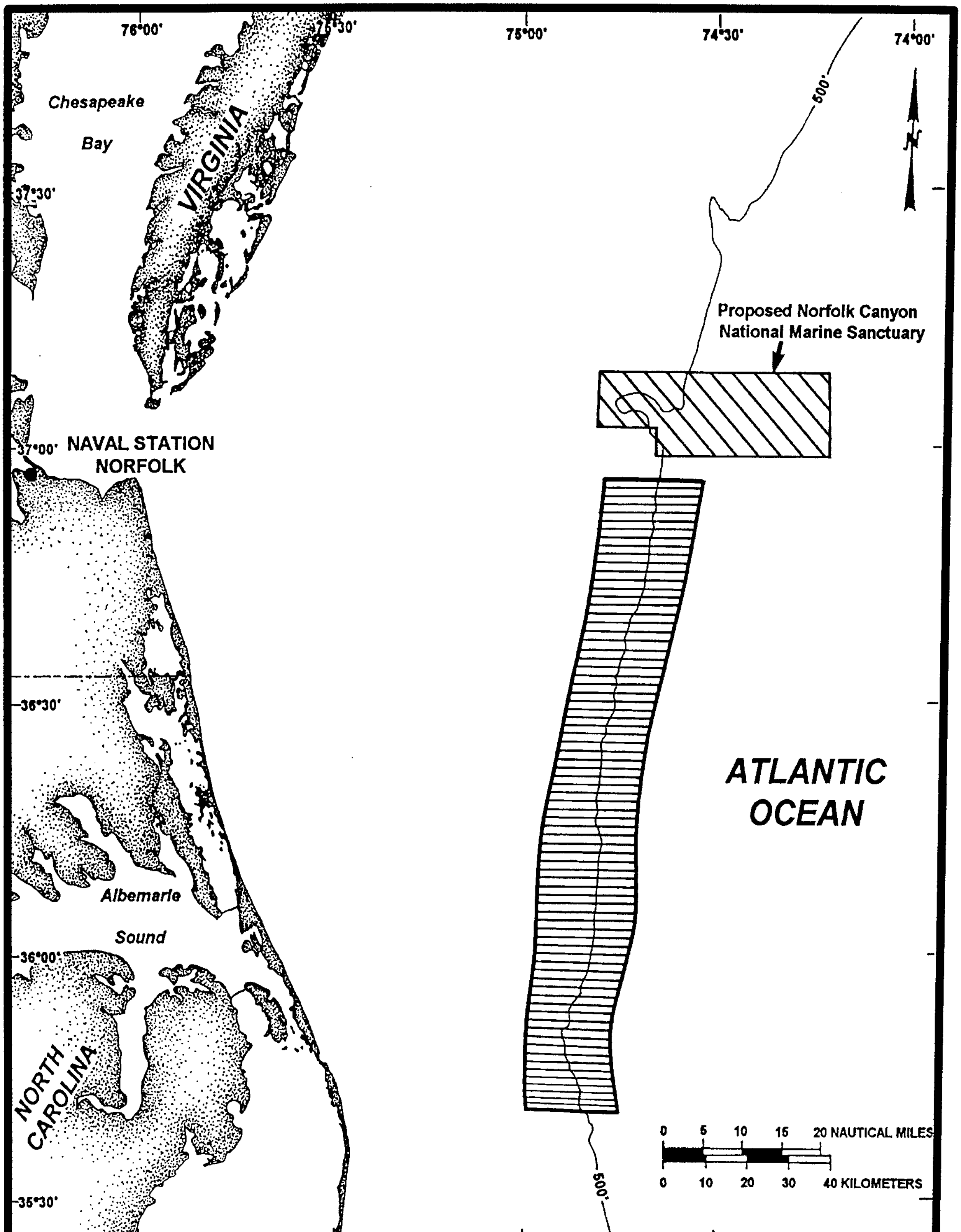


Figure B-3. Location of Norfolk aerial survey area showing transects relative to the 152 m (500 ft) depth contour.

Survey dates for the 1995 Norfolk and Mayport areas were as follows:

Survey	Norfolk Dates	Mayport Dates
1	April 7-9, 1995	April 11-18, 1995
2	May 11-16, 1995	May 18-26, 1995
3	June 12-15, 1995	June 17-25, 1995
4	July 11-13, 1995	July 15-21, 1995
5	August 3-5, 1995	August 7-14, 1995
6	September 6-9, 1995	September 11-19, 1995

Dates for the 1997 Mayport surveys were May 6-15, June 11-17, July 8-16, August 6-14, and September 13-18.

B.1.3.2 Survey Methods

Standard aerial transect surveying methods for marine mammals and sea turtles, as developed and approved by the NMFS, were adopted for the surveys (Blaylock, 1994). These methods use observers on both sides of the survey aircraft who, along predetermined transect lines, scan a swath of sea surface which is limited only by the effective angle of view from the aircraft's viewing port or window, and sea state. During 1995, the total area viewed during each survey was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area. During 1997 Mayport surveys, the total area viewed was larger (3,551 km^2 or 1,035 nmi^2) due to the use of a Partenavia aircraft with bubble windows that eliminated the "blind spot" beneath the plane (see explanation below).

Survey transects within the two survey areas were set up from east to west and with 1.85 km (1 nmi) line spacing, using current NOAA bathymetric maps and navigation charts. Based upon the limitations of fuel which could be carried by the survey aircraft, transit and per transect flight time, number of transects per survey area, estimates of time allotted for orbiting groups of animals, and expected observer fatigue, it was calculated that approximately 25 transects could be completed in one day. Therefore, the Norfolk survey area required about three days for completion and the Mayport survey area about six days for completion.

During the 1995 surveys, a Cessna C-337G Skymaster twin-engine aircraft, provided by Aero-Marine Surveys, Inc. (New London, Connecticut), was used as the survey platform (**Figure B-4**). A Partenavia aircraft was used for the 1997 Mayport surveys. A portable computer was interfaced with the onboard LORAN C receiver to collect navigation and supplemental survey data at one minute intervals while on transect. Navigation data included aircraft location (latitude and longitude), speed, course, and altitude. Supplemental data included survey area, transect number, estimates of weather conditions, sea state, and water clarity, and the extent of visual hindrance resulting from sunlight glare on the sea surface. An onboard radiation thermometer was also interfaced with the onboard computer to collect sea surface temperature data at each navigation fix (Thompson and Shoop, 1983; Schroeder and Thompson, 1987). The LORAN receiver was calibrated against an onboard Global Positioning System (GPS) receiver prior to each survey flight. This calibration was done at the same position on the airport taxiway each day. Similarly, the onboard radiation thermometer was calibrated using water tanks of known temperatures subsequent to each survey flight.

According to NMFS, the standard altitudes for marine mammal and sea turtle surveys are 229 m (750 ft) and 152 m (500 ft), respectively (Hoggard, 1994; Mullin, 1994). It was suggested that the surveys be conducted at an altitude of 198 m (650 ft), an altitude which is considered by NMFS as the

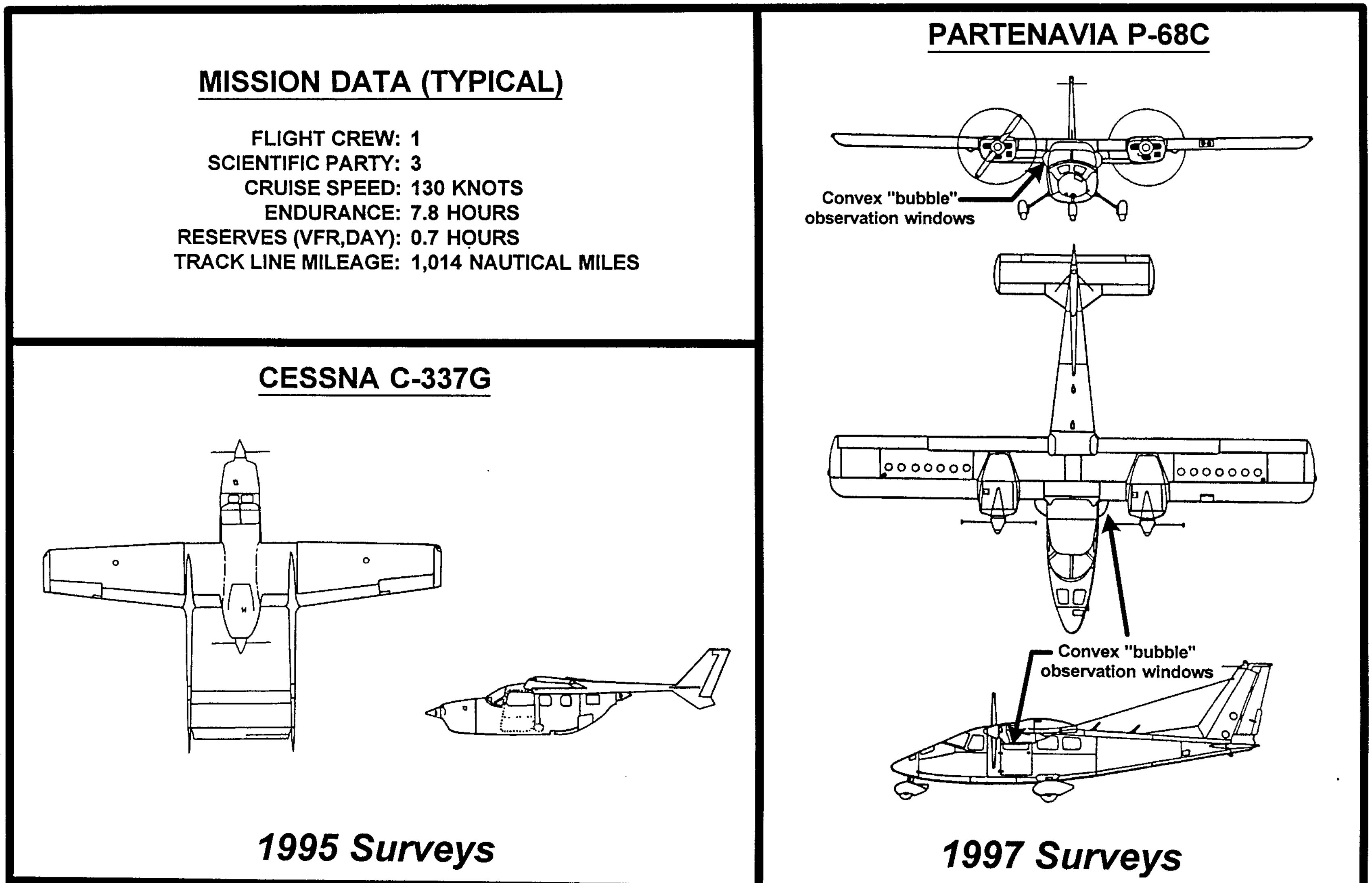


Figure B-4. Survey aircraft.

optimum compromise when conducting simultaneous surveys for both marine mammals and sea turtles. However, based on further discussions between the Navy and NMFS, it was decided that conducting the combined aerial survey at an altitude of 229 m (750 ft) was acceptable. Therefore, all transects were surveyed at an altitude of 229 m (750 ft) and a speed of 127 mi/h (110 kt).

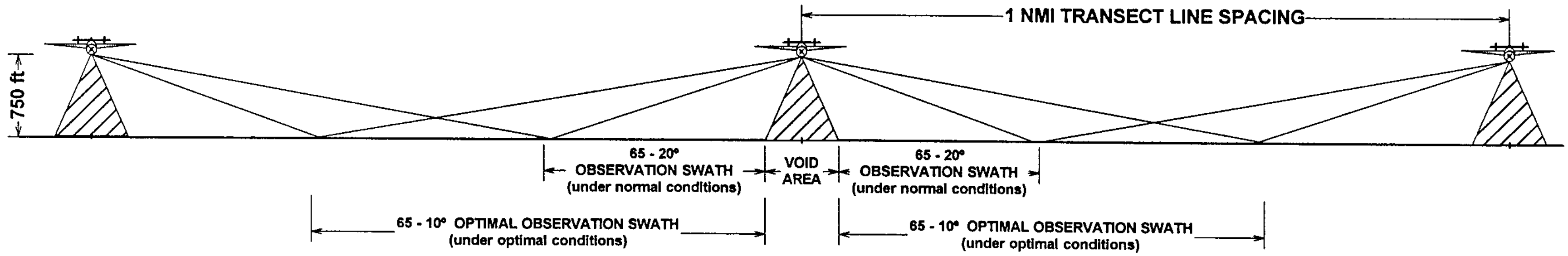
Surveys were generally conducted between 0800 and 1500 h for maximum light penetration below the sea surface. Two observers were seated in the rear of the aircraft, using the forward and second side windows for scanning. The data logger sat opposite the pilot. This method is commonly used by NMFS during aerial surveys (NMFS, 1991, 1992). Along each survey transect, the observers continually scanned the sea surface in a roughly circular pattern. This strategy allowed for observation of distant sea surface disturbances caused by marine mammals, approaching animals, and detailed close up views abeam and abaft the beam of the aircraft.

For the 1995 surveys, the effective sighting angles from the aircraft while on transect are shown in **Figure B-5**. The horizontal sighting angle was approximately 90°, or 45° forward and aft of the beam. The vertical and horizontal width of the transect swath varied inversely with local sea state conditions and sunlight glare; that is, observers tended to narrow their scan when sea conditions increased or during conditions of glare hindrance. As shown in Figure B-5, a substantial visual overlap between transects was attained during periods of low sea state and glare.

During the 1995 surveys, there were "blind areas" below the aircraft, shown as shaded voids on Figure B-5. The effective vertical sighting angles, or visual transect swath, was approximately 45 to 65°. During the 1997 surveys, the blind spot was eliminated because the bubble windows on the Partenavia aircraft allowed observers on both sides to see beneath the plane. Accordingly, the total area viewed during each Mayport survey was about 20% greater during the 1997 surveys. Density calculations took this difference into account (see below).

When an individual animal or group of animals was sighted, the observer would determine the perpendicular sighting distance of the sighting using a hand-held inclinometer (Suunto Model PM-5) (Musick et al., 1987; Barlow et al., 1988; Forney et al., 1991; Blaylock and Hoggard, 1994). Using the aircraft's intercom, the observer would then request a navigation fix, state animal type and approximate group number, and request, if deemed necessary for the determination of species identification(s), that the aircraft break transect and circle (i.e., orbit) for a closer examination. The pilot would, in the case of nonendangered marine mammals, lower altitude to approximately 183 m (600 ft) and return to the sighting fix. The marine mammal group in question was orbited until the identification of species was made and an accurate number of individuals assessed. Endangered marine mammals were, if possible, identified while on transect, or circled once at the survey altitude of 229 m (750 ft). Observations of individual or group behavior were also made during this time. Data relating to each sighting, along with exact location of the aircraft, transect number, observer, and location of the sighting in relation to the aircraft, were recorded onto data sheets by the data logger. After identification, the aircraft returned to the previous break position on the transect line and continued to survey.

Aerial surveys were usually conducted at a Beaufort sea state of 3 or less, which allows for the most accurate sighting and identification of individual marine mammals or sea turtles. Surveys were typically suspended when the Beaufort sea state exceeded 3 during the transit to the survey area or during the course of the survey.



Note: There was no void area beneath the plane during the 1997 surveys, due to use of a different aircraft (Partenavia).

Figure B-5. Transect observation swaths from survey aircraft under normal and optimal sighting conditions. Distances to scale.

B.1.3.3 Permits

All aerial surveys were conducted under the appropriate permits and authorizations or with specific permission from NMFS.

B.1.3.4 Numbers of Marine Mammals Seen

Table B-1 lists the number of marine mammals of each species seen during each 1995 aerial survey. A total of 1,303 individuals were seen at Mayport and 4,438 individuals were seen at Norfolk. Numbers should not be compared directly because of the difference in total area surveyed. Also, the April survey data for Mayport were not used to calculate mean densities because shock testing would not occur during April at Mayport. Standardized density estimates are discussed below.

Table B-2 lists the number of marine mammals of each species seen during each 1997 aerial surveys at Mayport. A total of 1,485 individuals were seen at Mayport during the May through September surveys. Numbers should not be compared directly with the 1995 data because of the difference in total area surveyed. Standardized density estimates are discussed below. **Figure B-6** shows the numbers of marine mammals along each transect during each of the 1997 surveys (similar figures for the 1995 surveys are shown in Section 3.0 of the FEIS).

Comparison of the Mayport surveys during 1995 and 1997 shows both similarities and differences. No mysticetes (baleen whales) were seen at Mayport during either year. All of the species seen at Mayport during 1995 were also seen during 1997. However, two additional species (pilot whale and rough-toothed dolphin) were seen during the 1997 surveys only; both species were listed in the DEIS as potentially occurring at Mayport. Only a few pantropical spotted dolphins were seen in 1997, in contrast with 1995 when this was the most abundant species. Conversely, bottlenose dolphins were much more abundant in the 1997 surveys.

B.1.4 Adjustment of Marine Mammal Densities for Submerged and Undetected Individuals

Mean observed densities for May-September at Mayport and April-September at Norfolk were calculated by dividing the total number of individuals by the number of surveys, then dividing by the total area viewed during a survey. For each of the 1995 surveys, the total area viewed was 2,948 km^2 (858 nmi^2) at the Mayport area and 1,470 km^2 (428 nmi^2) at the Norfolk area. For each of the 1997 surveys, the total area viewed was 3,551 km^2 (1,035 nmi^2).

Aerial surveys typically underestimate the true density because some animals are submerged and therefore not available to be seen (availability bias) and others may be present on the surface but missed by observers (perception bias) (Marsh and Sinclair, 1989). Adjusted densities were developed for each species seen during the surveys to correct for these two sources of bias.

B.1.4.1 Availability Bias

To correct for availability bias, raw densities can be divided by the proportion of time the animal is likely to be present on the surface within the viewing range. For example, if a species is submerged 50% of the time, the raw density would be divided by 0.5, effectively doubling the density estimate. For species with long dive times, the simplest estimate is the mean proportion of time the animal spends at the surface. However, for species with short dive times and surface intervals, the time within the range of the aerial observer becomes a significant factor. Based on the sighting angle, altitude, and aircraft speed, a given point on the sea surface would be within visual range for at least 10 seconds. The probability of being on surface during this interval (t) is given by Eberhardt et al. (1979) and Barlow et al. (1988) as follows:

Table B-1. Numbers of marine mammals seen during 1995 aerial surveys (From: Department of the Navy, 1995b).

Species	1995 Mayport Surveys							1995 Norfolk Surveys						
	1 (Apr)	2 (May)	3 (Jun)	4 (Jul)	5 (Aug)	6 (Sep)	Total	1 (Apr)	2 (May)	3 (Jun)	4 (Jul)	5 (Aug)	6 (Sep)	Total
MARINE MAMMALS														
Baleen Whales														
Fin whale (E)	0	0	0	0	0	0	0	0	40	5	1	0	0	46
Humpback whale (E)	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Minke whale	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Sei whale (E)	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Sei/Bryde's whale	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Unidentified *Balaenoptera*	0	0	0	0	0	0	0	0	11	1	0	0	0	12
Unidentified baleen whale	0	0	0	0	0	0	0	0	2	2	0	0	0	4
Toothed Whales and Dolphins														
Atlantic spotted dolphin	79	0	11	24	42	0	156	0	345	353	8	113	5	824
Bottlenose dolphin	167	0	0	63	5	10	245	0	78	14	0	183	239	514
Bottlenose/Atlantic spotted dolphin	0	0	15	0	11	0	26	0	26	0	6	32	0	64
Clymene/spinner/striped dolphin	25	0	0	16	3	0	44	187	8	0	0	50	0	245
Common dolphin	0	0	0	0	0	0	0	0	60	0	250	0	0	310
Cuvier's beaked whale	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Pantropical spotted dolphin	158	142	23	0	14	50	387	0	95	155	85	100	0	435
Pilot whale[a]	0	0	0	0	0	0	0	0	64	174	721	414	3	1376
Risso's dolphin	20	146	6	9	14	0	195	12	22	0	0	85	0	119
Sperm whale (E)	0	2	0	0	0	0	2	4	0	0	0	0	0	4
Spinner dolphin	0	0	0	50	0	0	50	62	0	0	0	0	0	62
Striped dolphin	0	0	0	0	0	0	0	24	0	0	0	0	0	24
Unidentified dolphin	10	48	43	52	35	10	198	101	90	140	0	30	25	386
Unidentified small whale	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Total Marine Mammals:	**459**	**338**	**98**	**214**	**124**	**70**	**1303**	**390**	**846**	**847**	**1071**	**1007**	**277**	**4438**

(E) = endangered species.

[a] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

Table B-2. Numbers of marine mammals seen during 1997 aerial surveys at Mayport (From: Department of the Navy, 1998).

Species	1997 Mayport Surveys					
	1 (May)	2 (Jun)	3 (Jul)	4 (Aug)	5 (Sep)	Total
MARINE MAMMALS						
Baleen Whales	0	0	0	0	0	0
Toothed Whales and Dolphins						
Atlantic spotted dolphin	4	0	35	7	32	78
Bottlenose dolphin	71	2	83	104	330	590
Bottlenose/Atlantic spotted dolphin	0	0	161	0	0	161
Clymene/spinner/striped dolphin	0	65	25	55	0	145
Pantropical spotted dolphin	4	0	0	0	0	4
Pilot whale[a]	20	0	0	0	0	20
Risso's dolphin	63	39	79	74	5	260
Rough-toothed dolphin	13	0	0	0	0	13
Sperm whale (E)	0	0	0	2	0	2
Spinner dolphin	0	45	0	0	0	45
Unidentified dolphin	98	7	29	31	2	167
Total Marine Mammals:	**273**	**158**	**412**	**273**	**369**	**1485**

(E) = endangered species.

[a] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

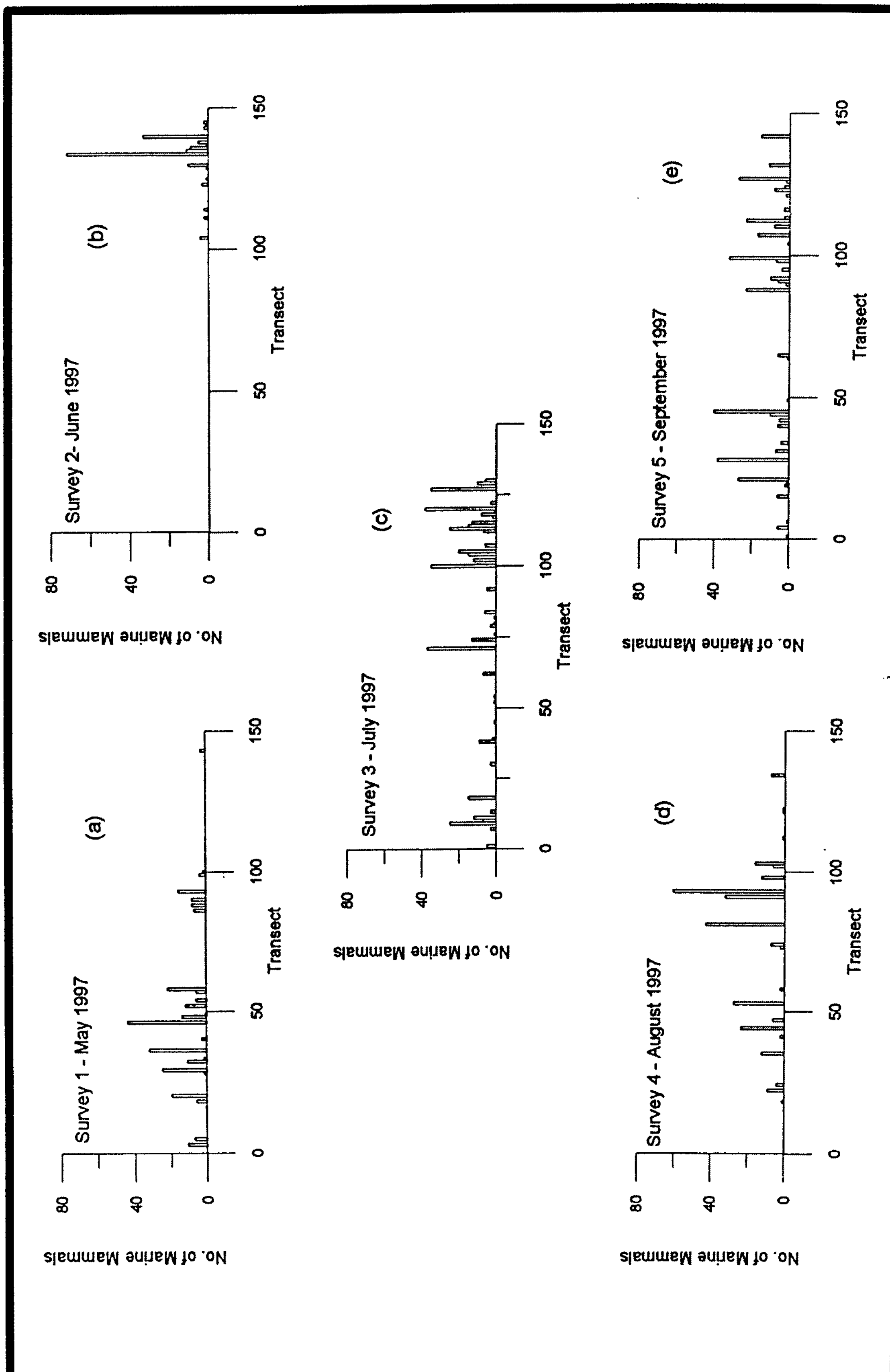


Figure B-6. Marine mammal abundance along individual transects at the Mayport area during 1997 aerial surveys (Data from: Department of the Navy, 1998).

$$S_t = (s + t)/(s + d)$$

where S_t = probability of being on surface within the aerial viewing interval (t); s = mean surface time; and d = mean dive time.

Several investigators have studied the problem of availability bias for whale sightings from vessels (Doi, 1974; Leatherwood et al., 1982; Stern, 1992). However, most of these data are not directly usable to correct aerial survey data because they rely on conspicuous surface behavior such as blows. Aerial detection is not restricted to the time of a blow and could cover considerably longer time intervals. The most useful data would be correction factors developed specifically from or for aerial observations (CETAP, 1982; Barlow et al., 1988; Calambokidis et al., 1989; Hain and Ellis, 1996; Barlow and Sexton, 1996). Telemetric data from tagged individuals has been used to estimate dive times and surface intervals in some marine mammals (Evans, 1974; Mate et al., 1987, 1994).

Table B-3 lists surface probabilities for various marine mammals. S_t values range from 0.07 to 0.83. For most species, only one estimate is available from limited observations. In reality, there could be large variations within a species depending on geographic location, water depth, individual size, sex, social context (group vs. individual), activity pattern (feeding vs. traveling, etc.) and other factors. For example, the behavior of many baleen whales typically includes several short dives during surface activity bouts, followed by a longer dive.

Because data are not available for many of the species seen during the 1995 and 1997 aerial surveys, and because the data for individual species are so limited, assigning species-specific probabilities does not seem justified. Instead, probabilities are assigned by category, with exceptions only where data from two or more sources support a higher or lower number.

- Baleen whales: 0.1 is a conservative value. A higher value of 0.2 was used for humpback whales (as used in the DEIS) is conservative based on data from CETAP (1982) and Calamobokidis et al. [1989; cited in Forney et al. (1995)]. Northern right whales would also have a much higher probability based on both CETAP (1982) and Hain and Ellis (1996), but no value is assigned because no right whales were seen during 1995 or 1997 aerial surveys.
- Sperm whale: 0.1 is a conservative value. According to Barlow and Sexton (1996), "the proportion of time spent during surfacing series is relatively constant at 17%" despite a wide range of dive times. This is based on Caldwell et al. [1966, as cited in Leatherwood et al. (1982)] and Gordon and Steiner (1992).
- Beaked whales: 0.07 is assigned based on Barlow and Sexton (1996) data for Cuvier's beaked whale, the only species seen during the aerial surveys.
- Dolphins and porpoises: 0.2 is a very conservative value for the group as a whole, based on Evans (1971, 1974), Barlow et al. (1988), and Mate et al. (1987, 1994).

B.1.4.2 Perception Bias

The second source of error is perception bias, which refers to animals which are present on the surface but not detected by aerial observers. For strip transect surveys, it is usually assumed that all individuals within an observed swath are detected. For the SEAWOLF surveys, it was assumed that some proportion of the surface population is detected and that this proportion is constant within the optimal viewing swath.

Based on the experience of the observers, species with large individuals (greater than 7.6 m or 25 ft) and species that tend to occur in large herds, would almost certainly be detected under the survey conditions. Small species (less than 1 m or 3 ft in length) and those that occur mainly as solitary

Table B-3. Probability of various marine mammal species being on the surface (i.e., available for aerial detection) rather than submerged. See text for explanation.

Species	Mean or median dive time (d) (minutes)	Mean or median surface time (s) (minutes)	Proportion of time on surface [s/(s+d)]	Probability of being on surface within viewing interval[a] (s+t)/(s+d)	Source
BALEEN WHALES					
Blue whale	4.25	2	0.32	0.35	Lockyer (1976) cited in Leatherwood et al. (1982)
Bryde's whale	5	1	0.17	0.19	Rice (1979) cited in Leatherwood et al. (1982)
Fin whale	2.89	0.22	0.07	0.12	Kopelman and Sadove (1995)
	2.38	0.86	0.25	0.32	CETAP (1982)
Humpback whale	?	?	0.37	0.37	Calambokidis et al. (1989) cited in Forney et al. (1995)
	1.53	0.69	0.28	0.39	CETAP (1982)
Minke whale	1.585	0.05	0.03	0.13	Stern (1992)
	10.25	2.4	0.19	0.20	Leatherwood et al. (1982)
Northern right whale					
- mother/calf pair	2.00	6.62	0.77	0.79	Hain and Ellis (1996)
- surface active group	1.21	4.22	0.78	0.81	
- single juvenile	3.15	1.82	0.36	0.40	
	5.38	2.55	0.34	0.34	CETAP (1982)
Sei whale	1 (0.03-11)	(0.017)	0.017	0.18	Schilling et al. (1992). No data on surface time; assumed 1 second (0.017 minutes) for calculation

Table B-3. (continued)

Species	Mean or median dive time (d) (minutes)	Mean or median surface time (s) (minutes)	Proportion of time on surface [s/(s+d)]	Probability of being on surface within viewing interval[a] (s+t)/(s+d)	Source
TOOTHED WHALES AND DOLPHINS					
Beaked Whales					
Cuvier's beaked whale	28.6	2.1	0.07	0.07	Barlow and Sexton (1996)
Mesoplodon spp.	20.7	2.7	0.12	0.12	Barlow and Sexton (1996)
Sperm Whales					
Sperm whale	20	4	0.17	0.17	Caldwell et al. (1966) cited in Leatherwood et al. (1982); Gordon and Steiner (1992)
Kogia spp.	8.6	1.2	0.12	0.14	Barlow and Sexton (1996)
Dolphins and Porpoises					
Atlantic white-sided dolphin	0.65	0.08	0.11	0.34	Mate et al. (1994)
Bottlenose dolphin	0.40	(0.017)	0.04	0.44	Dive times from Shane (1990). No data given for surface time; assumed 1 second for calculation
Common dolphin	0.20	(0.017)	?	0.83	Evans (1971). Mean dive time from respirations per minute during midmorning and midafternoon. No data on surface time; assumed 1 second (0.017 minutes) for calculation
Harbor porpoise	1.60	0.50	0.24	0.31	Barlow et al. (1988)
Pilot whale	0.87	0.32	0.27	0.41	Evans (1974)
	(0.87)	?	0.10	0.27	Mate et al. (1987). Mean dive and surface times not provided. Assumed mean dive time of 0.87 minutes from Evans (1974)

[a] Time (t) within viewing range during 1995 aerial surveys is estimated to be at least 10 seconds (0.167 minutes) based on aircraft speed, altitude, and forward and aft viewing angles.

individuals were considered to have a low probability of detection. Therefore, a scale was developed between these two extremes. Aerial detection probabilities (ADP) were estimated based on animal length and herding tendencies. Each species was scored using the following scales:

Length	Herding
0 = <1 m (<3 ft)	0 = Not likely
1 = 1-1.5 m (3-5 ft)	1 = Somewhat likely
2 = 1.8-3 m (6-10 ft)	2 = Likely
3 = 3.4-5.5 m (11-18 ft)	3 = Very likely
4 = 5.8-7.6 m (19-25 ft)	4 = Highly likely
5 = >7.6 m (>25 ft)	

For each species, the length and herding scores were summed and a corresponding ADP was assigned as follows:

Sum of Length and Herding Scores	Aerial Detection Probability (ADP)
0	0.1
1	0.3
2	0.5
3-4	0.7
5-9	0.9

Data from comparable aerial surveys off southern California indicate that these probabilities are reasonable. Forney et al. (1995) used an independent observer to estimate perception bias during aerial surveys off southern California. The surveys were flown at about the same altitude and speed, but at Beaufort states ranging from 0 to 4 (as compared with 0 to 3 for the SEAWOLF surveys). The probabilities of detection were estimated to be 0.67 for small cetaceans in groups of 1-10 individuals; 0.95 for small cetaceans in groups of more than 10 individuals; and 0.95 for large cetaceans in groups of 1-22 individuals.

B.1.4.3 Adjusted Mean Densities

Taking into account both availability bias and perception bias, adjusted mean densities were calculated as follows:

$$D_{adj} = D_{obs}/P$$

where D_{adj} is the adjusted mean density, D_{obs} is the observed mean density, and P is the proportion of the total population believed to be detected by the aerial surveys. P was calculated as follows:

$$P = S_t \times ADP$$

where S_t is the probability of an animal being on the surface within the aerial viewing interval, and ADP is the aerial detection probability (the probability that an individual on the surface would be detected from the air).

Table B-4 summarizes the results of these calculations for the 1995 aerial surveys. The table shows mean densities for the six-month survey period (April through September 1995). Because there would be no shock testing in April at Mayport, mean densities for Mayport were also calculated for the May-September period (i.e., excluding April). The estimated proportion of the population detected (P) ranged from 0.06 to 0.18. Observed densities were divided by these proportions (i.e.,

Table B-4. Adjustment of 1995 aerial survey data to account for submerged and undetected marine mammals.

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population	Mayport Densities[a] Excluding April (Individuals/100 km^2)		Norfolk Densities[a] All Six Surveys (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)	Detected ($P = S_t \times ADP$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
BALEEN WHALES									
Fin whale (E)	0.1	5	2	0.9	0.09	0	0	0.52	5.80
Humpback whale (E)	0.2	5	3	0.9	0.18	0	0	0.01	0.06
Minke whale	0.1	5	1	0.9	0.09	0	0	0.02	0.25
Sei whale (E)	0.1	5	2	0.9	0.09	0	0	0.02	0.25
Sei/Bryde's whale	0.1	5	2	0.9	0.09	0	0	0.01	0.13
Unidentified *Balaenoptera*	0.1[b]	5	NA	0.9[b]	0.09	0	0	0.14	1.51
Unidentified large whale	0.1[b]	5	NA	0.9[b]	0.09	0	0	0.05	0.50
TOOTHED WHALES AND DOLPHINS									
Atlantic spotted dolphin	0.2	2	4	0.9	0.18	0.52	2.90	9.34	51.90
Bottlenose dolphin	0.2	2	3	0.9	0.18	0.53	2.94	5.83	32.38
Bottlenose/Atlantic spotted dolphin	0.2	2	3	0.9	0.18	0.18	0.98	0.73	4.03
Clymene/spinner/striped dolphin	0.2	2	4	0.9	0.18	0.13	0.72	2.78	15.43
Common dolphin	0.2	2	4	0.9	0.18	0	0	3.51	19.53
Cuvier's beaked whale	0.07	4	2	0.9	0.06	0	0	0.02	0.36
Pantropical spotted dolphin	0.2	2	4	0.9	0.18	1.55	8.63	4.93	27.40
Pilot whale[c]	0.2	3	3	0.9	0.18	0	0	15.60	86.67

Table B-4. (continued).

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population	Mayport Densities[a] Excluding April (Individuals/100 km^2)		Norfolk Densities[a] All Six Surveys (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)	Detected ($P = S_t \times ADP$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
Risso's dolphin	0.2	3	3	0.9	0.18	1.19	6.60	1.35	7.50
Sperm whale (E)	0.1	5	2	0.9	0.09	0.01	0.15	0.05	0.50
Spinner dolphin	0.2	2	4	0.9	0.18	0.34	1.88	0.70	3.91
Striped dolphin	0.2	2	4	0.9	0.18	0	0	0.27	1.51
Unidentified dolphin	0.2[b]	NA	NA	0.9[b]	0.18	1.28	7.09	4.38	24.31
Unidentified small whale	0.2[b]	NA	NA	0.9[b]	0.18	0	0	0.06	0.32
TOTAL MARINE MAMMALS						**5.73**	**31.89**	**50.32**	**284.25**

(E) = endangered species. NA = not applicable.

[a] Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data. Some values may differ slightly from those one could calculate using the tabulated numbers.

[b] Unidentified sightings were assigned typical S_t and ADP values for the group.

[c] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

essentially multiplied by a factor of 6 to 17) to obtain adjusted densities. Adjusted mean densities were about 32 individuals/100 km^2 at Mayport and about 284 individuals/100 km^2 at Norfolk.

Table B-5 summarizes the results of these calculations for the 1997 aerial surveys at Mayport. The table shows mean densities for the five-month survey period (May through September 1997). The estimated proportion of the population detected (P) ranged from 0.09 to 0.18. Observed densities were divided by these proportions (i.e., essentially multiplied by a factor of 6 to 11) to obtain adjusted densities. Adjusted mean densities were about 47 individuals/100 km^2 at Mayport.

An alternative approach to the use of "correction factors" for unsighted individuals is to use uncorrected data but choose a more "conservative" value than the mean, such as the upper 95% confidence limit (Taylor, 1993) or the highest survey mean. This approach has the advantage of simplicity (there is no need for correction factors and their underlying assumptions), but it does not explicitly account for all undetected individuals; rather, it assumes that the higher value chosen is enough to make up for them. The adjusted mean densities used in the FEIS are greater than or equal to those calculated by the alternative approach. **Tables B-6, B-7, and B-8** compare the adjusted grand mean densities for each species with the range of survey means and the original survey observations. Generally, the adjusted grand mean density for each species exceeded the highest survey mean and 92% to 99% of the original observed densities. For "total marine mammals," the adjusted grand mean exceeded the highest survey mean and 95% to 100% of the original observed densities. That is, use of the adjusted grand mean density to represent the population is more conservative than using the highest observed survey mean and at least as conservative as using the 95th percentile of the original observations.

B.1.5 Mitigation Effectiveness Calculations for Marine Mammals

The Marine Mammal and Sea Turtle Mitigation Plan (see Section 5.0 of the FEIS) includes the use of aerial and shipboard observers and passive acoustic surveys to detect marine mammals within the Safety Range prior to detonation. For impact analysis, it was necessary to estimate mitigation effectiveness, i.e., the probability of detecting an animal if present.

Mitigation effectiveness was estimated separately for each component (aerial monitoring, surface monitoring, and passive acoustic monitoring), then combined. The approach to estimating mitigation effectiveness was based on previous environmental assessments (Department of the Navy, 1993, 1994) and reviewed by marine mammal experts.

B.1.5.1 Aerial Monitoring

For aerial monitoring, mitigation effectiveness (ME) was calculated as follows:

$$ME_{aerial} = ADP \times S_{aerial}$$

where ADP is aerial detection probability as defined previously, and S_{aerial} is the probability of an animal being on the surface at least once during aerial monitoring. S_{aerial} is not the same as S_t, which was used to adjust the aerial survey data as discussed above. Unlike the 1995 and 1997 surveys, aerial monitoring would include three complete passes over the site: one pass 2.5 hours prior to detonation, and two passes (transects and concentric circles) within 1 hour prior to detonation (see Section 5.0). Therefore, the probability of being on the surface during at least one pass is higher than for the aerial surveys, which consisted of a single pass over each transect.

Table B-5. Adjustment of 1997 Mayport aerial survey data to account for submerged and undetected marine mammals.

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population Detected	1997 Mayport Densities[a] (May through September) (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)	(P = S_t x ADP)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
BALEEN WHALES				(no baleen whales seen)			
TOOTHED WHALES AND DOLPHINS							
Atlantic spotted dolphin	0.2	2	4	0.9	0.18	0.439	2.441
Bottlenose dolphin	0.2	2	3	0.9	0.18	3.323	18.461
Bottlenose/Atlantic spotted dolphin	0.2	2	3	0.9	0.18	0.907	5.038
Clymene/spinner/striped dolphin	0.2	2	4	0.9	0.18	0.817	4.537
Pantropical spotted dolphin	0.2	2	4	0.9	0.18	0.023	0.125
Pilot whale[c]	0.2	3	3	0.9	0.18	0.113	0.626
Risso's dolphin	0.2	3	3	0.9	0.18	1.464	8.135
Rough-toothed dolphin	0.2	2	3	0.9	0.18	0.073	0.407
Sperm whale (E)	0.1	5	2	0.9	0.09	0.011	0.125
Spinner dolphin	0.2	2	4	0.9	0.18	0.253	1.408
Unidentified dolphin	0.2[b]	NA	NA	0.9[b]	0.18	0.941	5.225
TOTAL MARINE MAMMALS						**8.364**	**46.528**

(E) = endangered species. NA = not applicable.

[a] Densities shown are rounded to three decimal places, but calculations were done using original, unrounded data. Some values may differ slightly from those one could calculate using the tabulated numbers.

[b] Unidentified sightings were assigned typical S_t and ADP values for the group.

[c] The two species of pilot whales in the western Atlantic, the long-finned pilot whale (*Globicephala melaena*) and short-finned pilot whale (*G. macrorhynchus*), are difficult to differentiate in the field and have been combined in this analysis.

Table B-6. Comparison of adjusted mean densities of marine mammals at the Mayport area in 1995 with range and confidence intervals for original survey data (Data from: Department of the Navy, 1995b). Because shock testing would not be conducted in April at Mayport, calculations are based on May-September surveys only.

Species	Observed Grand Mean Density (Animals/ 100 km^2)	Range of Observed Survey Means (Animals/ 100 km^2)	95% Confidence Interval for Observed Grand Mean (Animals/ 100 km^2)	Adjusted Grand Mean Density[a] (Animals/ 100 km^2)	Percent of Original Survey Observations[b] Less than Adjusted Grand Mean
TOOTHED WHALES AND DOLPHINS					
Atlantic spotted dolphin	0.522	0 to 1.42	-0.23 to 1.27	2.902	97
Bottlenose dolphin	0.529	0 to 2.14	-0.60 to 1.66	2.940	95
Bottlenose/Atlantic spotted dolphin	0.176	0 to 0.51	-0.13 to 0.48	0.980	99
Clymene/spinner/striped dolphin	0.129	0 to 0.54	-0.16 to 0.42	0.716	99
Pantropical spotted dolphin	1.554	0 to 4.82	-0.84 to 3.95	8.631	95
Risso's dolphin	1.187	0 to 4.95	-1.44 to 3.81	6.596	96
Sperm whale	0.014	0 to 0.07	-0.02 to 0.05	0.151	99
Spinner dolphin	0.339	0 to 1.70	-0.60 to 1.28	1.885	99
Unidentified dolphin	1.275	0.34 to 1.76	0.57 to 1.98	7.086	93
TOTAL MARINE MAMMALS	**≈ 6** (5.726)	**2.37 to 11.46**	**1.14 to 10.31**	**≈ 32** (31.886)	**95**

[a] Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

[b] An original survey observation is defined as a group of five adjacent survey transects viewing an area of about 100 km^2, similar to the area of the Safety Range plus Buffer Zone (3 nmi radius) used for mitigation efforts.

Table B-7. Comparison of adjusted mean densities of marine mammals at the Mayport area in 1997 with range and confidence intervals for original survey data (Data from: Department of the Navy, 1998). Because shock testing would not be conducted in April at Mayport, calculations are based on May-September surveys only.

Species	Observed Grand Mean Density (Animals/ 100 km^2)	Range of Observed Survey Means (Animals/ 100 km^2)	95% Confidence Interval for Observed Grand Mean (Animals/ 100 km^2)	Adjusted Grand Mean Density[a] (Animals/ 100 km^2)	Percent of Original Survey Observations[b] Less than Adjusted Grand Mean
TOOTHED WHALES AND DOLPHINS					
Atlantic spotted dolphin	0.439	0 to 0.99	0.03 to 0.85	2.441	96
Bottlenose dolphin	3.323	0.06 to 9.29	0.25 to 6.40	18.461	94
Bottlenose/Atlantic spotted dolphin	0.907	0 to 4.53	-0.87 to 2.68	5.038	97
Clymene/spinner/striped dolphin	0.817	0 to 1.83	0.07 to 1.56	4.537	97
Pantropical spotted dolphin	0.023	0 to 0.11	-0.02 to 0.07	0.125	99
Pilot whale	0.113	0 to 0.56	-0.11 to 0.33	0.626	99
Risso's dolphin	1.464	0.14 to 2.22	0.71 to 2.22	8.135	93
Rough-toothed dolphin	0.073	0 to 0.37	-0.07 to 0.22	0.407	99
Sperm whale	0.011	0 to 0.06	-0.01 to 0.03	0.125	99
Spinner dolphin	0.253	0 to 1.27	-0.24 to 0.75	1.408	99
Unidentified dolphin	0.941	0.06 to 2.76	-0.01 to 1.89	5.225	96
TOTAL MARINE MAMMALS	**≈ 8** (8.364)	**4.45 to 11.60**	**5.93 to 10.80**	**≈ 47** (46.528)	**97**

a Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

b An original survey observation is defined as a group of five adjacent survey transects viewing an area of about 122 km^2 during the 1997 surveys, similar to the area of the Safety Range plus Buffer Zone (3 nmi radius) used for mitigation efforts.

Table B-8. Comparison of adjusted mean densities of marine mammals at the Norfolk area in 1995 with range and confidence intervals for original survey data (Data from: Department of the Navy, 1995b). Calculations are based on April-September surveys.

Species	Observed Grand Mean Density (Animals/ 100 km^2)	Range of Observed Survey Means (Animals/ 100 km^2)	95% Confidence Interval for Observed Grand Mean (Animals/100 km^2)	Adjusted Grand Mean Density[a] (Animals/ 100 km^2)	Percent of Original Survey Observations[b] Less than Adjusted Grand Mean
BALEEN WHALES					
Fin whale	0.522	0 to 2.72	-0.62 to 1.66	5.795	97
Humpback whale	0.011	0 to 0.07	-0.02 to 0.04	0.063	99
Minke whale	0.023	0 to 0.14	-0.04 to 0.08	0.252	98
Sei whale	0.023	0 to 0.14	-0.04 to 0.08	0.252	99
Sei/Bryde's whale	0.011	0 to 0.07	-0.02 to 0.04	0.126	99
Unidentified *Balaenoptera*	0.136	0 to 0.75	-0.18 to 0.45	1.512	97
Unidentified baleen whale	0.045	0 to 0.14	-0.03 to 0.12	0.504	98
TOOTHED WHALES AND DOLPHINS					
Atlantic spotted dolphin	9.342	0 to 24.01	-2.75 to 21.43	51.902	93
Bottlenose dolphin	5.828	0 to 16.26	-1.51 to 13.17	32.376	92
Bottlenose/Atlantic spotted dolphin	0.726	0 to 2.18	-0.31 to 1.76	4.031	93
Clymene/spinner/striped dolphin	2.778	0 to 12.72	-2.52 to 8.08	15.432	96
Common dolphin	3.515	0 to 17.01	-3.63 to 10.66	19.526	98
Cuvier's beaked whale	0.023	0 to 0.14	-0.04 to 0.08	0.360	99
Pantropical spotted dolphin	4.932	0 to 10.54	0.56 to 9.30	27.400	94
Pilot whales	15.601	0 to 49.05	-4.85 to 36.05	86.672	96
Risso's dolphin	1.349	0 to 5.78	-1.02 to 3.72	7.496	97
Sperm whale	0.045	0 to 0.27	-0.07 to 0.16	0.504	97
Spinner dolphin	0.703	0 to 4.22	-1.10 to 2.51	3.905	98
Striped dolphin	0.272	0 to 1.63	-0.43 to 0.97	1.512	99
Unidentified dolphin	4.376	0 to 9.52	0.52 to 8.23	24.313	93
Unidentified small whale	0.057	0 to 0.34	-0.09 to 0.20	0.315	98
TOTAL MARINE MAMMALS	**≈ 50** (50.317)	**18.84 - 72.86**	**26.84 to 73.79**	**≈ 284** (284.248)	**100**

[a] Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

[b] An original survey observation is defined as a group of five adjacent survey transects viewing an area of about 100 km^2, similar to the area of the Safety Range plus Buffer Zone (3 nmi radius) used for mitigation efforts.

Using the S_t values from Table B-4 to represent the probability of an animal being on the surface at any given time, the probability of an animal being visible on the surface during at least one of three passes can be estimated using binomial theory (Winkler and Hays, 1975):

$$P \text{ (on surface at least once in three trials)} = 1 - (1 - S_t)^3$$

For $S_t = 0.2$ (the most common value in Table B-4), this yields a value of 0.49 for S_{aerial}. In other words, if there is a 0.2 probability of being on the surface during a single pass, there is a 0.49 probability of being on the surface at least once during three passes.

This method assumes that the three passes during aerial monitoring would be independent sampling events. For short-diving species such as dolphins, small toothed whales, and many baleen whales, this is a reasonable assumption because individual animals could dive and surface several times between aerial passes. For large, deep-diving species (e.g., minke whale, sperm whale, and possibly Cuvier's beaked whale), an individual animal could be submerged on the same dive during successive passes, but the assumption would still be valid when applied to the population as a whole as long as dives of individual animals are independent. Because these whales have relatively low herding scores (Table B-4), this is a reasonable assumption.

Table B-9 shows the ADP and S_{aerial} values for each species. The product of these two values is the aerial mitigation effectiveness (ME_{aerial}) for each species.

B.1.5.2 Surface Monitoring

For aerial monitoring, mitigation effectiveness was calculated as:

$$ME_{surface} = SDP \times S_{surface}$$

where $S_{surface}$ is the probability of an animal being on the surface at least once during surface monitoring, and SDP is the probability that a species would be detected by surface observers, if present. The method for estimating SDP was similar to the approach described above for ADP, except that visibility enhancements such as leaping, blowing, spinning, and bow wave riding were also considered. Each species was scored using the following scales:

Length	**Herding**	**Visibility Enhancements**
0 = <1 m (<3 ft)	0 = Not likely	0 = Very Poor
1 = 1-1.5 m (3-5 ft)	1 = Somewhat likely	1 = Poor
2 = 1.8-3 m (6-10 ft)	2 = Likely	2 = Low
3 = 3.4-5.5 m (11-18 ft)	3 = Very likely	3 = Average
4 = 5.8-7.6 m (19-25 ft)	4 = Highly likely	4 = Significant
5 = >7.6 m (>25 ft)		5 = Conspicuous

For each species, the length, herding, and visibility enhancement scores were summed and a corresponding SDP was assigned as follows:

Table B-9. Estimated mitigation effectiveness of aerial monitoring for marine mammals.

Species	Length Score	Herding Score	Aerial Detection Probability (ADP)[a]	Probability of Being on Surface (S_{aerial})	Aerial Mitigation Effectiveness (ME_{aerial})[b]
BALEEN WHALES					
Fin whale (E)	5	2	0.9	0.27	0.24
Humpback whale (E)	5	3	0.9	0.49	0.44
Minke whale	5	1	0.9	0.27	0.24
Sei whale (E)	5	2	0.9	0.27	0.24
Sei/Bryde's whale	5	2	0.9	0.27	0.24
Unidentified *Balaenoptera* spp.	5	2	0.9	0.27	0.24
Unidentified baleen whale	NA	NA	0.9[c]	0.27	0.24
TOOTHED WHALES AND DOLPHINS					
Atlantic spotted dolphin	2	4	0.9	0.49	0.44
Bottlenose dolphin	2	3	0.9	0.49	0.44
Bottlenose/Atl. spotted dolphin	2	3	0.9	0.49	0.44
Clymene/spinner/striped dolphin	2	4	0.9	0.49	0.44
Common dolphin	2	4	0.9	0.49	0.44
Cuvier's beaked whale	4	2	0.9	0.20	0.18
Pantropical spotted dolphin	2	4	0.9	0.49	0.44
Pilot whale	3	3	0.9	0.49	0.44
Risso's dolphin	3	3	0.9	0.49	0.44
Rough-toothed dolphin	2	3	0.9	0.49	0.44
Sperm whale (E)	5	2	0.9	0.27	0.24
Spinner dolphin	2	4	0.9	0.49	0.44
Striped dolphin	2	4	0.9	0.49	0.44
Unidentified dolphin	NA	NA	0.9[c]	0.49	0.44
Unidentified small whale	NA	NA	0.9[c]	0.49	0.44

(E) = endangered species. NA = not applicable.

a ADP depends on sum of length and herding scores (see text).
b ME_{aerial} = ADP x S_{aerial}.
c Typical values were assigned for unidentified species.

Sum of Length, Herding, and Visibility Scores	**Surface Detection Probability (SDP)**
0	0
1	0.1
2	0.3
3	0.5
4-5	0.7
6-14	0.9

The other term in the equation, $S_{surface}$, is not the same as S_t, which was used to adjust the aerial survey data. Unlike the 1995 and 1997 aerial surveys, surface monitoring would include continuous observations during at least 2.5 hours prior to detonation (see Section 5.0). Depending on weather conditions, the observers could detect marine mammals out to 4 to 6nmi from the detonation point. $S_{surface}$ therefore refers to the probability that an animal would be on the surface within 4 to 6 nmi of the detonation point at least once during the 2.5 hours preceding detonation. In order to be not detectable by surface observers, an animal would have to be submerged during the entire time it was present in the area.

Typical dive times for dolphins, small toothed whales, and many baleen whales are on the order of several minutes (see Table B-3). It is reasonable to assume that if these animals were present in the area, they would probably be on the surface at least once during the 2.5 hours preceding detonation. Therefore, an $S_{surface}$ value of 0.95 was assigned to these animals.

Some species such as sperm whales and Cuvier's beaked whale can have longer dive times; dives of up to 2 hours have been reported for sperm whales (Jefferson et al., 1993). The probability of being on the surface at least once during 2.5 hours is obviously higher than the surface probability (S_t) listed in Table B-4. A conservative assumption is that $S_{surface}$ for these species would be no less than S_{aerial} defined above, which is based on three independent aerial passes rather than continuous surface observations. The following values were assigned:

- Dolphins and small toothed whales: $S_{surface} = 0.95$
- Baleen whales: $S_{surface} = 0.95$
- Sperm whale: $S_{surface} = S_{aerial} = 0.27$
- Cuvier's beaked whale: $S_{surface} = S_{aerial} = 0.20$

Table B-10 shows the SDP and $S_{surface}$ values for each species. The product of these two values is the surface mitigation effectiveness ($ME_{surface}$) for each species.

B.1.5.3 Passive Acoustic Monitoring

The passive acoustic monitoring system described in Section 5.0 is capable of detecting any marine mammal sounds within the Safety Range. The following values were estimated for acoustic detection probability (Tyack, 1996):

- Sperm whales and *Stenella* (clymene, spinner, striped dolphins) $ME_{acoustic} = 0.75$
- Other odontocetes except Cuvier's beaked whale: $ME_{acoustic} = 0.50$
- Baleen whales and Cuvier's beaked whale: $ME_{acoustic} = 0.25$

Table B-10. Estimated mitigation effectiveness of surface monitoring for marine mammals.

Species	Length Score	Herding Score	Visibility Enhance-ments Score	Surface Detection Probability (SDP)[a]	Probability of Being on Surface ($S_{surface}$)	Surface Mitigation Effectiveness ($ME_{surface}$)[b]
BALEEN WHALES						
Fin whale (E)	5	2	3	0.9	0.95	0.855
Humpback whale (E)	5	3	5	0.9	0.95	0.855
Minke whale	5	1	2	0.9	0.95	0.855
Sei whale (E)	5	2	3	0.9	0.95	0.855
Sei/Bryde's whale	5	2	4	0.9	0.95	0.855
Unidentified *Balaenoptera*	5	2	3	0.9	0.95	0.855
Unidentified baleen whale	5	NA	NA	0.9[c]	0.95[c]	0.855
TOOTHED WHALES AND DOLPHINS						
Atlantic spotted dolphin	2	4	3	0.9	0.95	0.855
Bottlenose dolphin	2	3	3	0.9	0.95	0.855
Bottlenose/Atl. spotted dolphin	2	3	3	0.9	0.95	0.855
Clymene/spinner/striped dolphin	2	4	3	0.9	0.95	0.855
Common dolphin	2	4	3	0.9	0.95	0.855
Cuvier's beaked whale	4	2	2	0.9	0.20	0.18
Pantropical spotted dolphin	2	4	3	0.9	0.95	0.855
Pilot whale	3	3	2	0.9	0.95	0.855
Risso's dolphin	3	3	3	0.9	0.95	0.855
Rough-toothed dolphin	2	3	3	0.9	0.95	0.855
Sperm whale (E)	5	2	4	0.9	0.27	0.24
Spinner dolphin	2	4	4	0.9	0.95	0.855
Striped dolphin	2	4	3	0.9	0.95	0.855
Unidentified dolphin	NA	NA	NA	0.9[c]	0.95	0.855
Unidentified small whale	NA	NA	NA	0.9[c]	0.95	0.855

(E) = endangered species. NA = not applicable.

a SDP depends on sum of length, herding, and visibility enhancements scores (see text).

b $ME_{surface} = SDP \times S_{surface}$.

c Composite values were assigned for unidentified species.

These estimates are based on the tendency of the animals to make detectable sounds. Sperm whales produce distinctive clicked vocalizations, or "codas" (Jefferson et al., 1993) and are considered very likely to be detected acoustically if present in the area (Tyack, 1996). As indicated by the herding scores in Table B-4, most of the dolphins are highly social, and the presence of a school would almost certainly be accompanied by whistles, clicks, and other detectable sounds.

B.1.5.4 Combined Mitigation Effectiveness

Mitigation effectiveness for all three components (aerial, surface, and passive acoustic monitoring) would be greater than for any individual component. Aerial and surface monitoring would be expected to have the greatest overlap in detection, but it is difficult to estimate the extent of overlap. Therefore, it was conservatively assumed that overall visual mitigation effectiveness would be equal to the greater of the two (aerial or surface detection). In other words, the calculation assumes that there would be no gain by using the combination of aerial and surface observers.

$$ME_{visual} = \max(ME_{aerial}, ME_{surface})$$

Passive acoustic monitoring would improve overall mitigation effectiveness by detecting some proportion of the non-visually detected population ($1 - ME_{visual}$). Because acoustic monitoring is assumed to be independent of visual monitoring, the proportion detected would be equal to $ME_{acoustic}$, as defined above. Total mitigation effectiveness was therefore calculated as follows:

$$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})]$$

For example, suppose 0.6 of the population would be detected aerially and 0.55 would be detected by surface observers. ME_{visual} would be the greater of the two, or 0.6. Therefore, 0.4 of the population would not be detected visually. Then suppose that passive acoustic monitoring detects 0.25 of the population, independent of whether the animals are visible to observers. Therefore, 0.25 of the "non-visible" animals would be detected acoustically. The additional proportion of the entire population detected acoustically would be 0.25 x 0.4 = 0.1. Combined mitigation effectiveness would therefore be 0.6 (visual) + 0.1 (acoustic) = 0.7 (total).

Table B-11 summarizes aerial, surface, acoustic, and combined mitigation effectiveness estimates for individual species. Combined mitigation effectiveness is estimated to be 0.89 for baleen whale species. Values are 0.93-0.96 for most dolphins and toothed whales; exceptions are sperm whale (0.81) and Cuvier's beaked whale (0.38).

B.2 SEA TURTLES

B.2.1 Species Descriptions of Sea Turtles

Five species of sea turtles may be found at the Mayport or Norfolk areas, based on historical sighting records. Endangered species are the hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), and leatherback sea turtles (*Dermochelys coriacea*). The loggerhead sea turtle (*Caretta caretta*) is a threatened species. The green sea turtle (*Chelonia mydas*) is listed as threatened, except for the Florida breeding population which is listed as endangered. Loggerhead and leatherback turtles are discussed first, as these are the species most likely to be found at either Mayport or Norfolk.

The loggerhead sea turtle (*Caretta caretta)* is found from South America to New England. This species generally occurs in subtropical waters. Juveniles are pelagic, often drifting in current gyres for several years. It is believed that subadults move to nearshore and into estuarine areas. Adult loggerheads concentrate within middle shelf to shelf edge waters (Schroeder and Thompson, 1987). Adults are found along the continental shelf of the Atlantic and Gulf of Mexico. Loggerheads feed

Table B-11. Summary of estimated mitigation effectiveness for marine mammals.

Species	Mitigation Effectiveness			
	Aerial (ME_{aerial})	Surface ($ME_{surface}$)	Acoustic ($ME_{acoustic}$)	Combined[a] ($ME_{combined}$)
BALEEN WHALES				
Fin whale (E)	0.24	0.855	0.25	0.89
Humpback whale (E)	0.44	0.855	0.25	0.89
Minke whale	0.24	0.855	0.25	0.89
Sei whale (E)	0.24	0.855	0.25	0.89
Sei/Bryde's whale	0.24	0.855	0.25	0.89
Unidentified *Balaenoptera*	0.24	0.855	0.25	0.89
Unidentified baleen whale	0.24	0.855	0.25	0.89
TOOTHED WHALES AND DOLPHINS				
Atlantic spotted dolphin	0.44	0.855	0.50	0.93
Bottlenose dolphin	0.44	0.855	0.50	0.93
Bottlenose/Atlantic spotted dolphin	0.44	0.855	0.50	0.93
Clymene/spinner/striped dolphin	0.44	0.855	0.75	0.96
Common dolphin	0.44	0.855	0.50	0.93
Cuvier's beaked whale	0.18	0.18	0.25	0.38
Pantropical spotted dolphin	0.44	0.855	0.50	0.93
Pilot whale	0.44	0.855	0.50	0.93
Risso's dolphin	0.44	0.855	0.50	0.93
Rough-toothed dolphin	0.44	0.855	0.50	0.93
Sperm whale (E)	0.24	0.24	0.75	0.81
Spinner dolphin	0.44	0.855	0.75	0.96
Striped dolphin	0.44	0.855	0.75	0.96
Unidentified dolphin	0.44	0.855	0.50	0.93
Unidentified small whale	0.44	0.855	0.50	0.93

(E) = endangered species.

[a] Combined mitigation effectiveness was calculated as:

$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})]$,

where ME_{visual} is equal to ME_{aerial} or $ME_{surface}$, whichever is greater.

primarily on benthic molluscs and crustaceans. Pelagic stages feed on coelenterates and cephalopods. Mating occurs in late March to early June. Nesting occurs from May to September. Most nesting of the western Atlantic population occurs on beaches of southeast Florida with other nesting areas located in northeast Florida, Georgia, South Carolina, and North Carolina, as well as the Gulf coast of Florida. Incubation lasts about 54 days in Florida and 63 days in Georgia. Hatchlings swim out to 22 to 28 km (12 to 15 nmi) offshore and begin a pelagic existence within *Sargassum* algae rafts. This species is currently listed as threatened. Murphy and Hopkins (1984) estimated that there were 14,150 nesting females utilizing southeast U.S. beaches in 1983, based on aerial and ground survey data. The NMFS and U.S. Fish and Wildlife Service (USFWS) (1991b) estimated that there are approximately 58,000 nests deposited per year in the southeastern U.S. State agencies in Florida, Georgia, South Carolina, and North Carolina have estimated that approximately 50,000 to 70,000 nests are deposited annually in this region, according to the loggerhead turtle recovery plan prepared by the NMFS and USFWS (1991b).

The leatherback sea turtle (*Dermochelys coriacea*) is a circumglobal species, currently divided into two subspecies (Thompson and Huang, 1993). The subspecies of interest here is *Dermochelys coriacea coriacea* which inhabits waters of the western Atlantic Ocean from Newfoundland to northern Argentina. It is believed that compared to other sea turtles, leatherbacks range the farthest north. This species may be found in shallow waters but is essentially open ocean, or pelagic (Marquez, 1990). Leatherback sea turtles are frequently observed in cool waters of higher latitudes, such as New England and the Canadian Maritime Provinces. Leatherback sea turtles are pelagic feeders (e.g., on coelenterates, particularly jellyfish). This species nests on high energy beaches (i.e., beaches exposed to strong wave action) in Florida as early as late February or March. Incubation lasts 65 days. Very little is known of the pelagic distribution of hatchling and/or juvenile leatherback turtles. Due to the endangered status of the leatherback turtle, all nesting areas are considered critical habitat.

The Atlantic green sea turtle (*Chelonia mydas*) occurs in U.S. Atlantic waters around the U.S. Virgin Islands, Puerto Rico, and continental waters from Texas to Massachusetts. This species may be found in convergence zones in deep water and in shallow, protected waters containing benthic (bottom) feeding grounds. Atlantic green sea turtles commonly feed upon seagrasses and algae, using reefs and rocky outcrops near grass beds for resting areas. Nesting areas are located on high-energy beaches along the Atlantic coast of Florida. The NMFS and USFWS (1991a) identified several large and important nesting areas along the central and southeast coast of Florida, including Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties. Mating occurs in waters off nesting areas. Nesting occurs at night, with females producing clutches of eggs every two years. Hatchlings swim out to sea and enter a pelagic stage in convergence zones.

Hawksbill sea turtles (*Eretmochelys imbricata)* occur in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. In the western Atlantic, hawksbill turtles are generally found in clear tropical waters of the Caribbean, including the Florida Keys, the Bahamas, and the southwest Gulf of Mexico. Hawksbill turtles are not frequently reported in waters north of Cape Canaveral, Florida. Adults can be found in waters up to 100 m (328 ft) deep. This species feeds on encrusting organisms, particularly sponges. Juvenile hawksbill sea turtles are usually found near shallow coral reefs. Nesting areas for hawksbills in the Atlantic are found in the U.S. Virgin Islands, Puerto Rico, and south Florida. Hatchlings enter a pelagic phase, drifting with *Sargassum* rafts. Juveniles shift to a benthic foraging existence in shallow waters, progressively moving to deep waters as they grow and become capable of deeper dives for sponges. Due to this turtle's endangered status, all nesting areas are critical habitat. Within the continental U.S., nesting beaches are restricted to the southeast coast of Florida (i.e., Volusia through Dade Counties) and the Florida Keys (Monroe County), as noted by Meylan (1992) and the NMFS and USFWS (1993).

The Kemp's ridley sea turtle (*Lepidochelys kempii*) is found from the Gulf of Mexico to New England, and occasionally as far north as Nova Scotia. Its distribution along the U.S. southeastern coast is mediated by the Gulf Stream. Adult turtles are usually found in the Gulf of Mexico. Juveniles may move northward along the U.S. Atlantic coast with the warm waters of the Gulf Stream. Individuals are reported to return southward when waters turn cold. It is believed that this species typically remains shoreward of the 50-m (164-ft) contour line. Kemp's ridley sea turtles forage in shallow water, feeding on crabs, shrimp, gastropods, and fish. Nesting occurs almost entirely in Rancho Nuevo beach, Tamaulipas, Mexico (NMFS and USFWS, 1992). Nesting occurs during the day in April, May, and June, with mature individuals returning on an annual basis (Prichard and Marquez, 1973). Due to the species' endangered status, all nesting areas are considered as critical habitat. According to the NMFS and USFWS (1992), juvenile and subadult Kemp's ridley sea turtles travel northward along the Atlantic seaboard in spring to feed in the productive, coastal waters between Georgia and New England; these migrants then move southward with the onset of cooler temperatures in late fall and winter. Henwood and Ogren (1987) and Schmid (1995) provided information on length frequency, seasonal occurrence, and long distance migratory patterns of Kemp's ridley sea turtles along the U.S. Atlantic coast.

B.2.2 Summary of 1995 and 1997 Aerial Surveys

Between April and September 1995, six aerial surveys of the Mayport and Norfolk areas were completed to estimate the density of sea turtles. Additional surveys were conducted from May through September 1997 at Mayport. Survey locations, dates, and methods have been described in Section B.1.3. **Table B-12** lists the numbers of sea turtles seen during each survey at the Mayport and Norfolk areas. During the 1995 surveys, a total of 138 individuals were seen at Mayport and 48 individuals were seen at Norfolk. During the 1997 surveys, a total of 240 individuals were seen at Mayport. Numbers should not be compared directly because of the difference in total area surveyed. Also, the April 1995 survey data for Mayport were not used to calculate mean densities because shock testing would not occur during April at Mayport (the 1997 surveys were conducted only from May through September). Standardized density estimates are discussed below. **Figure B-7** shows the numbers of sea turtles along each transect during each of the 1997 surveys (similar figures for the 1995 surveys are shown in Section 3.0 of the FEIS).

B.2.3 Adjustment of Sea Turtle Densities for Submerged and Undetected Individuals

Aerial surveys were conducted at Mayport and Norfolk during 1995 and at Mayport in 1997 to estimate densities of sea turtles, as described in Section B.1.3. Aerial surveys typically underestimate the true density because some animals are submerged and therefore not available to be seen (availability bias) and others may be present on the surface but missed by observers (perception bias) (Marsh and Sinclair, 1989). Adjusted densities were developed for the two species (loggerheads and leatherbacks) seen during the surveys to correct for these two sources of bias.

B.2.3.1 Availability Bias

To correct for availability bias, raw densities can be divided by the proportion of time the animal is likely to be present on the surface within the viewing range. Because sea turtles have long dive times, the simplest estimate is the mean proportion of time the animal spends at the surface.

The proportion of time sea turtles spend at the surface can be estimated based on telemetric studies. Keinath et al. (1996) tagged loggerhead sea turtles off the North Carolina coast and found that they spent 10.6% of their time on the surface. A similar value of 0.10 (i.e., 10%) was used in the DEIS

Table B-12. Numbers of sea turtles seen during 1995 and 1997 aerial surveys (From: Department of the Navy, 1995b, 1998).

Species	Mayport Surveys							Norfolk Surveys						
	1 (Apr)	2 (May)	3 (Jun)	4 (Jul)	5 (Aug)	6 (Sep)	Total	1 (Apr)	2 (May)	3 (Jun)	4 (Jul)	5 (Aug)	6 (Sep)	Total
1995 SURVEYS														
Loggerhead sea turtle (T)	61	11	17	12	12	15	128	0	13	6	3	6	16	44
Leatherback sea turtle (E)	0	0	0	1	1	4	6	0	0	0	1	0	0	1
Unidentified sea turtle	1	0	2	0	0	1	4	0	2	0	1	0	0	3
Total Sea Turtles (1995):	**62**	**11**	**19**	**13**	**13**	**20**	**138**	**0**	**15**	**6**	**5**	**6**	**16**	**48**
1997 SURVEYS														
Loggerhead sea turtle (T)	--[a]	42	29	28	33	47	179	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]
Leatherback sea turtle (E)	--[a]	1	2	3	10	23	39	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]
Unidentified sea turtle	--[a]	6	0	8	5	3	22	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]
Total Sea Turtles (1997):	**--[a]**	**49**	**31**	**39**	**48**	**73**	**240**	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]	--[b]

(E) = endangered species; (T) = threatened species.

[a] There was no April survey during 1997, since it had already been determined that shock testing would not be conducted in April if the Mayport area is selected.

[b] The 1997 surveys were conducted only at Mayport (the preferred alternative area).

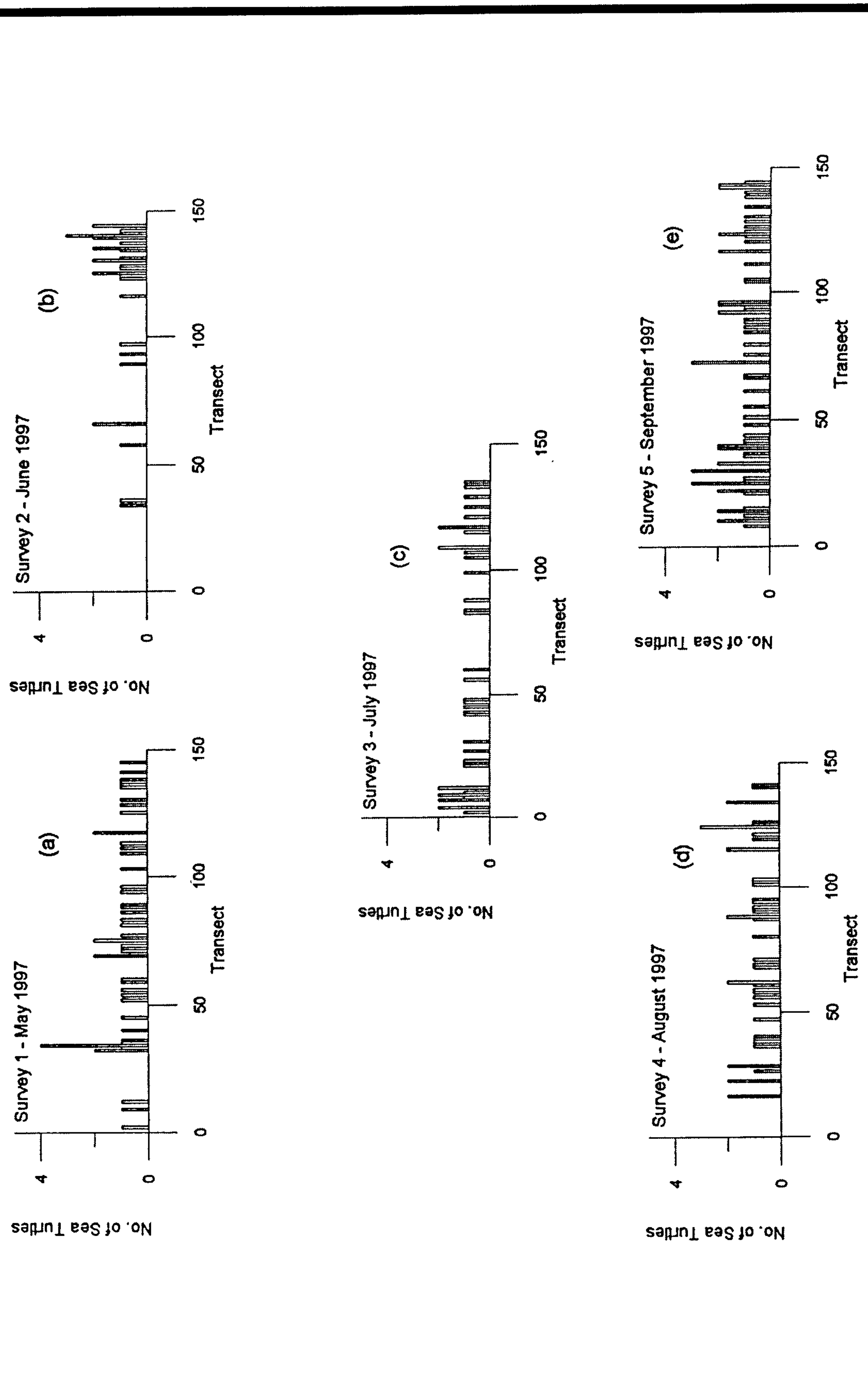


Figure B-7. Sea turtle abundance along individual transects at the Mayport area during 1997 aerial surveys (Data from: Department of the Navy, 1998).

based on personal communication with a sea turtle expert (Thompson, 1996), and this value is also used in the FEIS. For leatherbacks, Keinath and Musick (1993) reported that tagged animals at St. Croix, U.S. Virgin Islands, spent about 13% of their time on the surface. Other authors have reported higher values of 33% (Eckert et al., 1989), 40-48% (Eckert et al., 1986), and 23-64% (Standora et al., 1984). A conservative value of 0.12 (i.e., 12%) was used in the DEIS based on personal communication (Thompson, 1996) and is also used in the FEIS.

B.2.3.2 Perception Bias

To correct for perception bias, aerial detection probabilities (ADP) were estimated based on animal length and herding tendencies using the same scoring system developed for marine mammals (see Section B.1.4). Both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]) and herding scores of 0 (herding not likely), resulting in a total score of 1 and an ADP of 0.3.

The ADP of 0.3 is reasonable based on independent detection tests conducted by Epperly et al. (1995) using plywood turtles deployed in North Carolina coastal waters. The tests were conducted from an altitude of 152 m (500 ft) under Beaufort <2 conditions. The turtles were 0.1 to 0.3 km perpendicular distance from the transect line. Detection efficiency averaged 97.2%. SEAWOLF aerial surveys in 1995 were done at higher altitude (229 m or 750 ft) and Beaufort <3. Also, in the SEAWOLF surveys, the swath viewed was estimated to be 0.1 to 0.63 km (perpendicular distance) from the transect line, as compared with 0.1 to 0.3 km in the Epperly et al. tests. The efficiency from Epperly et al. (1995) cannot be applied directly, but can be approximated as follows.

In the Epperly et al. (1995) tests, the straight line distance from the aerial observer to the outer edge of the viewed swath would be 0.336 km. At the higher altitude used for SEAWOLF surveys, this distance would occur at a perpendicular distance of 0.246 km from the transect line. Therefore, the 97.2% sighting efficiency could apply to the swath between 0.1 km and 0.246 km perpendicular distance from the transect. Based on abundance vs. distance histograms presented by Epperly et al. (1995), a reasonable estimate for detection efficiency in the remainder of the SEAWOLF survey viewing swath would be 10%, although detection could be better than this because the viewing angle would be less oblique at higher altitude. Based on 97.2% efficiency from 0.1 km to 0.246 km and 10% efficiency from 0.246 km to 0.63 km, the average efficiency for the viewed swath would be about 34%, which compares well with the 30% figure used for FEIS calculations. Some of the SEAWOLF observations were at higher Beaufort (3), but these are still considered good viewing conditions.

B.2.3.3 Adjusted Mean Densities

Adjusted mean densities were calculated using the same method described above for marine mammals. The following equation was used:

$$D_{adj} = D_{obs}/P$$

where D_{adj} is the adjusted density, D_{obs} is the observed density, and P is the proportion of the total population believed to be detected by the aerial surveys. P was calculated as follows:

$$P = S_t \times ADP$$

where S_t is the probability of an animal being on the surface during the aerial viewing interval, and ADP is the aerial detection probability (the probability that an individual on the surface would be detected from the air).

Table B-13 summarizes the results of these calculations for sea turtles. The table shows mean densities at Norfolk for the six-month survey period (April through September 1995). Because there would be no shock testing in April at Mayport, mean densities for Mayport were calculated for the May-September period (i.e., excluding April). Observed mean densities from the 1995 data (May-September at Mayport, April-September at Norfolk) were about 0.5 individuals/100 km^2 at both areas. However, because only 10% of either population is believed to be on the surface and because only 30% of animals on the surface are estimated to have been detected from the air, adjusted densities are about 30 times higher than observed densities, or about 17-18 individuals/100 km^2.

Sea turtle densities were higher during the 1997 Mayport surveys. The observed mean density was 1.36 individuals/100 km^2, or about 2.6 times higher than the 1995 mean over the same months (May through September). Adjusted mean density was therefore about 44 individuals/100 km^2.

Table B-14 compares the adjusted grand mean densities for each species with the range of survey means and the original survey observations. Generally, the adjusted grand mean density for each species exceeded the highest survey mean and 95% of the original observed densities. For "total sea turtles," the adjusted grand mean exceeded the highest survey mean and 95% to 100% of the original observed densities. That is, use of the adjusted grand mean density to represent the population is more conservative than using the highest observed survey mean and at least as conservative as using the 95th percentile of the original observations.

B.2.4 Mitigation Effectiveness Calculations for Sea Turtles

The Marine Mammal and Sea Turtle Mitigation Plan (see Section 5.0 of the FEIS) includes the use of aerial and shipboard observers and passive acoustic surveys to detect sea turtles within the Safety Range prior to detonation. For impact analysis, it was necessary to estimate mitigation effectiveness, i.e., the probability of detecting an animal if present.

The approach to estimating mitigation effectiveness for sea turtles was similar to the one described above for marine mammals (Section B.1.5). However, it is assumed that passive acoustic monitoring would not detect any turtles; therefore, $ME_{combined}$ was defined as the maximum of ME_{aerial} or $ME_{surface}$ (whichever is greater).

B.2.4.1 Aerial Monitoring

For aerial monitoring, mitigation effectiveness (ME) was calculated as:

$$ME_{aerial} = ADP \times S_{aerial}$$

where ADP is aerial detection probability as defined previously, and S_{aerial} is the probability of an animal being on the surface at least once during aerial monitoring. ADP calculations have been discussed above in Section B.2.3; both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]) and herding scores of 0 (herding not likely), resulting in a total score of 1 and an ADP of 0.3.

Because aerial monitoring would involve three complete passes over the site prior to detonation (see Section 5.0), the probability of an animal being on the surface during at least one pass (S_{aerial}) would be higher than the S_t values presented above in Section B.2.3 (i.e., 0.1 for loggerheads and 0.12 for leatherbacks). Using the S_t values from Table B-13 to represent the probability of an animal being on the surface at any given time, the probability of an animal being on the surface during at least one of three passes can be estimated using binomial theory (Winkler and Hays, 1975):

Table B-13. Adjustment of 1995 and 1997 aerial survey data to account for submerged and undetected sea turtles.

Species	Probability of Being on Surface (S_t)	Aerial Detection Calculations			Proportion of Population Detected	Mayport Densities[a] (May-September only) (Individuals/100 km^2)		Norfolk Densities[a] (April-September) (Individuals/100 km^2)	
		Length Score	Herding Score	Aerial Detection Probability (ADP)	(P = S_t x ADP)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)	Observed Mean Density (D_{obs})	Adjusted Mean Density ($D_{adj} = D_{obs}/P$)
Loggerhead sea turtle (T)	0.10	1	0	0.3	0.030	0.46	15.15	0.50	16.63
Leatherback sea turtle (E)	0.12	1	0	0.3	0.036	0.04	1.13	0.01	0.31
Unidentified sea turtle	0.11[b]	NA	NA	0.3[b]	0.033[b]	0.02	0.62	0.03	1.03
Total Sea Turtles (1995 Surveys)						**0.52**	**16.90**	**0.54**	**17.97**
Loggerhead sea turtle (T)	0.10	1	0	0.3	0.030	1.014	33.793	--[c]	--[c]
Leatherback sea turtle (E)	0.12	1	0	0.3	0.036	0.220	6.102	--[c]	--[c]
Unidentified sea turtle	0.11[b]	NA	NA	0.3[b]	0.033[b]	0.124	3.755	--[c]	--[c]
Total Sea Turtles (1997 Surveys)						**1.357**	**43.650**	--[c]	--[c]

(E) = endangered species. (T) = threatened species. NA = not applicable.

[a] Densities shown are rounded to two decimal places, but calculations were done using original, unrounded data. Some values may differ slightly from those one could calculate using the tabulated numbers.
[b] Unidentified turtles were assigned S_t and ADP values midway between those of loggerhead and leatherback turtles.
[c] The 1997 aerial surveys were conducted only at Mayport (the preferred alternative area).

Table B-14. Comparison of adjusted mean densities of sea turtles at the Mayport and Norfolk areas with range and confidence intervals for original survey data (Data from: Department of the Navy, 1995b, 1998). Calculations are based on May-September surveys for Mayport and April-September surveys for Norfolk.

Species	Observed Grand Mean Density (Individuals/ 100 km^2)	Range of Observed Survey Means (Individuals/ 100 km^2)	95% Confidence Interval for Observed Grand Mean (Individuals/100 km^2)	Adjusted Grand Mean Density[a] (Individuals/ 100 km^2)	Percent of Original Survey Observations[b] Less than Adjusted Grand Mean
MAYPORT AREA 1995					
Loggerhead sea turtle	0.455	0.37 to 0.58	0.35 to 0.56	15.152	100
Leatherback sea turtle	0.041	0 to 0.14	-0.03 to 0.11	1.131	97
Unidentified sea turtle	0.020	0 to 0.07	-0.02 to 0.06	0.617	98
Total Sea Turtles	0.516	0.37 to 0.68	0.35 to 0.68	**17** (16.899)	100
MAYPORT AREA 1997					
Loggerhead sea turtle	1.014	0.82 to 1.32	0.81 to 1.21	33.793	100
Leatherback sea turtle	0.220	0.03 to 0.65	-0.01 to 0.45	6.102	100
Unidentified sea turtle	0.124	0.00 to 0.22	0.05 to 0.20	3.755	100
Total Sea Turtles	1.357	0.87 to 2.06	0.97 to 1.74	**44** (43.650)	100
NORFOLK AREA					
Loggerhead sea turtle	0.499	0 to 1.09	0.07 to 0.93	16.629	100
Leatherback sea turtle	0.011	0 to 0.07	-0.02 to 0.04	0.315	99
Unidentified sea turtle	0.034	0 to 0.14	-0.03 to 0.09	1.031	100
Total Sea Turtles	0.544	0 to 1.09	0.10 to 0.99	≈ **18** (17.975)	100

a Adjusted Mean Densities were calculated using correction factors for submerged and undetected individuals; see Appendix B.

b An original survey observation is defined as a group of five adjacent survey transects viewing an area of about 100 km^2 in 1995 and 122 km^2 in 1997, similar to the area of the Safety Range plus Buffer Zone (3 nmi radius) used for mitigation efforts.

$$P \text{ (on surface at least once in three trials)} = 1 - (1 - S_t)^3$$

This calculation yields S_{aerial} values of 0.27 for loggerheads and 0.32 for leatherbacks.

This method assumes that the three passes during aerial monitoring would be independent sampling events. Because some sea turtles can remain submerged for several hours, an individual animal could be submerged on the same dive during successive passes. However, the assumption would still be reasonable when applied to the population as long as dives of individual animals are independent (i.e., some could be surfaced and others submerged at a given time). Because most of the sea turtles seen during 1995 and 1997 aerial surveys were solitary animals, this is a reasonable assumption.

The S_{aerial} values are very conservative. For aerial mitigation during shock testing (in contrast to the aerial surveys), altitude would be reduced to 198 m (650 ft) and line spacing would be 0.46 km (0.25 nmi). Also, the blind spot under the aircraft would be removed by the addition of a third observer and the use of a Partenavia aircraft or equivalent with a belly window. Using the effective swath width of Epperly et al. (1995) corrected for altitude, turtles should be detected with high efficiency from 0-0.27 km (0-0.15 nmi) to either side of the aircraft. Therefore, swaths viewed along adjacent transects would overlap, providing over 100% coverage of the mitigation area. Mitigation effectiveness could be somewhat less than 97.2% depending on Beaufort conditions (0-4). However, the value of 0.3 (i.e, 30% detection probability) used for impact calculations is very conservative.

Table B-15 shows the S_{aerial} and aerial detection probability (ADP) values for each turtle species. The product of ADP and S_{aerial} is the aerial mitigation effectiveness (ME_{aerial}) for each species.

B.2.4.2 Surface Monitoring

For surface monitoring, mitigation effectiveness (ME) was calculated as:

$$ME_{surface} = SDP \times S_{surface}$$

Surface detection probabilities (SDP) were calculated as described above under marine mammals (Section B.1.5). Both loggerheads and leatherbacks were assigned length scores of 1 (length of 1-1.5 m [3-5 ft]), herding scores of 0 (herding not likely), and visibility enhancement scores of 0 (very poor), resulting in a total score of 1 and a SDP of 0.3.

$S_{surface}$ is probability that an animal would be on the surface within 4 to 6 nmi of the detonation point at least once during the 2.5 hours preceding detonation. In order to be not detectable by surface observers, an animal would have to be submerged during the entire time it was present in the area. Some sea turtles can dive deep and remained submerged for several hours. The probability of being on the surface at least once during 2.5 hours would be higher than the surface probability (S_t) listed in Table B-13. A conservative assumption is that $S_{surface}$ would be no less than S_{aerial} defined above, which is based on three independent aerial passes rather than continuous surface observations.

Table B-16 shows the SDP and $S_{surface}$ values for each turtle species. The product of these two values is the surface mitigation effectiveness ($ME_{surface}$) for each species.

B.2.4.3 Combined Mitigation Effectiveness

Mitigation effectiveness calculations for sea turtles are summarized in **Table B-17**. It is assumed that passive acoustic monitoring would not detect any turtles; therefore, $ME_{combined}$ was defined as the maximum of ME_{aerial} or $ME_{surface}$ (whichever is greater). $ME_{combined}$ is estimated at 0.08 for

Table B-15. Estimated mitigation effectiveness of aerial monitoring for sea turtles.

Species	Length Score	Herding Score	Aerial Detection Probability (ADP)[a]	Probability of Being on Surface (S_{aerial})	Aerial Mitigation Effectiveness (ME_{aerial})[b]
Loggerhead sea turtle (T)	1	0	0.3	0.27	0.08
Leatherback sea turtle (E)	1	0	0.3	0.32	0.10
Unidentified sea turtle	NA	NA	0.3[c]	0.30[c]	0.09

(E) = endangered species. (T) = threatened species. NA = not applicable.
[a] ADP depends on sum of length and herding scores (see text).
[b] ME_{aerial} = ADP x S_{aerial}.
[c] Unidentified turtles were assigned values midway between those of loggerhead and leatherback sea turtles.

Table B-16. Estimated mitigation effectiveness of surface monitoring for sea turtles.

Species	Length Score	Herding Score	Visibility Enhance-ments Score	Surface Detection Probability (SDP)[a]	Probability of Being on Surface ($S_{surface}$)	Surface Mitigation Effectiveness ($ME_{surface}$)[b]
Loggerhead sea turtle (T)	1	0	0	0.3	0.27	0.08
Leatherback sea turtle (E)	1	0	0	0.3	0.32	0.10
Unidentified sea turtle	NA	NA	NA	0.3[c]	0.30[c]	0.09

(E) = endangered species. (T) = threatened species. NA = not applicable.
[a] SDP depends on sum of length, herding, and visibility enhancements scores (see text).
[b] $ME_{surface}$ = SDP x $S_{surface}$.
[c] Unidentified turtles were assigned values midway between those of loggerhead and leatherback sea turtles.

Table B-17. Summary of estimated mitigation effectiveness for sea turtles.

Species	Mitigation Effectiveness			
	Aerial (ME_{aerial})	Surface ($ME_{surface}$)	Acoustic ($ME_{acoustic}$)	Combined[a] ($ME_{combined}$)
Loggerhead sea turtle (T)	0.08	0.08	0.00	0.08
Leatherback sea turtle (E)	0.10	0.10	0.00	0.10
Unidentified sea turtle	0.09	0.09	0.00	0.09

(E) = endangered species.

[a] Combined mitigation effectiveness was calculated as:

$ME_{combined} = ME_{visual} + [ME_{acoustic} \times (1 - ME_{visual})]$,

where ME_{visual} is equal to ME_{aerial} or $ME_{surface}$, whichever is greater.

loggerheads, 0.10 for leatherbacks, and 0.09 for unidentified turtles. In other words, most sea turtles presumably would not be detected because they are likely to be submerged or, if present on the surface, not visible to aerial or surface observers due to their small size, solitary habits, and lack of visibility enhancements.

These calculations do not directly address hatchling and juvenile turtles, which are small and difficult to detect because they inhabit sargassum rafts. However, mitigation protocols specify that detonation would be postponed if large sargassum rafts were seen within the Safety Range. Also, animals at the surface (such as juvenile turtles in sargassum rafts) are not exposed to the most severe shockwave impacts and are unlikely to be affected unless they are very close to the detonation point (see Appendix D). Considering these factors and the very conservative values used for aerial mitigation effectiveness, potential impacts to juvenile and hatchling turtles are taken into account.

B.3 SEABIRDS

The following range, habitat, general life history information, and expected presence for open ocean seabirds of concern which may occur offshore of Mayport, Florida and Norfolk, Virginia has been adapted from Rowlett (1980), Clapp et al. (1982a,b, 1983), Powers (1983), Lee (1984, 1985b, 1986), and Lee and Horner (1989).

Black-browed albatrosses (*Diomedea melanophrys*) are an accidental visitor to North Carolina in April, August, and December. Their presence in shelf waters of the northern Chesapeake Bight is hypothetical. They are classified as a vagrant (accidental) in the north Atlantic.

Northern fulmars (*Fulmarus glacialis*) are found in the Arctic Ocean south to Newfoundland. They winter at sea south of New Jersey and feed in the open ocean on squid, shrimp, and fish. Northern fulmars nest in rocky cliffs. They are common to abundant in waters off North Carolina in spring and fall. There are no records of this species south of the Carolinas.

Northern gannets (*Sula bassana*) are common to abundant visitors to waters off North Carolina in winter and spring, although present year round. They are also abundant in waters off Florida's Atlantic coast and present from October to April, with peak abundances seen from November to February.

Brown boobies (*Sula leucogaster*) are found in tropical waters in the Gulf of Mexico. They feed on flying fish and breed on coastal islands. Brown boobies are considered rare visitors to North Carolina waters with sightings noted for April and December. They are probably casual post-breeding vagrants in late summer and early fall over shelf waters of the northern Chesapeake Bight. Brown boobies are considered to be rare in waters off Florida's Atlantic coast, although occurrence is possible year round.

Masked boobies (*Sula dactylatra*) are associated with tropical waters around the Bahamas and West Indies. They are occasionally found in Florida, Louisiana, and Texas. Masked boobies feed in the open sea on fish, particularly flying fish, and breed in colonies on open ground. There is a single suspect record for North Carolina. Masked boobies are rare visitors to central and southern segments of Florida's Atlantic coast, with most records from August to September.

Red-billed tropicbirds (*Phaethon aethereus*) are uncommon visitors to waters off North Carolina in spring and summer. Similarly, they are uncommon in waters off Florida's Atlantic coast. Red-billed tropicbirds are more uncommon in the southeastern U.S. than their congeners, the white-tailed tropicbirds (*P. lepturus*).

White-tailed tropicbirds (*Phaethon lepturus*) are uncommon visitors to waters off North Carolina in summer. They are probably casual late summer and early fall vagrants over warm slope waters and eddies of the Gulf Stream (along the edge of the continental shelf) of the northern Chesapeake Bight. They are frequently sighted in waters off Florida's Atlantic coast.

Magnificent frigatebirds (*Fregata magnificens*) are uncommon visitors to waters off North Carolina in spring and summer and casual vagrants during spring, summer, and fall over shelf waters of the northern Chesapeake Bight. They occur year-round in waters off Florida's Atlantic coast, though more common during summer.

Cory's shearwaters (*Puffinus diomedea*) occur on the east coast of North America during summer and fall. They feed in the open ocean and typically follow ships. Cory's shearwaters nest in rock crevices or on open ground. They are common to abundant off North Carolina in spring, summer, and fall and a fairly common, widely dispersed summer visitor in shelf waters of the northern Chesapeake Bight. Cory's shearwaters are the most abundant shearwater in waters off Florida's Atlantic coast from May to December. Peak numbers are seen from September to November.

Greater shearwaters (*Puffinus gravis*) breed in large colonies on small islands in the southern Atlantic but migrate to the north Atlantic during summer. They feed in the open ocean on small fish and squid. Greater shearwaters are common in waters off North Carolina in spring and summer, though most abundant in waters of the Gulf Stream and along the edge of the continental slope. They are uncommon during late spring, summer, and fall as a visitor to shelf waters of the northern Chesapeake Bight. They are locally abundant during June and early July and, occasionally fairly common from late October to early November. Greater shearwaters are relatively uncommon in waters off Florida's Atlantic coast and are seen in all months except March and April.

Audubon's shearwaters (*Puffinus lherminieri*) are found in tropical waters but may occur as far north as New York during summer. They nest in colonies on islands. They are common to abundant off North Carolina in spring, summer, and fall. Audubon's shearwaters are rare summer and early fall visitors to shelf waters of the northern Chesapeake Bight. They are the second most abundant shearwater in waters off Florida's Atlantic coast, with peak numbers from July to early November. It is suggested that they are present year round.

Manx shearwaters (*Puffinus puffinus*) are occasional visitors in the western Atlantic. They are mostly seen at sea from Newfoundland to Cape Hatteras. Manx shearwaters undergo very long migrations. They breed in colonies on islands in the eastern Atlantic. They are rare visitors to waters off North Carolina in winter and spring. They are rare transients in spring and fall over shelf waters of the northern Chesapeake Bight and have been recorded only rarely in waters off Florida's Atlantic coast, with most observations during fall and winter.

Sooty shearwaters (*Puffinus griseus*) are abundant to common visitors in waters off North Carolina in May and June, although present year round. They are uncommon spring and early summer transients over the entire shelf of the northern Chesapeake Bight. Sooty shearwaters are relatively rare in waters off Florida's Atlantic coast. There, it is suggested that their peak abundance is in May and June, although data are limited.

Wilson's storm-petrels (*Oceanites oceanicus*) occur on the western Atlantic during summer. They generally feed in the open ocean but sometimes enter bays and estuaries. They breed in rocky cliffs and on offshore islands in the Antarctic and subantarctic seas and are common to abundant off North Carolina in spring, summer, and fall. Wilson's storm-petrels are summer visitors to shelf waters of the northern Chesapeake Bight and are locally abundant beyond 50 km (27 nmi) offshore. They are the most abundant storm-petrel in waters off Florida's Atlantic coast; presence noted from April to November with peak numbers seen in May and June.

Leach's storm-petrels (*Oceanodroma leucorhoa*) are found in Labrador south to Maine. They breed in colonies on rocky islands and coasts in the eastern Atlantic and winter in the open ocean. They are common off North Carolina in spring and late summer, although also present in fall. Leach's storm-petrels are rare and widely dispersed from April to November in shelf waters of the northern Chesapeake Bight, although probably present in fall and winter. They are considered rare visitors to waters off Florida's Atlantic coast.

Band-rumped (Harcourt's) storm-petrels (*Oceanodroma castro*) are inhabitants of tropical and subtropical seas. They occur in the western North Atlantic from late May through mid-August, although peak abundance is in mid-July. They are highly pelagic and generally solitary. Band-rumped storm petrels are common visitors to deep waters (500 to 1,000+ fathoms) off North Carolina in summer. Their occurrence in waters off Florida's Atlantic coast is considered accidental.

White-faced storm-petrels (*Pelagodroma marina*) are rare visitors to waters off North Carolina in fall. They are probably casual late summer and fall vagrants to shelf waters of the northern Chesapeake Bight. Strays may rarely be encountered south of Cape Hatteras. No records for this species are known from waters off Florida's Atlantic coast.

Black-capped petrels (*Pterodroma hasitata*) are tropical to subtropical in distribution. Nesting occurs within burrows located on steep forested cliffs of Caribbean islands. They are common visitors to waters off North Carolina year round, most commonly in May, October, and December. The majority of sightings have been over deep water (914 to 1,829+ m [3,000 to 6,000+ ft]), though less common between 183 to 914 m (600 to 3,000 ft). Black-capped petrels are thought to be casual vagrants to shelf waters of the northern Chesapeake Bight. They apparently migrate to Gulf Stream waters. Only a few historic sightings of this species have been made in waters off Florida's Atlantic coast.

Bermuda petrels (Cahow) (*Pterodroma cahow*) are subtropical. Their distribution at sea is unknown. They are a very rare species which feed on squid, shrimp, and small fish in the open sea. They breed in burrows in Bermuda, though not likely to be found at the Mayport or Norfolk areas except accidentally. Bermuda petrels are considered rare visitors to waters off North Carolina, with sightings noted in April and December. No sightings records for this species have been made in waters off Florida's Atlantic coast.

Red-necked phalaropes (*Phalaropus lobatus*) are common to abundant visitors to waters off North Carolina in spring and fall. They are abundant as transients in waters off Florida's Atlantic coast and most abundant in April and May and September and October.

Red phalaropes (*Phalaropus fulicaria*) are common to abundant visitors to waters off North Carolina in fall, winter, and spring. They are fairly common spring and fall transients to shelf waters of the northern Chesapeake Bight, though uncommon and irregular in winter. They are found usually beyond 70 km (38 nmi) from shore. Red phalaropes are common to abundant in waters off Florida's Atlantic coast as a winter migrant.

Pomarine jaegers (*Stercorarius pomarinus*) are common visitors to waters off North Carolina in spring and fall. They are primarily transients over shelf waters of the northern Chesapeake Bight. Pomarine jaeger are uncommon in spring, though fairly common in fall. Data suggests that they are present year round.

Parasitic jaegers (*Stercorarius parasiticus*) are common visitors to waters off North Carolina in fall, although uncommon in spring. Similarly, they are uncommon spring and fall transients to shelf waters of the northern Chesapeake Bight, with few sightings noted in summer.

Long-tailed jaegers (*Stercorarius longicaudus*) are uncommon visitors to waters off North Carolina year round. They are rare spring and fall transients to shelf waters of the northern Chesapeake Bight.

Great skuas (*Catharacta skua*) are rare visitors to waters off North Carolina in winter. They are rare but regular winter visitors and probable spring transients over shelf waters of the northern Chesapeake Bight. They occur primarily seaward of the 120-m (394-ft) contour to the continental slope.

South polar skuas (*Catharacta maccormicki*) are uncommon visitors to waters off North Carolina in summer.

Black-legged kittiwakes (*Rissa tridactyla*) are common visitors to waters off North Carolina in winter. They are common fall and early spring transients and winter visitors to shelf waters of the northern Chesapeake Bight, seaward of 10 km (5.4 nmi) offshore.

Sabine's gulls (*Larus sabini*) are rare visitors to waters off North Carolina in May, September, and October. They are casual spring and fall transients over shelf waters of the northern Chesapeake Bight.

Arctic terns (*Sterna paradisaea*) are rare in waters off North Carolina in spring. Similarly, they are rare spring and probably fall transients over shelf waters of the northern Chesapeake Bight, beyond the 55-m (180-ft) contour. Data suggest they occur off the Atlantic coast of Florida in spring over pelagic waters.

Bridled terns (*Sterna anaethetus*) are found in the nonbreeding season in offshore waters from the Carolinas to Florida. They breed in colonies in tropical waters of the Atlantic on rocky or sandy islands. They are abundant to common in waters off North Carolina in summer and fall. Similarly, they are casual late summer visitors (i.e., when surface temperatures reach a maximum) to shelf waters of the northern Chesapeake Bight. Bridled terns occur regularly in some numbers in waters off Florida's Atlantic coast in summer and fall, with peak numbers realized in late April and May, and again in August and September.

Sooty terns (*Sterna fuscata*) are common visitors to waters off North Carolina in summer. They are casual vagrants in summer and early fall over shelf waters of the northern Chesapeake Bight, and are most frequently observed following tropical storms and hurricanes. Sooty terns occur frequently in waters off Florida's Atlantic coast, and often seen following hurricanes. Their highest abundances are noted from late summer through early fall.

Brown noddies (*Anous stolidus*) are rare visitors to waters off North Carolina in summer. They are rare in waters off Florida's Atlantic coast and often seen following hurricanes.

Dovekies (*Alle alle*) are uncommon visitors to waters off North Carolina in fall and winter. They are uncommon winter visitors (November to March) to shelf waters of the northern Chesapeake Bight.

Thick-billed murres (*Uria lomvia*) are uncommon visitors to waters off North Carolina in winter.

Razorbills (*Alca torda*) are uncommon visitors to waters off North Carolina in winter. They generally range offshore to the 55-m (180-ft) contour within shelf waters of the northern Chesapeake Bight.

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APPENDIX C

SUMMARY OF CHANGES TO IMPACT CRITERIA FOR MARINE MAMMALS AND TURTLES

CONTENTS

APPENDIX C

SUMMARY OF CHANGES TO IMPACT CRITERIA FOR MARINE MAMMALS AND TURTLES

This Appendix summarizes revisions to the marine mammal and sea turtle impact criteria between the Draft Environmental Impact Statement (DEIS) and Final Environmental Impact Statement (FEIS). Mortality and injury criteria are discussed in detail in Appendix D, and acoustic criteria are discussed in Appendix E.

C.1 CRITERIA USED IN THE DEIS

C.1.1 Mortality (Appendix D)

For a mortality criterion, the DEIS used "onset of extensive lung injury" as predicted by the Goertner (1982) lung injury model. The impulse associated with "onset of extensive lung injury" is predicted to cause 1% mortality based on a regression equation developed by Yelverton (1981). The predicted threshold varied depending on animal size, with smaller animals at greater risk; therefore, the criterion was based on a small marine mammal, a calf dolphin weighing 12.2 kg (27 lb). The predicted maximum range was 1,524 m (5,000 ft).

C.1.2 Injury (Appendix D)

For an injury criterion, the DEIS used 10% probability of tympanic membrane (TM) rupture. The criterion was assumed to be independent of animal size, but dependent on animal depth; to obtain the most conservative range, the animal was assumed to be at the bottom (152m or 500 ft). The criterion was based on analysis of data for dogs and sheep exposed to underwater detonations as reported by Richmond et al. (1973) and Yelverton et al. (1973). The predicted range was 3,792 m (12,440 ft). This was the basis for the DEIS Safety Range of 3.8 km (2.05 nmi); for mitigation, a Buffer Zone of 1.8 km (0.95 nmi) was added to reach a total radius of 5.6 km (3 nmi).

C.1.3 Harassment (Appendix E)

In the absence of temporary threshold shift (TTS) data for marine mammals, the DEIS developed a new criterion called "acoustic discomfort," based on data from humans immersed in water. The criterion was based on tests in which divers were exposed to brief, pure tones of increasing intensity until they "wanted to go no further." (The exposures did not cause TTS). The maximum range predicted was 11.1 km (6 nmi).

C.2 SUBSEQUENT DISCUSSIONS

A Navy meeting was held in San Diego on January 28, 1997. The approach used in the DEIS was discussed among the 20+ participants. There were no significant challenges to the mortality criterion based on the Goertner lung injury model. However, significant issues were identified with both the injury and harassment criteria. In particular, the following constructive comments were made:

- An auditory safety criterion should be based on TTS, which is a known and accepted criterion for humans, rather than "acoustic discomfort." Behavioral change or self-reported "discomfort" is not a reliable basis for a criterion; in fact, humans can unknowingly experience TTS at levels well below those causing discomfort or avoidance. It was recommended that TTS data for bottlenose dolphins, which would subsequently become available from the Ridgway et al. (1997) experiments, be used.

- The 10% eardrum rupture criterion should be replaced. Eardrum rupture becomes unpredictable and idiosyncratic when dealing with such low percentages. Generally, 50% rupture is a widely used criterion and is well correlated with 30% incidence of permanent threshold shift (PTS). It was also stated that the data for sheep and dogs summarized in Appendix D should be supplemented with eardrum rupture data from other mammals.

Another issue discussed briefly at the meeting was the 160 dB pressure criterion used in some previous environmental assessments. As discussed in the Response to Comments (Appendix H, comment set Q), the Navy believes that the 160 dB pressure criterion is inappropriate for a harassment criterion for the SEAWOLF shock test. The 160 dB criterion was based on avoidance of repeated seismic pulses by migrating gray whales. This criterion does not apply to the SEAWOLF shock test because the test has been scheduled to avoid migratory whales and there would be only a single pulse each week.

C.3 REVISED CRITERIA

Appendix E was revised to incorporate the results of the Ridgway et al. (1997) study, which was officially issued in July 1997. Portions of Appendix D were also rewritten. Both appendices also included changes in response to public and agency comments on the DEIS. The following revised criteria were developed.

C.3.1 Mortality (Appendix D)

The mortality criterion is the same one used in the DEIS, that is, onset of extensive lung injury for a calf dolphin. This is a theoretical prediction based on the Goertner (1982) model. For a calf dolphin (12.2 kg or 27 lb), the impulse associated with the predicted onset of extensive lung hemorrhage is 55.1 psi-msec.

The maximum range has been recalculated as 1,123 m (3,683 ft) at a depth of 28 m (91 ft). This compares with a maximum range of 1,524 m (5,000 ft) stated in the DEIS. The range in the DEIS was the maximum range for any charge depth down to 200 ft (61 m). The calculations were intended to be applicable to ship shock trials in general, including those for surface ships which typically use a charge depth of 200 ft (61 m). The recalculation used the charge depth of 100 ft (30 m) planned for SEAWOLF shock testing.

C.3.2 Injury (Appendix D)

The 10% TM rupture criterion used in the DEIS was replaced with 50% TM rupture. This criterion has the following advantages:

- It is widely used in the auditory safety field (Ketten, 1995).

- It is known to be associated with 30% incidence of PTS (Ketten, 1995).

- The range is similar to that for onset of slight lung injury, another injury criterion independently calculated using different models and assumptions.

TM rupture *per se* is not necessarily a serious or life-threatening injury. Rather, 50% TM rupture serves as an index of potential injury (including PTS, as noted above). FEIS calculations conservatively assume that 100% of animals within this range would be injured.

To develop the 50% TM rupture criterion, the data originally presented in Appendix D were reanalyzed, dropping those data sets with a low percentage of ruptures (based on Dr. Ketten's comment that eardrum rupture is unpredictable at relatively low pressures). The analysis used total shockwave energy as the basis for predicting the response of the mammalian ear to underwater noise, based on the discussion in Appendix E. The criterion is 1.17 in-lb/in^2 and the maximum range (which occurs at the bottom, 152 m or 500 ft) is estimated to be 1,855 m (6,086 ft) or about 1 nmi.

As noted above, it was suggested that the Yelverton data be supplemented with data from other mammals (in air). The revised Appendix D includes a brief comparison with TM rupture data presented in the Ketten (1995) paper. The comparison shows that the 50% TM rupture range estimated in Appendix D is reasonable and greater than would be derived using other mammalian TM rupture data.

The following other criteria were considered for injury but had ranges less than that for 50% TM rupture:

- Onset of slight lung injury. This criterion was also initially presented in Appendix D of the DEIS and is a theoretical prediction based on the Goertner (1982) lung injury model. The impulse associated with the predicted onset of slight lung injury for a calf dolphin is 28.1 psi-msec. The range has been recalculated using the planned charge depth of 100 ft (30 m) for SEAWOLF shock testing (see explanation above under the Mortality criterion). The maximum range of 1,774 m (5,821 ft), or just under 1 nmi, occurs at a depth of 28 m (91 ft).

- PTS. Richardson et al. (1995) discuss a Damage Risk Criterion (DRC) for marine mammals, based on extrapolations from human DRC. As discussed in the revised Appendix E, Richardson et al. apparently overlooked the fact that sound pressure levels measured in air cannot be directly compared to levels measured in water. The DRC has been recalculated using the same logic but correcting the assumptions. The result is a PTS criterion that varies from 250 to 241 dB (peak pressure) depending on animal depth in the water column. The predicted range varies from 207 to 500 m (680 to 1,638 ft).

C.3.3 Harassment (Appendix E)

A dual criterion for harassment has been developed for the FEIS: (1) an energy-based TTS criterion of 182 dB re 1 $\mu Pa^2 \cdot$ sec derived from the Ridgway et al. (1997) data; and (2) 12 psi peak pressure, cited by Ketten (1995) as associated with "a safe outer limit for the 10,000 lb charge for minimal, recoverable auditory trauma" (i.e., TTS). The harassment range is the minimum distance at which neither criterion is exceeded.

TTS is based on the Ridgway et al. (1997) study with bottlenose dolphins. Although TTS onset level varied with frequency, the Ridgway et al. data are too limited to determine the relationship; therefore, the lowest pressure causing TTS at any frequency (192 dB re 1 μPa) was used. Using an integration time of 0.1 seconds for the dolphin ear (Johnson, 1968), the energy-based criterion is 182 dB re 1 $\mu Pa^2 \cdot$ sec.

The same TTS criterion is used for toothed whales (odontocetes) and baleen whales (mysticetes), for the following reasons:

- The Ridgway et al. results are the only TTS data available for any marine mammal and as such are the best available data until an experiment is done with baleen whales.

- Extrapolation from the best available data is consistent with previous approaches and other analyses in the EIS. Previously accepted harassment criteria have either been extrapolated from baleen whales to all marine mammals (e.g., the 160 dB criterion based on gray whale avoidance of seismic pulses) or extrapolated from humans to marine mammals (e.g., acoustic discomfort as used in the DEIS). Appendix D of the FEIS extrapolates from terrestrial mammals to marine mammals (and turtles) to predict lethal and sublethal injury. There is probably no greater error in extrapolating the TTS criterion across cetacean taxa than there is in any of these other extrapolations.

- According to Ketten (1997), extrapolation from a small odontocete (bottlenose dolphin) to large mysticetes is both *reasonable* based on the anatomical similarities and *conservative* because smaller animals are more vulnerable to auditory damage.

- Extrapolation across mammalian taxa is consistent with the approach of Ketten (1995), who reviewed blast injury and auditory trauma in relation to marine mammal ear anatomy and used data mainly from terrestrial mammals and pinnipeds to develop auditory impact zones (including PTS and TTS) for all marine mammals.

- The 192 dB bottlenose dolphin criterion is within the range of reported TTS levels for other mammals. TTS data for humans, monkeys, and chinchillas exposed to impulsive noise are reviewed in Appendix E. Source levels reportedly causing TTS (converted to in-water values) ranged from 188 to 230 dB peak pressure.

Therefore, using a single TTS criterion for both odontocetes and mysticetes is a reasonable approach based on the best available data. However, the FEIS recognizes that there could be differential effects on the two groups due to their differing sensitivity to low frequencies. As an attempt to take into account this difference, separate TTS ranges were calculated for odontocetes and mysticetes. For odontocetes, all frequencies greater than or equal to 100 Hz were included. For mysticetes, all frequencies greater than or equal to 10 Hz were included. For the Mayport area, the TTS range is predicted to be 15.7 km (8.5 nmi) for odontocetes and 23.5 km (12.7 nmi) for mysticetes. Corresponding TTS ranges at Norfolk are 13 km (7 nmi) for odontocetes and 22.2 km (12 nmi) for mysticetes. These replace the single range of 11.1 km (6 nmi) used for "acoustic discomfort" in the DEIS.

C.4 SAFETY RANGE

In the DEIS, the Safety Range of 3.8 km (2.05 nmi) was based on the injury criterion (10% probability of eardrum rupture). A Buffer Zone of 1.8 km (0.95 nmi) was added to create the 5.6 km (3 nmi) buffered Safety Range. The DEIS stated that detonation would occur only when there are no marine mammals or turtles within the Safety Range. The Buffer Zone was not part of the "go/no-go" decision but was basically intended to detect animals that could enter the Safety Range prior to detonation.

The Biological Opinion issued by NMFS in December 1996 specified additional criteria regarding site selection, wave and sea state, and sargassum and jellyfish in the Safety Range (see Appendix G). The Biological Opinion also specified postponement if listed marine mammals are detected in the Buffer Zone, essentially requiring a 5.6 km (3 nmi) "go/no-go" range for these species. Section 5.0 of the FEIS states the "go/no-go" criteria that incorporate the Biological Opinion requirements.

As a result of the revised criteria and calculations discussed above, both the mortality and injury ranges have been reduced in the FEIS. For example, using 50% TM rupture as an injury criterion decreases the estimated injury range to about 1.85 km (1 nmi). However, the Safety Range and Buffer Zone remain unchanged, except that the 2.05 nmi (3.8 km) Safety Range has been rounded to 2 nmi (3.7 km) (since the specific value "2.05" was based a 10% TM rupture criterion which has been eliminated). The "go/no-go" criteria incorporate this rounding of 2.05 to 2 nmi. The 5.6 km (3 nmi) postponement range for listed species, as specified in the Biological Opinion, is unaffected by this rounding.

The Safety Range and Buffer Zone are more than adequate to prevent death and serious injury to marine mammals and turtles. The 3.7 km (2 nmi) Safety Range is three times the predicted mortality range and twice the predicted injury range. The 5.6 km (3 nmi) buffered Safety Range is five times the predicted mortality range and three times the predicted injury range.

C.5 SUMMARY

Mortality, injury, and acoustic harassment criteria developed in the DEIS were reevaluated based on internal Navy discussions as well as public and agency comments on the DEIS. Also, since the DEIS was issued, the first data for TTS in any marine mammal became available in July 1997 from experiments by Ridgway et al. (1997). Subsequently, Appendix E was rewritten to incorporate the TTS results, and some of the data in Appendix D were recalculated. The following criteria were developed for the FEIS:

- Mortality. There have been no changes to the mortality criterion used in the DEIS – onset of extensive lung injury for a calf dolphin based on the Goertner (1982) model. However, the maximum range has been recalculated as 1,123 m (3,683 ft), compared with 1,524 m (5,000 ft) in the DEIS. The DEIS calculations used the maximum range for any charge depth down to 61 m (200 ft). The recalculation uses the charge depth of 30 m (100 ft) planned for the SEAWOLF shock testing.

- Injury. The 10% TM rupture criterion used in the DEIS has been replaced by 50% TM rupture, which is a widely used standard in the auditory safety field and is well correlated with PTS. Data initially presented in Appendix D of the DEIS were reanalyzed and a revised 50% TM rupture criterion was developed. Comparisons with other mammalian TM rupture data from Ketten (1995) indicate that the revised criterion is reasonable. The maximum range is estimated to be 1,855 m (6,086 ft) or about 1 nmi.

- Harassment. To replace "acoustic discomfort" as used in the DEIS, a dual criterion was developed: (1) an energy-based TTS criterion of 182 dB re 1 $\mu Pa^2 \cdot$ sec derived from the Ridgway et al. (1997) data; and (2) 12 psi peak pressure, cited by Ketten (1995) as associated with "a safe outer limit for the 10,000 lb charge for minimal, recoverable auditory trauma." The harassment range is the minimum distance at which neither criterion is exceeded. The same TTS criterion was used for both odontocetes and mysticetes, but different frequencies were used to calculate TTS ranges. For the Mayport area, maximum range is predicted to be 15.7 km (8.5 nmi) for odontocetes (frequencies $\geq$100 Hz) and 23.5 km (12.7 nmi) for mysticetes (frequencies $\geq$10 Hz). Corresponding TTS ranges at Norfolk are 13 km (7 nmi) for odontocetes and 22.2 km (12 nmi) for mysticetes. These replace the single range of 11.1 km (6 nmi) used for "acoustic discomfort" in the DEIS.

- Safety Range. The Safety Range and Buffer Zone remain the same as in the DEIS, except that the 2.05 nmi (3.8 km) Safety Range has been rounded to 2 nmi (3.7 km) (since the specific value "2.05" was based on a criterion which has been eliminated). Similarly, the Buffer Zone was rounded from 0.95 nmi (1.8 km) to 1 nmi (1.85 km), for a total buffered Safety Range of 3 nmi (5.6 km) (same as in the DEIS). The "go/no-go" criteria have been revised in the FEIS to incorporate the requirements of the NMFS Biological Opinion (see Appendix G).

- Impact Calculations. Based on the revised criteria, predicted mortalities and injuries would decline in the FEIS. However, the FEIS adopts the DEIS numbers where they are higher. Harassment numbers increased at both Mayport and Norfolk because the predicted TTS ranges are greater than the "acoustic discomfort" range used in the DEIS.

Criteria used in the DEIS and FEIS are summarized in **Table C-1**.

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Table C-1. DEIS vs. FEIS impact criteria and ranges.

	DEIS		FEIS	
Impact	Criterion	Max Range	Criterion	Max Range
Mortality	Onset of extensive lung hemorrhage	1,524 m (5,000 ft) (0.8 nmi)	Same as DEIS (but range recalculated)[a]	1,123 m (3,683 ft) (0.6 nmi)
Injury	10% incidence of TM rupture	3,792 m (12,440 ft) (2.05 nmi)	50% incidence of TM rupture	1,855 m (6,086 ft) (1 nmi)
Harassment	"Acoustic discomfort"	11.1 km (6 nmi)	TTS (182 dB energy) or 12 psi (peak pressure)	Odonotocetes Mayport:[b] 15.7 km (8.5 nmi) Mysticetes, Mayport:[b] 23.5 km (12.7 nmi) Odonotocetes, Norfolk:[b] 13.0 km (7.0 nmi) Mysticetes Norfolk:[b] 22.2 km (12.0 nmi)

[a] Range was recalculated using the planned charged depth of 100 ft (30 m) instead of the maximum range for any charge depth down to 200 ft (61 m).

[b] Two different TTS ranges were calculated for the Mayport and Norfolk areas: one for odontocetes based on frequencies ≥100 Hz and the second for mysticetes based on frequencies ≥10 Hz. The 12 psi peak pressure criterion does not consider frequency and therefore yields a range of about 7 - 11 km (4 - 6 nmi) for both groups at either area.

APPENDIX D

PHYSICAL IMPACTS OF EXPLOSIONS ON MARINE MAMMALS AND TURTLES

James C. Craig
Christian W. Hearn

Naval Surface Warfare Center
Carderock Division
Bethesda, MD

This appendix summarizes information on the potential physical effects of underwater explosions on marine mammals and turtles. A review of marine mammal anatomy and mechanisms for injury from underwater explosions is included. Results from experiments conducted mainly with terrestrial mammals are used to develop criteria and ranges for lethal and non-lethal injury. Limited data for sea turtles are also reviewed. These data are used in the Environmental Consequences section of the FEIS to estimate numbers of marine mammals and turtles that could be killed or injured, and to determine the safety range for mitigation.

CONTENTS

APPENDIX D

PHYSICAL IMPACTS OF EXPLOSIONS ON MARINE MAMMALS AND TURTLES

The effects of an underwater explosion on a marine mammal or turtle are dependent upon many factors, including the size, type, and depth of both the animal and the explosive, the depth of the water column, and the standoff distance from the charge to the animal. Potential impacts can range from brief acoustic annoyance, tactile perception and physical discomfort to both non-lethal and lethal injuries. Annoyance of and discomfort to marine mammals and turtles could occur as a result of non-injurious physiological responses to both the acoustic signature and the shockwave from the underwater explosion. Non-lethal injury includes slight injury to internal organs and the auditory system; however, delayed lethality can be a result of complications from individual or cumulative sub-lethal injuries. Short term or immediate lethal injury would be a result of massive combined trauma to internal organs as a direct result of proximity to the point of detonation. It is very unlikely that injury would occur from exposure to the chemical by-products released into surface waters [Young, 1984; Naval Surface Warfare Center (NSWC), 1992; also see Section 4 of this FEIS].

Criteria developed in this appendix are used in the FEIS to estimate numbers of marine mammals and turtles that could be killed or injured and to determine the safety range for mitigation. The appendix discusses several criteria for physical impacts to marine mammals and turtles:

- Lethality assessments can be made on the basis of the predicted cavitation region of an explosion (section D.5), lethal peak shockwave pressures (section D.2.2.2), or model predictions of lethal injury to internal organs based on *impulse* (pressure integrated over time) (section D.2.2.1). The most conservative of the mortality criteria discussed here is the predicted onset of extensive lung hemorrhage for a calf dolphin. The impulse associated with the predicted onset of extensive lung hemorrhage is 55.1 psi-msec (380.2 Pa-sec), and the estimated maximum range for this criterion under SEAWOLF shock test conditions is 3,683 ft (1,123 m).

- Potential injury criteria discussed include the onset of slight lung injury (section D.2.1) and tympanic membrane (TM) rupture (section D.2.3). A criterion of 50% TM rupture is used in the FEIS to calculate numbers of animals potentially injured. TM rupture *per se* is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing loss (see Appendix E). The energy associated with predicted 50% TM rupture is 1.17 in-lb/in^2 (20.44 milli-Joules/cm^2), and the maximum range for this criterion under SEAWOLF shock test conditions is estimated to be 6,086 ft (1,855 m) or about 1 nautical mile.

- Two non-injurious physical effects, physical discomfort and tactile perception (such as a brief "sting"), are discussed in section D.4. Brief physical discomfort (strong stings) would be highly probable at ranges less than about 0.4 to 0.7 nmi (0.8 to 1.3 km). Tactile perception would be unlikely at ranges that exceed 4 to 5 nmi (7.4 to 9.3 km). Between these two ranges, tactile perception and/or moderate stings are possible. These criteria are not used for FEIS calculations because more conservative "harassment" criteria based on auditory effects are developed in Appendix E.

While most of the available data and models are applicable to mammals, the predictions are believed to be reasonable for sea turtles as well, as discussed in section D.6.

This appendix includes numerous supporting tables and figures. To avoid interrupting the flow of the discussion, they are presented at the end of the appendix.

D.1 MARINE MAMMAL ANATOMY IN RELATION TO EFFECTS OF UNDERWATER EXPLOSIONS[1]

"Considerable information about the anatomy of marine mammals is available, particularly with regard to the adaptations necessary for survival in the underwater environment. The possible effects of underwater shock waves on these animals can be inferred from the similarities and differences in anatomy between marine and land mammals...." (Hill, 1978).

"All true marine mammals dive for food and are therefore adapted to changes in hydrostatic pressure.... The adaptations necessary to permit marine mammals to withstand the pressure changes involved in deep diving are found primarily in the air-filled spaces of the body – notably the lungs, respiratory passages, outer and middle ear and accessory sinuses. Since the air-filled spaces of the body are the primary sites of damage to land mammals by underwater shock waves, adaptations which allow marine mammals to tolerate pressure changes may also make them resistant to damage from shock waves" (Hill, 1978).

The ranges at which different species and sizes of marine mammals may be injured are estimates based largely on experiments with terrestrial mammals. Effects on marine mammals may differ due to anatomical and physiological characteristics which have been shaped by their aquatic existence. Some characteristics, such as highly reinforced lung tissues, would tend to decrease the risk of lung injury. Other characteristics, such as light, oil-filled bones and near loss of certain skeletal structures, have no direct effect in the lung injury model used. The higher lung volume to body mass ratio of marine mammals (Kooyman, 1973) has been taken into account. A reduction in lung volume with hydrostatic pressure is taken into account; partial or total lung collapse at depth (as occurs in some marine mammals) would further reduce the risk of lung injury. However, because of the uncertainties in extrapolating from terrestrial to marine mammals, effect ranges in this appendix have been calculated using conservative assumptions which deliberately overestimate the risk of injury.

The actual vulnerability of marine mammals to underwater explosions is largely unknown (Ketten, 1995). Results of "seal bomb" tests on dolphin carcasses as reported by Myrick et al. (1990) are discussed in Section D.2.2.2. Blast injuries to humpback whales near a Canadian construction site as reported by Ketten (1995) and Todd et al. (1996) are discussed in Section D.2.3.1.

D.1.1 Thorax

"The thorax of marine mammals is much more flexible than that of land mammals. Very few ribs are connected to the sternum with costal cartilage – especially in cetaceans – and the costal cartilage itself is flexible. Some odontocetes (toothed whales) have "floating ribs," unconnected either to the sternum or to other ribs. Such a loosely-connected thoracic cage may not reduce the effects of shock waves on the lungs, since a rigid shield may be necessary to afford considerable protection against damage" (Hill, 1978).

[1] This section is largely excerpted from Hill (1978).

D.1.2 Respiratory System

"Respiratory passages and lungs of marine mammals, particularly cetaceans, are highly modified for diving.... Compared to terrestrial mammals, there is a striking increase in the amount of supportive structures, namely cartilage, collagen, smooth muscle and elastic tissue in the peripheral portions of the lung. Extensive supportive structures are also found in the upper airways. Cartilaginous support extends from the trachea into the smaller airways up to the junction with alveolar ducts. Dense layers of elastic tissue, just beneath the mucous membrane, encircle and connect the cartilage. All these supportive tissues probably make cetacean lungs and airways less vulnerable to damage by shock waves, since the boundaries between tissue and air are not as fragile as in land animals" (Hill, 1978).

"The lung structure of pinnipeds, especially seals, is more similar to that of land mammals, but there are other modifications of the respiratory system which are shared by both pinnipeds and cetaceans.... The lung size relative to body size of marine mammals does not differ much from that of land mammals. However, the ratio of tidal air volume to the total lung volume, and the ratio of air passage volume to the total air volume are higher for marine mammals. These are modifications for deep diving. Increased tidal air ratio means that more air in the lungs is renewed with each breath, facilitating rapid gas exchange. Larger relative air passage volume may permit total lung collapse during deep dives. Lungs are usually placed dorsally, and the diaphragm typically extends obliquely across the thoracic cavity; thus, the lungs can completely flatten against the dorsal thoracic wall. The flexible thorax of these animals permits such a collapse, with the compressed air from the lungs being forced into the more rigid air passages..." (Hill, 1978).

"Seals generally exhale before diving, or during the initial part of the dive, whereas some cetaceans have been observed to dive after inspiration. Thus, the diving depth at which total lung collapse occurs is probably less for pinnipeds than for cetaceans. Nevertheless, when the lungs are collapsed, they will certainly be less vulnerable to damage from shock waves. Upper air passages in land mammals (and probably marine mammals as well) are not primary damage sites" (Hill, 1978).

D.1.3 Ears and Other Air-Spaces in the Head Region

"The middle and outer ears, and the various sinuses associated with the ears of diving mammals also have protection against pressure changes. True seals (*Phocidae* – this group includes all the common seals of the Arctic) and cetaceans do not have any external ears. Instead, the external ear opening is usually a small pore or slit on the side of the head region. In pinnipeds, the external auditory canal is long and narrow and is supported by cartilage. The canal is also lined with a thick, highly vascularized "cavernous" tissue; it may expand during a dive by filling with blood and thus occupy the air-filled space in the canal. The seal's external ear-opening is usually closed while diving. Very dense bone surrounds the middle ear cavity, which is also lined with thick cavernous tissue, called the *corpus cavernosum*. Seal biologists believe that this tissue fills with blood as the seal descends in order to equalize the air pressure within the middle ear cavity with the pressure in other ear passages connected to the inner ear via the eustachian tube" (Hill, 1978).

"In toothed whales, the external ear opening is very small, or closed entirely. The auditory canal and the middle ear are lined with cavernous tissue; the middle and inner ears are also surrounded by a system of air sinuses filled with a foam formed from an oil-mucous emulsion. These sinuses are bounded closely by the bones of the skull and by thick cavernous tissue. As in the pinniped ear, the cavernous tissue probably fills with blood as the animal dives, thus expanding into the cavity to equalize the internal air pressure with the external hydrostatic pressure" (Hill, 1978).

"It appears that the air spaces associated with the ears of pinnipeds and cetaceans are well protected against shock-wave damage, because these spaces are typically surrounded by bone or cartilage and are lined with cavernous tissue which is itself bounded by a tough, fibrous membrane. During deep dives, these air spaces might be reduced in size by filling of the cavernous tissue with blood. The eardrum of pinniped and baleen whales – it is not functional in toothed whales – may be damaged by shock waves. An injured animal may be partially incapacitated in this way, but it is not known to what extent pinnipeds and baleen whales rely on hearing for their survival. A ruptured eardrum could also cause a fatal secondary infection of the middle ear" (Hill, 1978).

"The highly modified nostrils (nares) of cetaceans contain additional air-containing sacs and passages. The lining of these passages is tough and elastic in sperm whales, and it seems possible that this is the case in all whales. If so, the nostrils are not likely to be principal sites of damage by shock waves" (Hill, 1978).

Ketten (1994, 1995) has reviewed the functional anatomy of marine mammal ears, the latter paper focusing on blast injury and acoustic trauma. Ketten (1995) concludes that, "[W]hale middle and inner ears are most heavily modified structurally from those of terrestrial mammals in ways that accommodate rapid pressure changes. The end product is an acoustically sensitive ear that is simultaneously adapted to sustain moderately rapid and extreme pressure changes... It is possible that these special adaptations coincidentally may provide protective mechanisms that lessen the risk of injury from high intensity noise, but no behavioural or psychometric studies are available which directly address this issue."

D.1.4 Viscera

"Other principal damage sites in *terrestrial* mammals are regions of hollow viscera containing gas.... Such gas bubbles are *probably* uncommon, since the presence of significant quantities of gas in the intestinal tracts of animals which spend a great deal of time passing through pressure differences of 20 atmospheres or more could cause considerable discomfort, pain, and even injury" (Hill, 1978).

D.1.5 Skin and Body Walls

"In the review of the effects of shock waves on terrestrial mammals, it is noted that larger animals are less vulnerable to damage than small animals. This is likely a function of the thicker body walls of the larger mammals. Most marine mammals are large animals, possessing thick body walls. The skin of cetaceans consists of a tough epidermis, usually less than 1 cm thick, under which is the thinner dermis, composed mainly of thick bundles of connective tissue. Below the dermis lies the hypodermis, or blubber, a layer of fatty tissue – up to 60 cm thick in larger whales. The skin of pinnipeds is similar, except that all layers are proportionately thinner. The blubber layer of the ringed seal ranges from 10 mm to 63 mm in thickness, depending on the size of the animal and the season. Arctic pinnipeds (except walrus) also have a layer of fur which, along with the skin, is waterproofed by a thin film of oil" (Hill, 1978).

"[Measurements of] the acoustic properties of the blubber coat in porpoises (indicated that) although sound easily entered the blubber coat, "the blubber/muscle interface proved an excellent sound reflector." Shock waves are reflected and absorbed in a roughly similar manner to low amplitude sound waves. Thus, although only a small fraction of shock-wave energy would be reflected at the skin and water interface, a considerable fraction would be reflected at the blubber and muscle interface. This would correspondingly reduce the peak pressures of the shock wave entering the body of the animal. The unwettable skin and fur of pinnipeds would not be a good acoustic couple between the water and the body of the animal, and could reduce the intensity of a shock wave more than would the wet skin of cetaceans" (Hill, 1978).

D.2 MARINE MAMMAL INJURY FROM UNDERWATER EXPLOSIONS

"Events taking place during the reflection and absorption of shock waves at boundaries between two different media may cause death or damage when these boundaries are within living organisms. When a shock wave passes from tissue of one density to tissue of a different density (for example, from muscle to bone), the particle velocities imparted to these tissues will be different. If the peak pressure of the shock wave is high and the density difference between the tissues is large, resulting in a large difference in particle velocity, the two tissues may be literally torn apart" (Hill, 1978).

"Shock wave reflections at an interface between tissue and an air-filled cavity within a living organism can cause great damage to tissues at the interface. This situation is physically analogous to the reflection of an underwater shock wave from a water surface. If the peak pressure of the shock wave is high enough, a form of cavitation will occur within the tissue near the boundary. Tissue at this boundary will also explode into the air-space because of the high particle velocity normal to the boundary imparted by the reflecting shock wave. Pathological consequences of these two effects could be destruction of tissues, loss of integrity of the boundary, and possible haemorrhage if capillaries or blood vessels are present" (Hill, 1978).

During the early 1970's, numerous tests were conducted on terrestrial mammals to determine injury mechanism and injury tolerance from underwater explosions. General details on these tests are provided by Yelverton et al. (1973). Specific explosion shockwave parameters and detailed pathological reports are provided by Richmond et al. (1973). "[These and other] experiments have shown that the principal damage sites in mammals are the gas-containing organs – the most seriously affected major organs being the lungs and the hollow viscera" (Hill, 1978).

"Lung injuries consist of the rupture of alveolar walls and lacerations of larger areas, with subsequent massive haemorrhage. Air emboli can also result when the boundaries between the alveolar spaces and adjacent capillary-beds rupture" (Hill, 1978).

"Damage to the viscera is mainly restricted to those portions of the lower intestine containing pockets of gas.... The most common injuries to the viscera are rupture and bruising of intestinal walls, and bleeding from the blood vessels of the walls. Gut contents can escape into the peritoneal space if the intestinal wall is perforated" (Hill, 1978).

"...(A)ir emboli produced by sublethal lung damage can lodge in the heart and brain, causing death by cardiac arrest or stroke.... (P)athological changes to the central nervous system [have been reported], but it is not clear whether these are caused by direct damage to the nervous system or are side-effects of injuries to the lungs or circulatory system. Extreme blast injury can involve the fracture of extremities and violent trauma to the thoracic cage and abdominal contents" (Hill, 1978).

"(L)arger animals are *less* subject to injury than small animals. This may be due to higher absorption of energy in the thicker body walls of larger animals. A rigid mass, either of bone or of an artificial nature, can afford some protection against shock waves. `Rib markings' – areas of bruising and haemorrhage – have been noted on the lungs of animals injured by underwater shock waves. These markings, indicating areas of greater damage, actually correspond to the spaces between the ribs, showing that the ribs protect the lungs beneath them.... (L)arge, uninflated lungs are less prone to be damaged by underwater shock waves than small, fully-inflated lungs" (Hill, 1978).

Figure D-1 shows regression analyses of terrestrial animal test data from Yelverton (1981), as reported by BBN Systems and Technologies (1993). The curves shown in Figure D-1 represent the best fit for "No Injury," "1% Mortality," and "50% Mortality" test data. These regression curves can be described by:

$$\ln I = 1.969 + 0.386 \ln M \quad \text{(No Injury)}$$
$$\ln I = 2.588 + 0.386 \ln M \quad \text{(1\% Mortality)}$$
$$\ln I = 3.019 + 0.386 \ln M \quad \text{(50\% Mortality)}$$

where I is impulse in psi-msec and M is body mass in kg.

D.2.1 Onset of Slight Injury

Using data from the Yelverton et al. (1973) report, Goertner (1982) developed a conservative theoretical model for two internal organ injury mechanisms to mammals exposed to underwater explosion shockwaves. These mechanisms are (1) lung hemorrhage, and (2) contusions and hemorrhage of the gastrointestinal (G.I.) tract. For lung hemorrhage, the Goertner model considers lung volume as a function of animal weight and depth and considers shockwave duration and impulse tolerance as a function of animal weight and depth. Goertner indicated that slight injury to the G.I. tract is related to the magnitude of the peak shockwave pressure over the hydrostatic pressure and would be independent of mammal size and weight. Slight contusions to the G.I. tract occurred during small charge tests (Richmond et al., 1973) when the peak shockwave pressure was 104 psi above hydrostatic pressure. Significant G.I. tract injury (G.I. tract hemorrhage) would be expected to occur at ranges significantly less than the maximum ranges for the onset of slight lung injury.

Table D-1 presents a comparison between actual small charge injury data (Richmond et al., 1973) and predicted values based on the Goertner model. The reference values used in this application of the Goertner model are the lowest impulse and body mass for which slight lung injury was reported by Richmond et al. (1973): 22.8 psi-msec (157.3 Pa-sec) and 93 lb (42 kg). After correcting for the atmospheric and hydrostatic pressures for the data, the minimum impulse for predicting onset of slight lung hemorrhage is:

$$I = 19.7\ (M/42)^{1/3} \text{ psi-msec, or}$$
$$I = 136\ (M/42)^{1/3} \text{ Pa-sec,}$$

where M is the body mass (in kg) of the subject animal. The test data indicate the ranges, peak shockwave pressures and impulses for which slight lung hemorrhage actually occurred to the test subject. The model predictions are ranges, peak pressures, and impulses which should describe conditions sufficient for the onset of slight lung hemorrhage. Regression curve values (Yelverton, 1981) indicate that for the range of body weights (masses) of 13 to 93 lb (6 to 42 kg), the "No Injury" impulses would be expected to range from 14.3 to 30.3 psi-msec (98.7 to 209.1 Pa-sec). Predictions for onset of slight lung injury based on actual test conditions using the Goertner model indexed to 19.7 psi-msec (136 Pa-sec) for a 93 lb (42 kg) mammal range from 10.1 to 22.2 psi-msec (69.7 to 153.2 Pa-sec). **Figure D-2** presents a comparison between the Yelverton (1981) "No Injury" regression curve for impulse vs. body mass and a plot of the predicted impulses for onset of slight lung hemorrhage for the test conditions in Table D-1. In order for the onset of slight lung injury model to be conservative, the predicted impulse values must be no greater than either the test values or regression curve predictions and the predicted ranges must be no less than the test values. As can be seen in Table D-1 and Figure D-2, these conditions are met by the onset of slight lung injury model.

Figure D-7 in Section D.3 summarizes maximum calculated ranges for the onset of slight lung hemorrhage and G.I. tract contusion as a function of marine mammal weight for a 10,000 lb

(4,536 kg) charge detonated at a depth of 100 ft (30 m). *For a calf dolphin (27 lb or 12.2 kg), the impulse associated with the predicted onset of slight lung hemorrhage is 28.1 psi-msec (194 Pa-sec), the maximum horizontal range is 5,821 ft (1,774 m), and the calculated peak shockwave pressure at this range is 37 psi (255 kPa).* For a 220 lb (100 kg) marine mammal, the maximum range is 4,351 ft (1,326 m) and the calculated peak shockwave pressure at this range is 52 psi (359 kPa). The maximum calculated horizontal range for slight contusions to the G.I. tract is 2,306 ft (703 m). The calculated peak shockwave pressure at this range is 106 psi (731 kPa). G.I. tract contusion and slight lung hemorrhage are injuries from which a mammal would be expected to recover on its own and would not be debilitating.

D.2.2 Lethal Injury

D.2.2.1 Lethality from Injury to Internal Organs

According to Hill (1978), the main cause of immediate death due to underwater shock waves is suffocation caused by extensive lung hemorrhage. "Air emboli can cause death soon after sublethal lung injury. In addition, fatal circulatory failure can occur, probably as a result of the obstruction of pulmonary circulation due to lung damage combined with general system shock. Death often occurs at some considerable time after the original injury. This usually comes about as a result of complications, such as broncho-pneumonia in damaged lungs, or peritonitis resulting from perforations of the intestinal wall" (Hill, 1978).

Richmond et al. (1973) reported that the lowest impulse level to inflict extensive lung injury was 44.4 psi-msec (306 kPa-sec) for a 75 lb (34 kg) mammal. After correcting for atmospheric and hydrostatic pressures, and based on the cube root scaling of body mass as used in the Goertner lung injury model, the minimum impulse for predicting onset of extensive lung hemorrhage is:

$$I_{1\%} = 42.9\ (M/34)^{1/3} \text{ psi-msec, or}$$
$$I_{1\%} = 296\ (M/34)^{1/3} \text{ Pa-sec,}$$

where M is the body mass (in kg) of the subject animal and $I_{1\%}$ is the minimum impulse for 1% mortality. For a 93 lb (42 kg) animal, the predicted impulse for onset of extensive lung hemorrhage would be 46 psi-msec (318 Pa-sec). (From Section D.2.1, the minimum impulse level for predicting slight lung hemorrhage for the same 93 lb [42 kg] animal is 19.7 psi-msec [136 Pa-sec]). Although the Goertner model was not originally developed for mortality calculations, it lends itself to this use because of the ability to specify reference impulse and body mass values.

Table D-2 provides a comparison between actual injury data (Richmond et al., 1973) and predicted values based on the Goertner model as used in this document. The test data indicate ranges, peak shockwave pressures and impulses for which extensive lung hemorrhage actually occurred to the test subjects. The model predictions are ranges, peak pressures, and impulses which should describe conditions sufficient for the onset of extensive lung hemorrhage when using the modified Goertner model.

Regression curve values (Yelverton, 1981) indicate that for the range of body weights (masses) of 75 to 110 lb (34 to 50 kg) the "1% Mortality" impulses would be expected to range from 51.9 to 60.2 psi-msec (354 to 410 Pa-sec). Predictions for onset of extensive lung hemorrhage based on actual test conditions using the Goertner model indexed to 42.9 psi-msec (296 Pa-sec) for a 75 lb (34 kg) mammal range from 43.5 to 48.2 psi-msec (296 to 328 Pa-sec).

Figure D-3 presents a comparison between the impulses based on the Yelverton (1981) 1% Mortality regression curve and the model predictions from Table D-2. In order for the onset of extensive lung injury model to be conservative, the predicted impulse values must be no greater than either the test values or the regression curve values, and the predicted ranges must be no less than the test values.

As can be seen in Table D-2 and Figure D-3, these conditions are met by the onset of extensive lung injury model. Therefore, the predicted onset of extensive lung hemorrhage can be used as a conservative index for onset of mortality (1%). (Because of the possible extreme combinations of very small charges and large to extremely large mammals, the onset of extensive lung injury model would not always apply. The extreme short ranges and resultant high peak shockwave pressures become indicative of external tissue damage and associated injuries. The onset of extensive lung injury model is therefore limited to ranges and impulses where the peak shockwave pressure is less than 1,400 psi [9.7 MPa).

Figure D-7 in section D.3 summarizes maximum calculated ranges for the onset of extensive lung hemorrhage (1% mortality) as a function of mammal weight for the 10,000 lb (4,536kg) charge at a 100 ft (30 m) detonation depth. *For a calf dolphin (27 lb or 12.2 kg), the impulse associated with the predicted onset of extensive lung injury is 55.1 psi-msec (380 Pa-sec), the maximum calculated horizontal range is 3,683 ft (1,123 m), and the calculated peak shockwave pressure at this range is 62 psi (428 kPa).* For a 220 lb (100 kg) marine mammal, the maximum range is 2,732 ft (833 m) and the calculated peak shockwave pressure at this range is 88 psi (607 kPa).

Extensive lung hemorrhage is an injury which would be debilitating and not all animals would be expected to survive (1% mortality is predicted at the onset level). Based on pathology reports (Richmond et al., 1973), G.I. tract injuries associated with the onset of extensive lung hemorrhage would include contusions with no ulcerations. As the severity of extensive lung hemorrhage increases beyond the onset level, G.I. tract injuries can increase significantly to include contusions with ulcerations throughout the entire G.I. tract and ultimately to include ruptures of the G.I. tract. The expected mortality level associated with these combined severe injuries would be significantly higher than 1%.

Based on the Yelverton (1981) 50% Mortality regression curve, impulses sufficient for 50% mortality range from 79.9 to 92.7 psi-msec (551 to 640 Pa-sec) for the range of body weights (masses) of 75 to 110 lb (34 to 50 kg). Referring to Table D-2 it can be seen that the first six rows of test data have values near or within the Yelverton 50% Mortality requirements. **Table D-3** presents a comparison of test data (Richmond et al., 1973) and Goertner model predictions. For occurrence of extensive lung hemorrhage, the Goertner model was indexed to 84.9 psi-msec (586 kPa-sec) for a 93 lb (42 kg) mammal:

$$I_{50\%} = 84.9\ (M/42)^{1/3} \text{ psi-msec, or}$$
$$I_{50\%} = 586\ (M/42)^{1/3} \text{ Pa-sec,}$$

where M is the body mass (in kg) of the subject animal and $I_{50\%}$ is impulse for 50% mortality.

Figure D-4 presents a comparison between the impulses based on the Yelverton (1981) 50% Mortality curve and the model predictions from Table D-3. The extensive lung hemorrhage calculations are in good agreement with the test data and the Yelverton 50% Mortality regression curve. The predicted impulse values are less than the regression curve values and the predicted ranges are slightly greater than the test values. The range and impulse values predicted for the occurrence of extensive lung hemorrhage and its attendant severe to extensive G.I. tract injuries can be used as an index for 50% mortality.

Figure D-7 in section D.3 summarizes maximum calculated ranges for the occurrence of extensive lung hemorrhage (50% mortality) as a function of mammal weight for a 10,000 lb (4,536 kg) charge at a 100 ft (30 m) detonation depth. *For a calf dolphin (27 lb or 12.2 kg), the impulse associated with extensive lung injury is 99.5 psi-msec (687 Pa-sec) and the maximum calculated horizontal range is 2,442 ft (745 m).* For a 220 lb (100 kg) marine mammal, the maximum horizontal range is 1,791 ft (546 m) and the calculated peak shockwave pressure at this range is 142 psi (980 kPa). (As with the onset of extensive lung injury model, the extensive lung injury model is limited to ranges and impulses where the peak shockwave pressure is less than 1,400 psi [9.7 Mpa]).

D.2.2.2 Lethal Injury from Shockwaves with High Peak Pressure

Myrick et al. (1990) reported on the effects to dolphin carcasses from underwater explosion tests using a 0.15 oz (5.76 g) "seal bomb." No damage was noted at a detonation distance of 2.3 ft (0.7 m). When the "seal bomb" was detonated 2 ft (0.6 m) away, "... a 5 x 7-cm jagged wound 4-cm deep was incurred above the right shoulder.... Subsequent examination of the carcass disclosed that the right shoulder blade had been shattered, the diaphysis of the humerus fractured, and the subscapular and intercostal musculature pulverized, but no penetration was made into the pulmonary cavity. Examination of the cranial bones revealed fractures to hamular processes of both pterygoids and a fractured left temporal bone. No internal damage was found, except possible evidence of compression on the right lung by the first right rib, thought perhaps to have been associated with the shoulder-blast damage. Participants in the examination of the specimen could not attribute cause of the cranial damage to test explosions partly because the temporal fracture was on the side opposite the shoulder damage. Further, there was no certainty that the cranial damage was not incurred elsewhere since postmortem history of the specimen was unknown" (Myrick et al., 1990).

Assuming the "seal bomb" to have a 90% TNT equivalence, the calculated peak shockwave pressures are 1451 psi (10.0 MPa) at a distance of 2.3 ft (0.7 m), and 1,711 psi (11.8 MPa) at a distance of 2 ft (0.6 m). Animals exposed to shockwave pressures of these magnitudes, regardless of the charge size or animal body weight, will be subjected to extremely high impulse levels. Depending upon the size of the animal, these impulse levels may or may not be lethally injurious to the animals' internal organs; however, overall system shock and significant external tissue damage as well as severe localized damage to the skeletal system would be expected. Animals suffering these types of injuries also would probably be at increased risk of disease and predation. All internal organ injury models used in this document use the 1,400 psi (9.7 MPa) peak shockwave pressure as a limiting value. Animals exposed to peak shockwave pressures in excess of 1,400 psi (9.7 MPa) would be considered lethally injured. For a 10,000 lb (4,536 kg) charge, the nominal calculated range for a peak shockwave pressure of 1,400 psi (9.7 MPa) is 243 ft (74 m).

D.2.3 Auditory System Injury

Tympanic membrane (TM) rupture, while not necessarily a serious or life-threatening injury, is a useful index of possible injury that is well correlated with measures of permanent hearing loss (Ketten, 1995; also see Appendix E).

TM rupture criteria can be developed based on a limited number of small charge tests as reported by both Yelverton et al. (1973) and Richmond et al. (1973). TM rupture-specific tests were conducted with dogs using nominal 1 lb (0.45 kg) TNT charges. Additional TM rupture data from general injury tests conducted with sheep using nominal 0.5 lb and 1 lb (0.23 kg and 0.45 kg) pentolite charges are also included. The test conditions and results from Richmond et al. (1973) are provided in **Table D-4**. Seven of the 11 test groups were conducted with only three subjects; two with six subjects; and two with 12 subjects. In some instances, eardrums were not accessible or readable following a test. For conservatism, these cases are counted as TM ruptures. To simplify the analysis, only eardrums directly facing the blast are used. Eardrums facing away from the blast were potentially subjected to significantly different shockwave loading than those directly facing the blast. Additionally, eardrums facing away from the blast may have been damaged by later-occurring intra-cranial pressures and/or cranial trauma rather than by directly measurable or readily calculable shockwave parameters. Handling and submergence tests conducted with control animals not subjected to explosions did not cause any TM ruptures.

Damage to terrestrial mammal internal organs has typically been referenced to total shockwave *impulse* (pressure integrated over time). Richmond et al. (1973) and Yelverton et al. (1973) also referenced TM rupture to total shockwave impulse. **Figure D-5** shows percentage of eardrum ruptures as a function of calculated total shockwave impulse from Table D-4. Total shockwave impulse appears to be an indicator for the occurrence of TM rupture. However, Appendix E provides a detailed discussion of potential acoustic effects on marine mammal auditory systems and indicates that acoustic *energy* (proportional to the *square* of pressure integrated over time) is the appropriate parameter for evaluation of the response of the mammalian ear to underwater noise.

Figure D-6 is percent TM rupture as a function of calculated total shockwave energy flux density using the calculated values from Table D-4. The upper bound (e.g., highest percentage of TM rupture observed for a specific energy level) for percentages of eardrums ruptured and the computed shockwave energy flux density values from data sets 1, 2, 5, 9, and 11 fall reasonably into place along an exponential curve. The shockwave energy flux density will be considered as a predictor of auditory system injury (TM rupture). The small sample sizes for the tests reported in Table D-4 in combination with the inherent variability in the occurrence of TM rupture at levels less than ~50% preclude realistic predictions of small percentages of occurrence of TM rupture. Ketten (1995) indicates that eardrum rupture is not synonymous with permanent hearing loss, although the two are correlated. In zones where > 50% tympanic membrane rupture occurs, 30% have long-term or permanent loss (Ketten, 1995).

Table D-5 provides the calculated shockwave energy flux densities for TM rupture percentages ranging from ~8% to 100%. Interpolation between the values for data sets 2 and 5 (42% and 67% TM rupture, respectively) indicates that the calculated energy flux density required for the occurrence of 50% TM rupture (~30% PTS) is 1.167 in-lb/in^2 (20.44 milli-Joules/cm^2).

Table D-6 provides the predicted ranges and shockwave peak pressure at selected depths for 50% terrestrial mammal TM rupture for the 10,000 lb (4,536 kg) charge using an energy flux density of 1.167 in-lb/in^2 (20.44 milli-Joules/cm^2). The maximum range (for an animal at the bottom) is 6,086 ft (1,855 m) and the predicted peak shockwave pressure at this range is 61 psi. (Figures 8-11 in section D.3 show the calculated 50% TM rupture contour.)

The Yelverton/Richmond TM rupture data used to develop the criterion can be evaluated by comparing with other mammalian TM rupture data. Table 1 of Ketten (1995) lists overpressures (in air) needed to induce 50% TM rupture in sheep, pigs, dogs, monkeys, humans, rabbits, and guinea pigs. According to Ketten (1995), sheep and pigs have ears closest anatomically to those of whales; Ketten (personal communication) has also indicated that rabbits and guinea pigs are least similar to marine mammals and should not be used for comparison. Excluding only rabbits and guinea pigs from consideration, overpressures ranging from 57-345 kPa are needed to cause 50% TM rupture. The overpressures convert to in-water pressures of 491-2,973 psi (3.4-20.5 MPa), and calculated ranges for the 10,000 lb (4,536 kg) charge are 443 to 2,139 ft (135 to 652 m). This comparison shows that the 50% TM rupture criterion developed based on the Yelverton/Richmond data set is reasonable and more conservative than would be derived using other mammalian TM rupture data.

D.2.3.1 Lethality as a Result of Auditory System Injury

As noted above, TM rupture is not necessarily a serious or life-threatening injury. However auditory damage has been reported to affect the mortality rate of whales in at least one case. Todd et al. (1996), reporting on the observed impacts of construction project blasting operations on seasonally resident humpback whales, noted that, "humpback whales showed little behavioral reaction to the detonations in terms of decreased residency, overall movements, or general behavior. However, it appears that the increased entrapment rate [in fishing gear] may have been influenced by the long term effects of exposure to deleterious levels of sound... " Lien et al. (1993) initially reported on the humpback whale behavioral responses; Ketten et al. (1993) and Ketten (1995) provided a detailed pathological description of the eardrum injuries.

The construction project differs significantly from the SEAWOLF project described in this document in several important respects:

- The whales at the construction site were seasonal residents, whereas marine mammals in the SEAWOLF test area are expected to be transients and would probably not be exposed to high sound pressure levels from multiple detonations.
- The construction project used a 1 nmi (1.9 km) safety range for all charge weights, from less than 2,200 lb (1,000 kg) to 12,125 lb (5,500 kg). The SEAWOLF shock tests will use a much greater safety range of 2 nmi (3.7 km).
- The blasting site for the construction project was a narrow, shallow fjord with rock walls and a hard reflective bottom. The highly reflective bottom and walls could have increased the intensity of the pressure levels to which the animals were exposed. In contrast, the SEAWOLF test area is in open ocean waters away from highly reflective side and bottom surfaces.

In addition, because the sound levels to which the whales were exposed is unknown, this event does not provide any information that could be used to evaluate the predicted injury ranges developed in this appendix.

D.3 CALCULATED INJURY RANGES FOR MARINE MAMMALS

Figure D-7 summarizes the maximum calculated ranges for 50% TM rupture, G.I. tract contusion, the onset of slight lung injury, 1% mortality, 50% mortality and 100% mortality as a function of marine mammal weight for a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

Figures D-8 through **D-11** provide calculated range contours for 50% TM rupture, onset of slight injury, 1% mortality (onset of extensive lung hemorrhage), and 50% mortality (extensive lung hemorrhage) for the 10,000 lb (4,536 kg) charge at a 100 ft (30 m) detonation depth. Separate figures are provided for representative cetaceans ranging from 3.3-ft-long/27-lb (1-m/12.2-kg) calf and 8-ft-long/384-lb (2.4-m/174-kg) adult dolphins to 20-ft-long/3,110-lb (6.1-m/1410-kg) and 55-ft-long/64,800-lb (16.8-m/29,400-kg) whales. Lung volume to body mass ratios of 3.9% have been presumed (Kooyman, 1973). These cetacean sizes were previously used by Goertner (1982) and O'Keeffe and Young (1984) in previous assessments of the potential effects of underwater explosions on marine mammals and are used in this document for continuity with prior efforts.

The injury ranges shown in **Figures D-8** through **D-11** are based on limited terrestrial animal test data and do not include any reduction for the inherent robustness of marine mammals which could significantly increase their resistance to these types of injuries. According to Hill (1978), "marine mammals are probably less vulnerable to *gross* physical damage from underwater shock waves than are land mammals of comparable size. This is primarily because of adaptations to pressure changes which enable these animals to dive and, secondarily, because of the increased thickness of their body walls." Therefore, on the basis of the best available information, the ranges shown in these figures for internal organ and auditory system injuries are believed to be conservative.

It should be noted that marine mammals with very large body mass should be significantly more resistant to internal organ injuries than to auditory system injury. That is, baleen whales could be at a relatively high degree of risk for auditory system injury while at a very low degree of risk for injury to internal organs.

D.4 MARINE MAMMAL PHYSICAL DISCOMFORT/TACTILE PERCEPTION

Marine mammals could experience physical effects such as brief discomfort or tactile perception of the detonation at ranges well beyond those for TM rupture or lung injury. These effects are not injuries, and they may or may not be considered harassment under the Marine Mammal Protection Act. The "harassment" issue is addressed in Section 4 of the FEIS; it is not necessary to discuss it here, because a more conservative criterion for harassment (i.e., one with a greater range) is developed in Appendix E based on auditory effects.

Occurrence of brief physical discomfort to cetaceans from the shockwave is inferred from data on voluntary human subjects exposed to the shockwave from a 1 lb (0.45 kg) pentolite charge and a 300 lb (136 kg) TNT charge (Christian and Gaspin, 1974). "This inference seems plausible given studies on dolphin skin sensitivity where the authors concluded that the most sensitive areas of the dolphin skin (mouth, eyes, snout, melon, and blowhole) are about as sensitive as the skin of the human lips and fingers (Ridgway and Carder, 1990 and 1993). Overall skin sensitivity of dolphins equals that of humans (Ridgway and Carder, 1993). Skin sensitivity for... large whales has not been tested." (Moore, 1993).

Exposed to the shockwave from the 1 lb (0.45 kg) charge, human subjects reported feeling no stings or pressure at a 120 ft (36.6 m) range [3.0 psi-msec (20.4 Pa-sec) impulse and 96 psi (654 kPa) peak pressure]; feeling moderate stings at a 115 ft (35.1 m) range [3.3 psi-msec (22.5 Pa-sec) impulse and 98 psi (668 kPa) peak pressure]; and feeling strong stings at a 100 ft (30.5 m) range [4.2 psi-msec (28.6 Pa-sec) impulse and 115 psi (784 kPa) peak pressure]. Shockwave durations were 0.033, 0.035, and 0.040 msec; and calculated energy flux densities were 0.06, 0.06, and 0.08 in-lb/in^2 (1.1, 1.1, and 1.4 milli-Joules/cm^2), respectively. Exposed to the shockwave from the 300lb (136 kg) TNT charge at a 4050 ft (1,235 m) range, human subjects heard "a muffled `thud' or rumbling.... No sensation of pressure on the body was experienced by any of the four divers..." (Christian and Gaspin, 1974). Nominal calculated shockwave parameters for the 300 lb (136 kg) test include a total impulse of 4 psi-msec (28 kPa-sec), total shockwave energy flux density of 0.01 in-lb/in^2 (0.18 milli-Joules/cm^2) and a 15 psi (104 kPa) peak shockwave pressure. The calculated total shockwave duration for the direct and bottom reflected shockwaves is 0.3 msec.

Consideration of partial impulse, energy flux density and peak shockwave pressure are used to assess the potential for occurrence of tactile perception and physical discomfort resulting from shockwaves from large charges. Tactile perception is unlikely when the peak shockwave pressure is less than 15 psi (104 kPa) *and* the energy flux density is less than 0.01 in-lb/in^2 (0.18 milli-Joules/cm^2). Moderate stings are possible when the peak shockwave pressure exceeds 15 psi (104 kPa) *and* the shockwave energy flux density exceeds 0.06 in-lb/in^2 (1.1 milli-Joules/cm^2). Strong stings are probable when the partial impulse exceeds 3.3 psi-msec (22.8 Pa-sec) within 0.035 msec.

The occurrence of brief physical discomfort is considered to be independent of mammal type, size, or weight. Depth-dependent horizontal ranges for brief physical discomfort and tactile perception as well as the shockwave peak pressures at these ranges for the 10,000 lb (4,536 kg) charge are presented in **Table D-7**. Brief physical discomfort (strong stings) would be highly probable at ranges less than about 0.4 to 0.7 nmi (0.8 to 1.3 km). Tactile perception would be unlikely at ranges that exceed 4 to 5 nmi (7.4 to 9.3 km). Between these two ranges, tactile perception and/or moderate stings are possible.

Figure D-12 presents nominal calculated range contours for brief physical discomfort and tactile perception for the 10,000 lb (4,536 kg) charge at a 100 ft (30 m) detonation depth. The non-injurious physical discomfort would only occur to animals which were undetected by active mitigation measures and would be of such brevity that it would be expected to cause at most a momentary startle response.

D.5 EFFECTS OF BULK CAVITATION ON MARINE MAMMALS

"Cavitation occurs when compression waves, which are generated by the underwater detonation of an explosive charge, propagate to the surface and are reflected back into the water as rarefaction waves. These rarefaction waves cause a state of tension to occur within a large region of water. Since water cannot ordinarily sustain a significant amount of tension, it cavitates and the surrounding pressure rises to the vapor pressure of water. The region in which this occurs is known as the bulk cavitation region, and it includes all water which cavitates at any time after the detonation of the explosive charge. The upper and lower boundaries, which show the maximum extent of the cavitated region, form what is referred to as the bulk cavitation envelope. ...The time of bulk cavitation closure is defined as the time at which the lower boundary displacement equals the surface layer displacement. It is at this time that the accreting surface layer and the accreting lower boundary collide and generate the water hammer pressure pulse" (Costanzo and Gordon, 1989).

The direct effects of cavitation on marine mammals are unknown. Presence within the negative pressure cavitation zone could injure the auditory system or lungs. A mammal located at (or in the immediate vicinity of) the cavitation closure depth would be subjected to the water hammer pressure pulse. The magnitude of the closure impulse can range from insignificant (smaller charges) to substantial (larger charges); however, at the calculated ranges for onset of lung hemorrhage as well as both 1% and 50% mortalities, the closure impulse is less than the required shockwave impulse required to cause the stated degree of injury.

The presence of a marine mammal within the cavitation region created by the detonation of small charges could annoy, injure, or even increase the severity of the injuries caused by the shockwave. The area of cavitation from a 10,000 lb (4,536 kg) charge would be expected to be an area of near total physical trauma. It is not expected that any fish or smaller animals would survive the combined effects of the relatively high shockwave impulses and the violent cavitation. The maximum lateral extent of this cavitation area is 1,620 ft (494 m) for the 10,000 lb (4,536 kg) charge, using the methods of Costanzo and Gordon (1989). (Refer to **Figure D-13** for delineation of the cavitation region.) Peak shockwave pressure at the above horizontal distance from the charge is 159 psi (1,097 kPa).

D.6 EFFECTS ON SEA TURTLES

There are virtually no quantitative data concerning the direct effects of underwater explosions on sea turtles. The only known data are those reported by O'Keeffe and Young (1984) and Klima et al. (1988), as summarized in **Table D-8**.

The O'Keeffe and Young (1984) data are from three underwater shock tests carried out off Panama City, Florida in 1981. During each test, a charge equivalent of 1,200 lb (544 kg) of TNT was detonated at mid-depth in water about 120 ft (37 m) deep. At least three turtles were noted in the area following the detonations. One turtle at a range of 500 to 700 ft (152 to 213 m) was killed. A second turtle at a range of 1,200 ft (366 m) received minor injuries. A third turtle at 2,000 ft (610 m) was apparently unaffected.

Klima et al. (1988) conducted an experiment in which Kemp's ridley and loggerhead turtles were placed in cages at four distances from a oil platform to be removed with explosives. The cages were submerged to a depth of 15 ft (4.5 m) over the 30 ft (9 m) sea bottom just prior to the simultaneous explosion of four 50.75 lb (23 kg) charges of nitromethane placed inside the platform pilings at a depth of 16 ft (5 m) below the mudline. Loggerhead and Kemp's ridley turtles at 750 ft (213 m) and 1,200 ft (366 m), as well as one loggerhead at 3,000 ft (915 m) were rendered unconscious. The Kemp's ridley turtle closest to the explosion (range of 750 ft or 229 m) was slightly injured, with an everted cloacal lining; ridleys at ranges of 1,200 ft (366 m), 1,800 ft (549 m) and 3,000 ft (915 m) were apparently unharmed. All loggerheads displayed abnormal pink coloration caused by dilated blood vessels at the base of the throat and flippers, a condition which persisted for about 3 weeks.

A major problem with the Klima et al. (1988) experiment was the lack of pressure measurements to estimate the magnitude and duration of the shockwave received by the turtles. As a follow-up, Connor (1988) states that "several turtles were to have been tethered near the site of ongoing platform/leg piling severance operations in the Gulf of Mexico... Strong ecological objections were raised, and these tests have been canceled for the foreseeable future." Although pressure measurements were subsequently made during a platform removal (Connor, 1990), further sea turtle experiments were never conducted (Connor, 1996). Gitschlag and Herczeg (1994) subsequently reported that only two turtles were impacted by explosive platform removals during 1986-1992. The authors did not present any data on the specific effects or turtle distance from the explosions.

The observations presented by O'Keeffe and Young (1984) are the best and most useful data, although the shallow water depth potentially increased the actual blast effects significantly due to bottom reflected shockwaves. In the absence of any model for shockwave effects on turtles, the Goertner (1982) model was run for the test conditions for onset of lung hemorrhage, onset of extensive lung hemorrhage, and extensive lung hemorrhage. **Figures D-14 and D-15** present the results. Because turtle depths at the time of detonation are unknown (but presumably well below the surface), the post-detonation ranges are indicated with a vertical line from water surface to the bottom in both figures.

As can be seen from Figure D-14, the 400 lb (181 kg) turtle located 500 to 700 ft (152 to 213 m) from the detonation and at depths of 10 ft (3 m) or greater would have been in a zone of 1% to greater than 50% mortality. The mortal injury suffered by this turtle is fully consistent with the model predictions.

Figure D-15 presents the predicted 50% TM rupture, onset of slight injury, 1% mortality, and 50% mortality curves for the two 200 to 300 lb (91 to 136 kg) turtles. To be conservative, the lower end of this weight range (200 lb or 91 kg) was used for calculations. The turtle at a range of 2,000 ft (610 m) would be expected to be uninjured if located in the upper half of the water column. The turtle at a range of 1,200 ft (366 m) would be expected to suffer minor to severe injuries depending on its depth. Again, the actual responses of the turtles are reasonably consistent with model predictions; the turtle at 2,000 ft (610 m) was uninjured and the turtle at 1,200 ft (366 m) suffered minor injuries.

Figure D-16 presents the calculated bulk cavitation region and closure depth for the 1,200 lb (544 kg) charge. The deep water predictions may not accurately represent the shallow water cavitation region.

Again, turtle ranges are indicated by a vertical line from water surface to the seafloor. Only the 400 lb (181 kg) turtle was within the bulk cavitation region. If the turtle were close to a depth of 20 to 35 ft (6.1 to 10.7 m) at the range of 500 to 700 ft (152 to 213 m), it would have been subjected to the bulk cavitation closure impulse ("water hammer" effect) at the closure depth. The "water hammer" impulse is the impulse imparted to an object in the immediate vicinity of the closure depth where the upper cavitated region collapses upon the lower cavitated region. At a range of 500 ft (152 m) and a depth of 27 ft (8.2 m), the closure impulse is calculated to be 99.6 psi-msec (679 Pa-sec) – higher than the 74.9-psi-msec (500 Pa-sec) based on the Goertner model index value 1% mortality impulse. At a range of 700 ft (213 m) and a depth of 29 ft (8.8 m), the closure impulse is calculated to be 35.9 psi-msec (245 Pa-sec) – slightly over the 32.1 psi-msec (211 Pa-sec) no-injury impulse based on the Goertner model index values. Although the cavitation closure impulses are similar in magnitude to shockwave impulses, the delivery time of the impulse is longer, potentially reducing the damaging power. The cavitation closure impulses could be expected to cause injury or increase the severity of shockwave injuries.

The Klima et al. (1988) data set with the buried 203 lb (93 kg) charges presents interesting low-level, non-injury response data. However, the lack of pressure measurements and the use of buried charges in shallow water present very nearly a total analysis conundrum. Peak shockwave pressures for buried charges can be as low as 10% of the expected free-field values for non-buried charges (Connor, 1990). The estimated/calculated peak pressures presented by the researchers are of such low magnitude that injury would not be expected. Based on the ranges and estimated pressures for this data set, standard similitude equations and weak shock theory (Gaspin, 1983) were used to calculate an equivalent "non-buried" charge weight. A 2 lb (0.92 kg) TNT charge detonated free-field would produce the shockwave pressures at the ranges shown in Table D-8. However, since the water depth was extremely shallow, multiple shockwave pulses and bulk cavitation resulting from bottom and surface-reflected shockwaves could have impacted the turtles. With no recorded pressure-time histories from which to analyze actual shockwave peak pressures and durations, realistic impulse and energy calculations cannot be made.

On the basis of the first data set in Table D-8, O'Keeffe and Young (1984) proposed that a safe range for turtles from an underwater explosion could be expressed by $R = 200\ w^{1/3}$, where R is the safe range in feet and w is the charge weight in pounds. This equation was subsequently modified by Young (1991) based on safe ranges established by the National Marine Fisheries Service for platform removal operations using explosives. The revised equation is $R = 560\ w^{1/3}$. Applied to the Klima et al. (1988) observations, this equation predicts a safe range of 3,291 ft (1,003 m), which exceeds the greatest distance at which an effect was observed (turtle unconscious at 3,000 ft or 915 m). For SEAWOLF shock testing, this equation would predict a safe range of 12,065 ft (3,677 m), which is slightly less than the actual safety range of 12,152 ft (3,700 m).

In conclusion, the very limited data available for mortality and injury of sea turtles from underwater explosions are consistent with the lung injury and 50% TM rupture predictions developed in this appendix. Therefore, use of the same mortality and injury criteria for sea turtles and marine mammals is reasonable. Further, the proposed safety range of 12,152 ft (3,700 m) for the SEAWOLF detonations exceeds the predicted safe range for sea turtles calculated using the O'Keeffe and Young (1984) or Young (1991) equations.

Lung injury criteria for marine mammals developed in this appendix vary with animal size, with smaller animals being more vulnerable. Mortality calculations in the FEIS are conservatively based on the values for a very small marine mammal -- a calf dolphin (27 lb or 12.2 kg). Because adult sea turtles can weigh several hundred pounds, the mortality range would be less for them (i.e., they would have to be much closer to the detonation to be killed). Therefore, using the marine mammal mortality range for sea turtles tends to overestimate turtle impacts. Juvenile and hatchling turtles have a small body mass, but they are typically associated with floating sargassum in near-surface waters. As shown in Figure D-8, ranges for both mortality (onset of extensive lung hemorrhage) and injury (50% TM rupture) are generally much less near the surface (i.e., the animals would have to be closer to the detonation to be affected). This is also true for cavitation (Figure D-13). Again, using the marine mammal mortality and injury criteria for juvenile and hatchling sea turtles is believed to be conservative.

D.7 CONCLUSIONS

A variety of physical impacts to marine mammals and turtles have been discussed in this appendix. Criteria and estimated ranges are summarized in **Table D-9**. The mortality and injury criteria adopted for calculations in the Environmental Consequences section of the FEIS are as follows:

- Mortality. The mortality criteria is the predicted onset of extensive lung hemorrhage for a 27 lb (12.2 kg) calf dolphin based on the Goertner (1982) model. The impulse associated with the predicted onset of extensive lung hemorrhage is 55.1 psi-msec (380.2 Pa-sec), and the estimated maximum range for this criterion under SEAWOLF shock test conditions is 3,683 ft (1,123 m).

- Injury. The injury criterion is 50% TM rupture, based on experiments with terrestrial mammals exposed to detonations. TM rupture *per se* is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing loss (see Appendix E). The energy associated with predicted 50% TM rupture is 1.17 in-lb/in^2 (20.44 milli-Joules/cm^2), and the maximum range for this criterion under SEAWOLF shock test conditions is estimated to be 6,086 ft (1,855 m) or about 1 nautical mile.

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Table D-1. Model verification for "slight lung hemorrhage."

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[1]			MODEL PREDICTIONS		
Weight lb/(kg)	Depth ft/(m)	Body Mass lb/(kg)	Depth ft/(m)	Range ft/(m)	Peak Pressure psi/(kPa)	Impulse psi-msec/(Pa-sec)	Range[2] ft/(m)	Peak Pressure[2] psi/(kPa)	Impulse[3] psi-msec/(Pa-sec)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	33 (10.1)	403 (2746)	20.2 (138)
1.052 (0.48)	10.0 (3.0)	101 (46)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	44 (13.4)	290 (1976)	19.9 (136)
1.052 (0.48)	10.0 (3.0)	75 (34)	1.0 (0.30)	26 (7.9)	588 (1007)	50.6 (345)	47 (14.3)	272 (1854)	18.0 (123)
1.052 (0.48)	10.0 (3.0)	35 (16)	1.0 (0.30)	26 (7.9)	588 (1007)	50.6 (345)	54 (16.5)	233 (1588)	14.0 (95)
1.052 (0.48)	10.0 (3.0)	44 (20)	1.0 (0.30)	26 (7.9)	478 (3257)	41.5 (283)	52 (15.9)	244 (1663)	15.1 (103)
1.052 (0.48)	10.0 (3.0)	13 (6)	1.0 (0.30)	26 (7.9)	478 (3257)	41.5 (283)	65 (19.8)	191 (1302)	10.1 (69)
1.052 (0.48)	10.0 (3.0)	82 (37)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4 (303)	60 (18.3)	207 (1411)	18.9 (129)
1.052 (0.48)	10.0 (3.0)	90 (41)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4 (303)	59 (17.9)	212 (1445)	19.5 (133)
1.052 (0.48)	10.0 (3.0)	93 (42)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	85 (25.9)	142 (968)	22.2 (151)
1.052 (0.48)	10.0 (3.0)	90 (41)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	86 (26.2)	141 (961)	22.0 (150)
1.052 (0.48)	10.0 (3.0)	88 (40)	10.0 (3.05)	48 (14.6)	269 (1833)	45.5 (310)	86 (26.2)	139 (947)	21.8 (149)
1.052 (0.48)	10.0 (3.0)	93[4] (42)	10.0 (3.05)	84 (25.6)	153 (1043)	22.8[4] (155)	85 (25.9)	142 (968)	22.2 (151)
2.618 (1.19)	10.0 (3.0)	79 (36)	1.0 (0.30)	36 (11.0)	538 (3666)	40.3 (275)	58 (17.7)	304 (2072)	18.4 (125)
2.618 (1.19)	10.0 (3.0)	75 (34)	1.0 (0.30)	36 (11.0)	538 (3666)	40.3 (275)	58 (17.7)	301 (2051)	18.0 (123)
8.373 (3.80)	10.0 (3.0)	79 (36)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	357 (2433)	18.4 (125)
8.373 (3.80)	10.0 (3.0)	82 (37)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	359 (2447)	18.5 (126)
8.373 (3.80)	10.0 (3.0)	79 (36)	1.0 (0.30)	52 (15.8)	556 (3789)	33.2 (226)	73 (22.3)	357 (2433)	18.4 (125)

[1] Occurrence of slight lung hemorrhage in test animals (Richmond et al., 1973)
[2] Peak pressure and range for a given impulse, calculated using Weak Shock Theory (Gaspin, 1983)
[3] Impulse for predicted onset of slight lung hemorrhage based on the Goertner (1982) model
[4] Reference value for calculations
Source: CD-NSWC/UERD.

Table D-2. Model verification for "onset of extensive lung hemorrhage."

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[1]			MODEL PREDICTIONS		
Weight lb/(kg)	Depth ft/(m)	Body Mass lb/(kg)	Depth ft/(m)	Range ft/(m)	Peak Pressure psi/(kPa)	Impulse psi-msec/ (Pa-sec)	Range ft/(m)	Peak Pressure[2] psi/(kPa)	Impulse[3] psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	95 (43)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	21 (6.4)	684 (4661)	45.8 (312)
1.052 (0.48)	10.0 (3.0)	106 (48)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	702 (4784)	47.5 (324)
1.052 (0.48)	10.0 (3.0)	110 (50)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	708 (4825)	48.2 (328)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	20 (6.1)	705 (4805)	47.9 (326)
1.052 (0.48)	10.0 (3.0)	95 (43)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	26 (7.9)	522 (3557)	46.2 (315)
1.052 (0.48)	10.0 (3.0)	99 (45)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	26 (7.9)	528 (3598)	46.9 (320)
1.052 (0.48)	10.0 (3.0)	75[4] (34)	2.0 (0.61)	33 (10.1)	436 (2971)	44.4[4] (303)	34 (10.4)	394 (2685)	43.5 (296)

1 Occurrence of extensive lung hemorrhage in test animals (Richmond et al., 1973)
2 Peak pressure and range for a given impulse, predicted using Weak Shock Theory (Gaspin, 1983)
3 Impulse for predicted onset of extensive lung hemorrhage based on the Goertner (1982) model
4 Reference value for calculations

Source: CD-NSWC/UERD

Table D-3. Model verification for "extensive lung hemorrhage."

EXPLOSIVE (Pentolite)		MAMMAL		TEST DATA[1]			MODEL PREDICTIONS		
Weight lb/(kg)	Depth ft/(m)	Body Mass lb/(kg)	Depth ft/(m)	Range ft/(m)	Peak Pressure psi/(kPa)	Impulse psi-msec/ (Pa-sec)	Range[2] ft/(m)	Peak Pressure[2] psi/(kPa)	Impulse[3] psi-msec/ (Pa-sec)
1.052 (0.48)	10.0 (3.0)	95 (43)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1072 (7306)	84.1 (573)
1.052 (0.48)	10.0 (3.0)	106 (48)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1105 (7531)	87.3 (595)
1.052 (0.48)	10.0 (3.0)	110 (50)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1117 (7612)	88.5 (603)
1.052 (0.48)	10.0 (3.0)	108 (49)	0.5 (0.15)	13 (4.0)	1089 (7422)	85.7 (584)	14 (4.3)	1111 (7571)	87.9 (599)
1.052 (0.48)	10.0 (3.0)	95 (43)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	17 (5.2)	875 (5963)	84.9 (579)
1.052 (0.48)	10.0 (3.0)	99 (45)	1.0 (0.30)	16 (4.9)	987 (6726)	99.6 (679)	17 (5.2)	887 (6045)	86.2 (587)

[1] Occurrence of extensive lung hemorrhage in test animals (Richmond et al., 1973)
[2] Peak pressure and range for a given impulse, predicted using Weak Shock Theory (Gaspin, 1983)
[3] Impulse for predicted extensive lung hemorrhage using the Goertner (1982) model

Source: CD-NSWC/UERD

Table D-4. Eardrum damage test conditions and results.

DATA SET	EXPLOSIVE[1]		RANGE	PEAK PRESSURE[2]	TOTAL IMPULSE[2]	TOTAL ENERGY[2]	EARDRUMS[3]			
	Type	Weight lb / (kg)	ft / (m)	psi / (kPa)	psi-msec / (Pa-sec)	in-lb/in^2 / (milli-Joules/cm^2)	No.	Depth ft / (m)	No. Ruptured	Percent Ruptured
1	TNT	1.047 (0.47)	20 (6.1)	672 (4580)	59.4 (405)	4.244 (74.34)	3	1 (0.3)	3	100
2	TNT	1.047 (0.47)	40 (12.2)	306 (2085)	21.2 (144)	0.854 (14.96)	12	1 (0.3)	4 - 5[4]	33 - 42[4]
3	TNT	1.047 (0.47)	45 (13.7)	269 (1833)	17.3 (118)	0.637 (11.16)	6	1 (0.3)	0	0
4	TNT	1.047 (0.47)	60 (18.3)	195 (1329)	10.5 (71)	0.301 (5.27)	3	1 (0.3)	0	0
5	Pentolite	1.047 (0.47)	33 (10.1)	401 (2733)	44.4 (303)	1.912 (33.49)	3	2 (0.6)	2	67
6	Pentolite	1.047 (0.47)	54 (16.5)	232 (1581)	22.2 (151)	0.653 (11.44)	3	2 (0.6)	0	0
7	Pentolite	1.047 (0.47)	83 (253)	145 (988)	10.9 (74)	0.228 (3.99)	3	2 (0.6)	0	0
8	Pentolite	1.047 (0.47)	48 (14.6)	264 (1799)	37.4 (255)	0.931 (16.31)	3	10 (3.0)	0	0
9	Pentolite	1.047 (0.47)	84 (25.6)	143 (975)	22.3 (152)	0.313 (5.48)	6	10 (3.0)	0 - 1[4]	0 - 17[4]
10	Pentolite	0.485 (0.22)	93 (28.3)	97 (661)	6.9 (47)	0.093 (1.63)	3	2 (0.6)	0	0
11	Pentolite	0.485 (0.22)	100 (30.5)	89 (607)	12.0 (82)	0.106 (1.86)	12	10 (3.0)	1	8

[1] Minimum charge weights; all tests conducted with charge at 10 ft (3.0 m) depth.
[2] Calculated values.
[3] Eardrums facing the charge.
[4] Not all eardrums were accessible or readable after a test; the second value given presumes that these eardrums were ruptured.
Source: Richmond et al. (1973); CD-NSWC/UERD

Table D-5. Observed percentage of tympanic membrane (TM) ruptures for upper bound values of calculated shockwave energy flux density.

Energy Flux Density		TM Rupture Percentage	Data Set[1]
in-lb/in^2	(milli-Joules/cm^2)		
0.106	(1.86)	8	11
0.313	(5.48)	0-17	9
0.854	(14.96)	33-42	2
1.912	(33.49)	67	5
4.244	(74.34)	100	1

[1] From Table 4

Table D-6. Predicted ranges for small terrestrial mammal tympanic membrane (TM) rupture for a 10,000 lb (4,536 kg) charge detonated at 100 ft (30 m depth).

Mammal Depth (ft / (m)	50% TM Rupture Range[1] ft / (m)	Shockwave Peak Pressure psi / (dB re 1 microPa)
50 / (15)	3,470 / (1,058)	67 / (233)
250 / (76)	4,279 / (1,304)	53 / (231)
500 / (152)	6,086 / (1,855)	61 / (232)

[1] Based on shockwave energy flux density.
Source: NSWCCD/UERD

Table D-7. Maximum ranges for brief physical discomfort from and tactile perception of underwater explosion shockwaves from a 10,000 lb (4,536 kg) charge detonated at 100 ft (30 m) depth.

	Maximum Range for Probable Brief Physical Discomfort		Maximum Range for Possible Tactile Perception	
Depth ft / (m)	Range ft / (m)	P_{max} psi / (kPa)	Range ft / (m)	P_{max} psi / (kPa)
50 / (15)	2550 / (777)	95 / (656)	19,200 / (5852)	9 / (62)
250 / (76)	2550 / (777)	95 / (656)	24,320 / (7413)	7 / (48)
500 / (152)	4140 / (1262)	95 / (656)	30,250 / (9220)	10 / (69)

Source: NSWCCD/UERD, after Christian and Gaspin (1974).

Table D-8. Underwater explosion effects on sea turtles reported by O'Keeffe and Young (1984) and Klima et al. (1988).

CHARGE WEIGHT lb/(kg)	CHARGE DEPTH ft/(m)	WATER DEPTH ft/(m)	TURTLE WEIGHT lb/(kg)	TURTLE DEPTH ft/(m)	RANGE ft/(m)	PEAK PRESSURE psi/(kPa)	INJURIES Immediate	INJURIES 1-hr after blast
O'KEEFFE AND YOUNG (1984)								
1200[1]/(544)	60/(18.3)	120/(36.6)	400/(181)	unknown	500-700/ (152-213)	258-178/ (1758-1213)[2]	Mortal injury	---
1200[1]/(544)	60/(18.3)	120/(36.6)	200-300/ (91-136)	unknown	1200/(366)	99/(675)[2]	Minor injury	---
1200[1]/(544)	60/(18.3)	120/(36.6)	200-300/ (91-136)	unknown	2000/(610)	57/(388)[2]	None	---
KLIMA ET AL. (1988)								
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	14.8/(6.7)	14.8/(4.5)	750/(229)	16.3/(111)[3]	Unconscious	Vasodilation around throat and flippers (lasted 2-3 wks); 2 cm of cloacal lining everted
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	9.3/(4.2)	14.8/(4.5)	750/(229)	16.3/(111)[3]	Unconscious	As above and including redness around eyes and nose
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	1.3/(0.6)	14.8/(4.5)	1200/(366)	10.3/(70)[3]	Unconscious	Appeared normal
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	12.1/(5.5)	14.8/(4.5)	1200/(366)	10.3/(70)[3]	Unconscious	Normal behavior, but vasodilation around base of flippers (lasted 2-3 wks)
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	2.9/(1.3)	14.8/(4.5)	1800/(549)	6.5/(44)[3]	None visible	Appeared normal
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	8.8/(4.0)	14.8/(4.5)	1800/(549)	6.5/(44)[3]	None visible	Appeared normal except for vasodilation around throat and flippers (lasted 2-3 wks)
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	3.3/(1.5)	14.8/(4.5)	3000/(915)	4.1/(28)[3]	None visible	Appeared normal
203[2]/(92)	14.8/(4.5)[3]	29.5/(9.5)	15.0/(6.8)	14.8/(4.5)	3000/(915)	4.1/(28)[3]	Unconscious	Appeared normal except for vasodilation around throat and flippers (lasted 2-3 wks)

1 TNT equivalent.
2 Four 50.75 lb (23 kg) nitromethane charges buried 16.4 ft (5 m) below the mudline.
3 Calculations for buried charges assumed a 2 lb (0.92 kg) TNT charge detonated "free-field" at mid-depth in the water column.

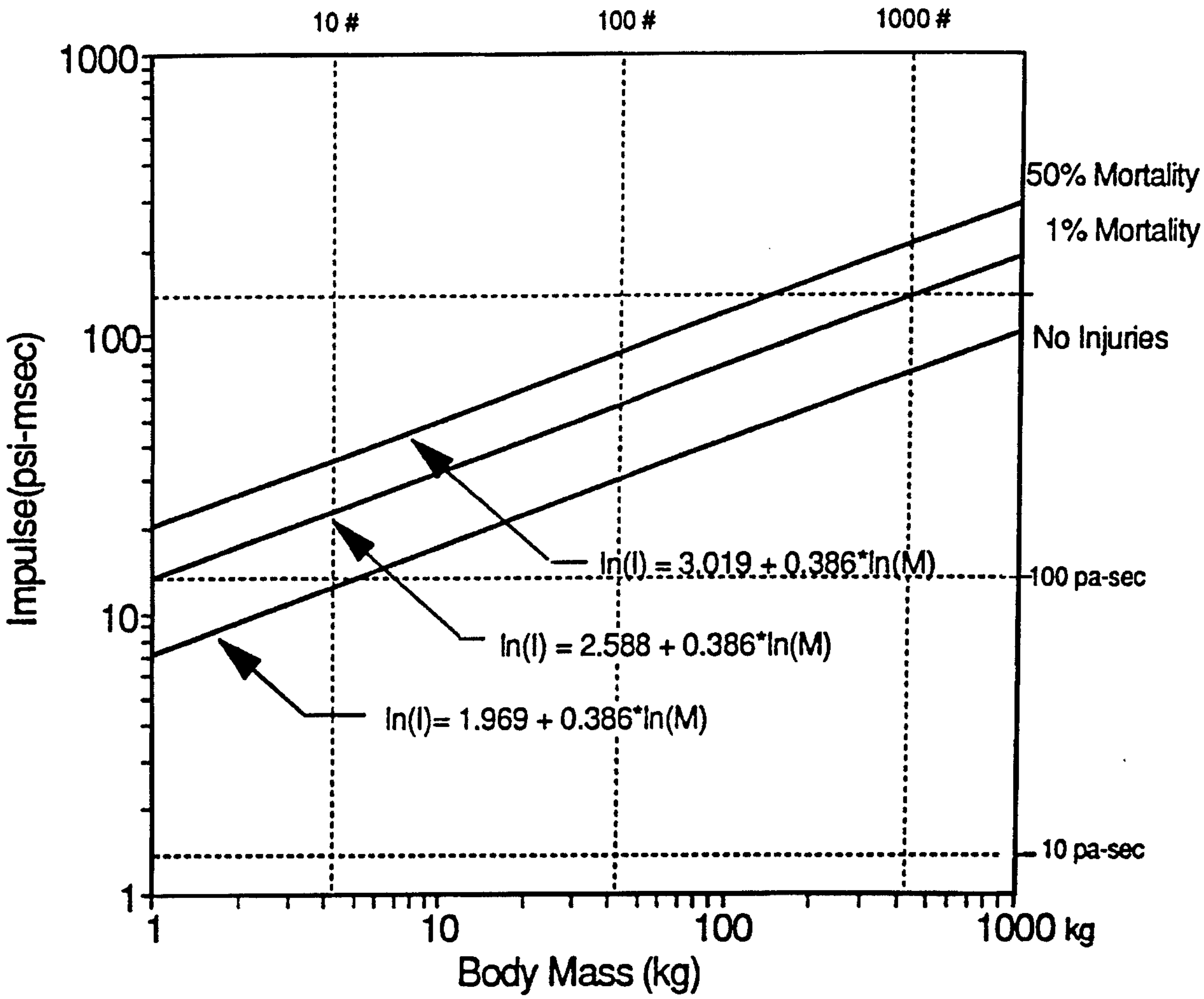
Table D-9. Summary of potential effects discussed in this appendix.

Type of Effect	Criterion	Predicted Maximum Range
Lethality from high peak pressure	Peak pressure 1,400 psi (9,660 kPa)	243 ft (74 m)
Lethality due to cavitation	Maximum horizontal extent of bulk cavitation region	1,620 ft (494 m)
Extensive lung hemorrhage (50% mortality)[1]	Impulse 99.5 psi-msec (687 Pa-sec)	2,442 ft (745 m)
Onset of extensive lung hemorrhage (1% mortality)[1,2]	Impulse 55.1 psi-msec (380 Pa-sec)	3,683 ft (1,123 m)
Brief physical discomfort (strong stings)	Partial impulse 3.3 psi-msec (22.8 Pa-sec) within 0.035 msec	4,140 ft (1,262 m)
Onset of slight lung hemorrhage[1]	Impulse 28.1 psi-msec (194 Pa-sec)	5,821 ft (1,774 m)
50% tympanic membrane rupture[3]	Energy flux density 1.17 in-lb/in^2 (20.44 milli-Joules/cm^2)	6,086 ft (1,855 m)
Tactile perception	Pressure >15 psi (104 kPa) and energy flux density >0.01 in-lb/in^2 (0.18 milli-Joules/cm^2)	30,250 ft (9,220 m)

[1] Criterion varies with animal size, with smaller animals being more vulnerable. The value given is for a very small marine mammal -- a calf dolphin (27 lb or 12.2 kg). Criteria for adult dolphins and whales would be higher and effect ranges would be lower (i.e., they would have to be closer to the detonation to be affected).

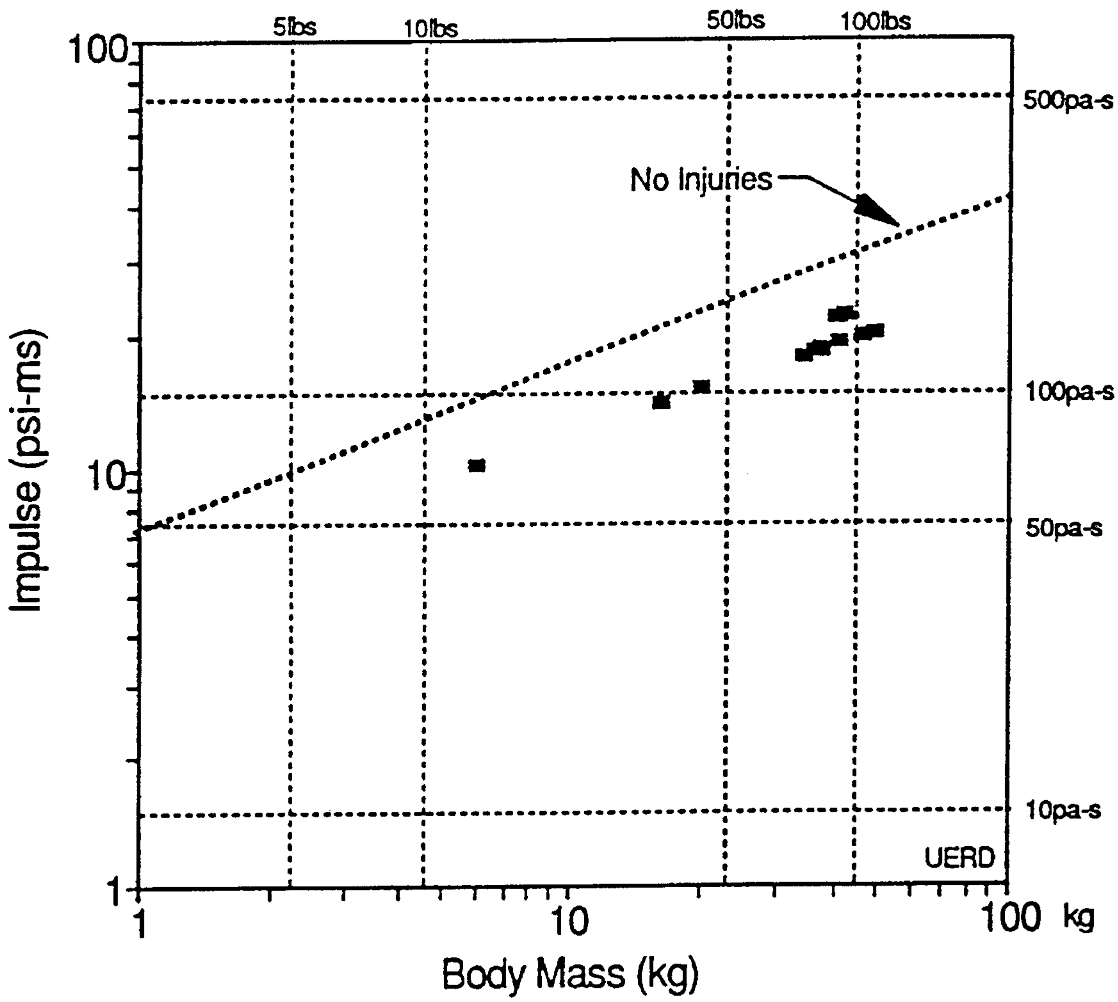
[2] Mortality criterion used for calculations in the Environmental Consequences section of the FEIS.

[3] Injury used for calculations in the Environmental Consequences section of the FEIS. Criterion is assumed independent of animal size but varies with animal depth. The maximum range (given here) is for an animal at the bottom (500 ft or 152 m).



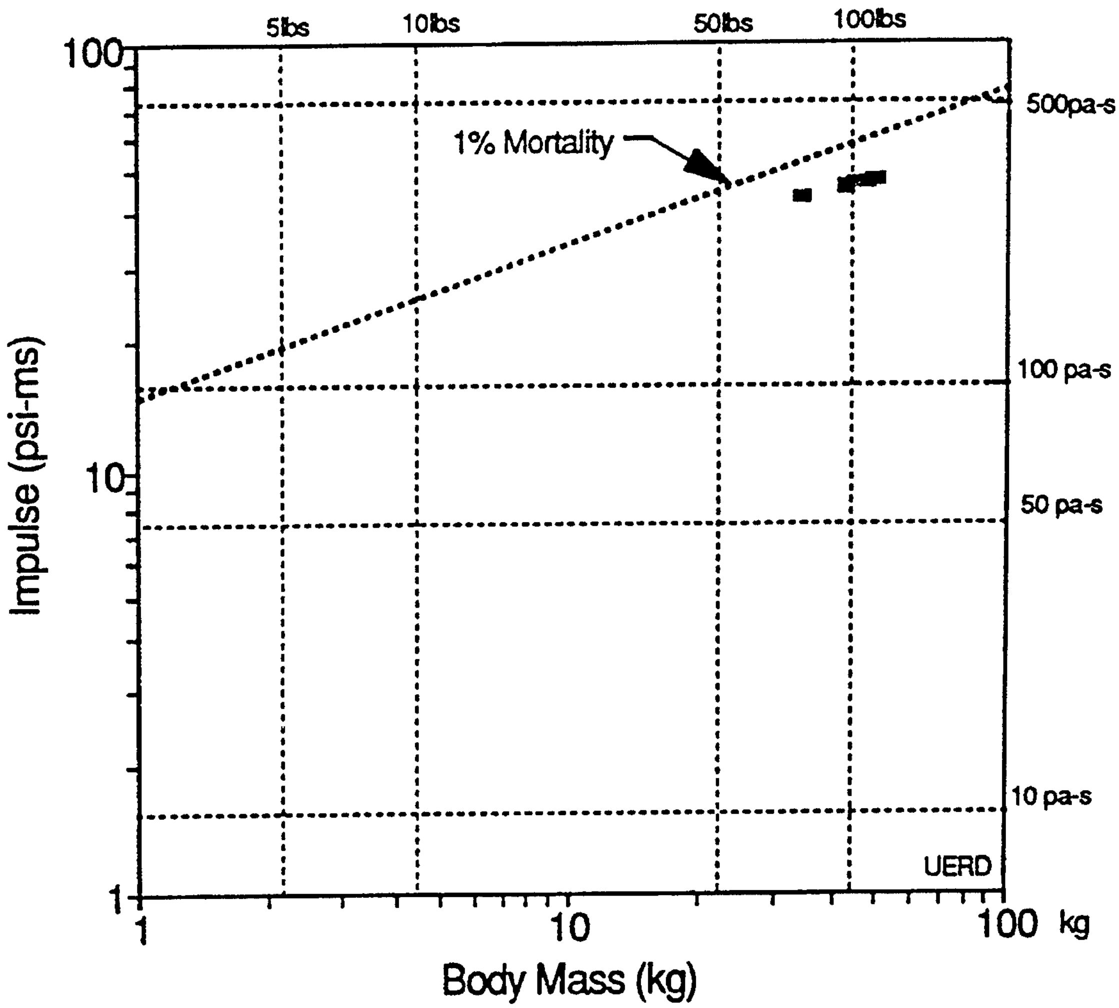
Source: Yelverton (1981)

Figure D-1. Regression curves for blast damage to mammals as a function of mammal mass.



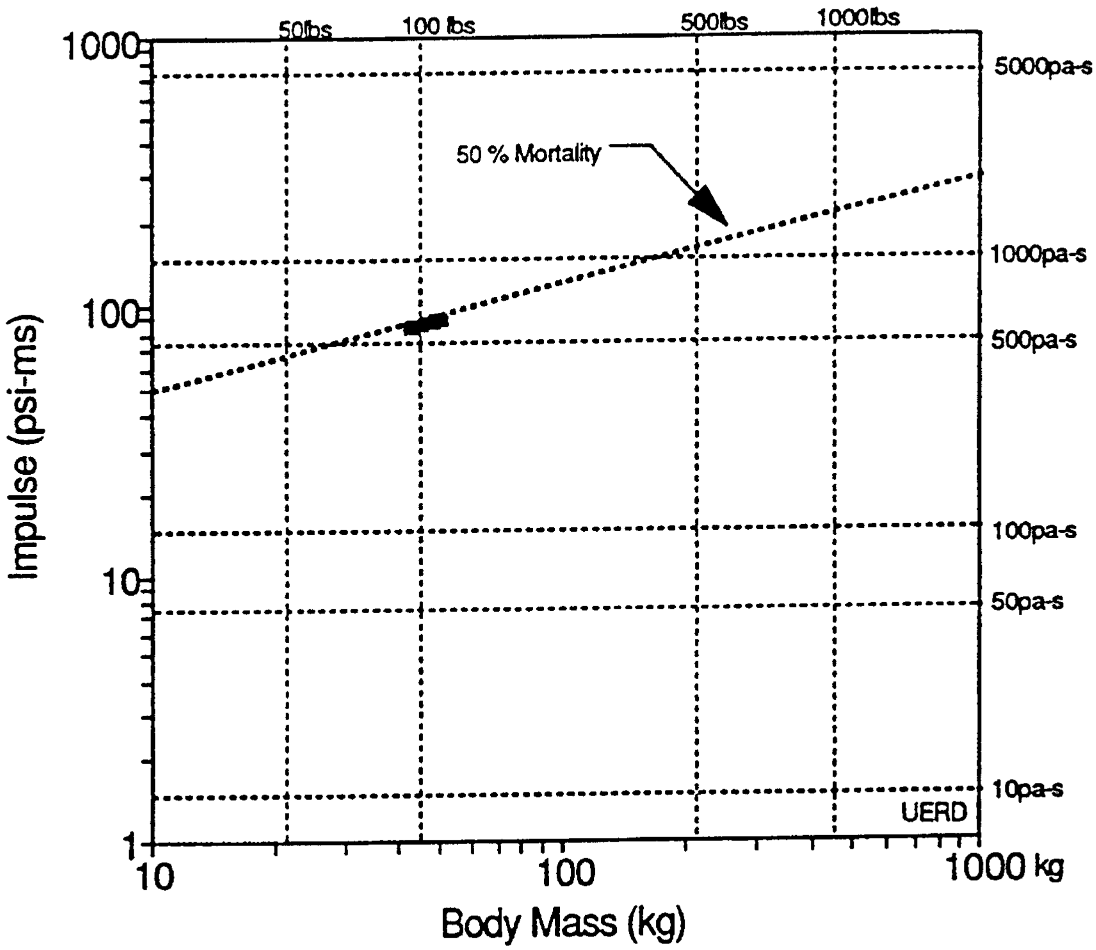
Source: Yelverton (1981), CD-NSWC/UERD

Figure D-2. Comparison of impulses for "no injury" and for "onset of slight lung hemorrhage."



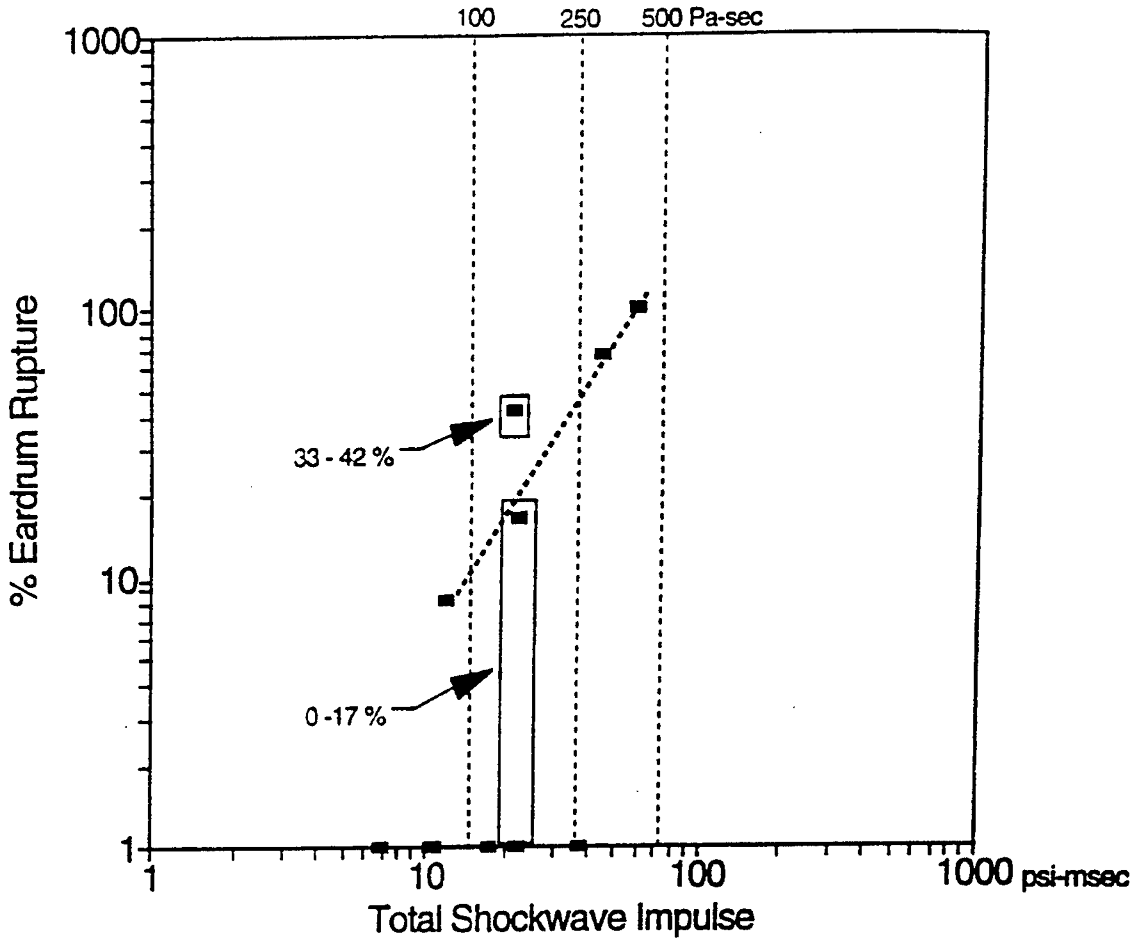
Source: Yelverton (1981), CD-NSWC/UERD

Figure D-3. Comparison of predicted 1% mortality and calculated "onset of extensive lung hemorrhage" impulses.



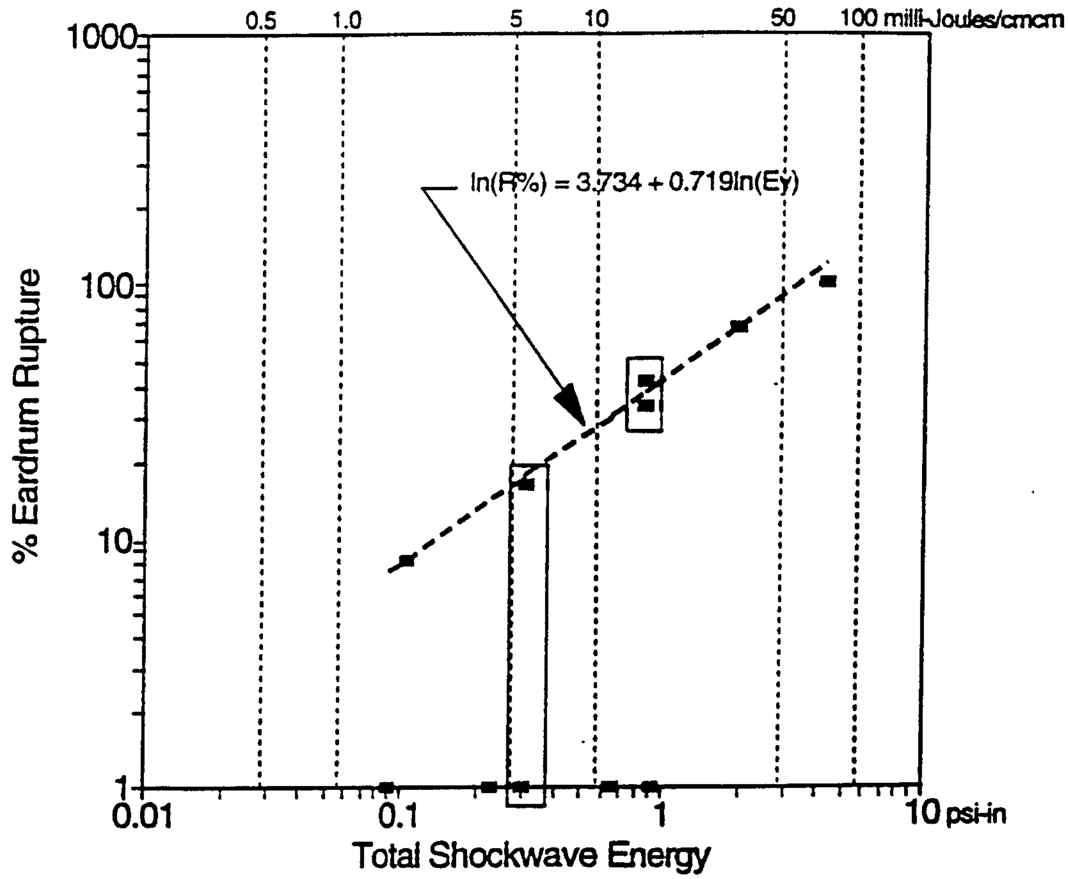
Source: Yelverton (1981), CD-NSWC/UERD

Figure D-4. Comparison of predicted 50% mortality and calculated "extensive lung hemorrhage" impulses.



Source: CD-NSWC/UERD after Richmond, et al. (1973) and Yelverton, et al. (1973)

Figure D-5. Eardrum rupture as a function of calculated total shockwave impulse.



Source: CD-NSWC/UERD

Figure D-6. Eardrum rupture as a function of calculated total shockwave energy.

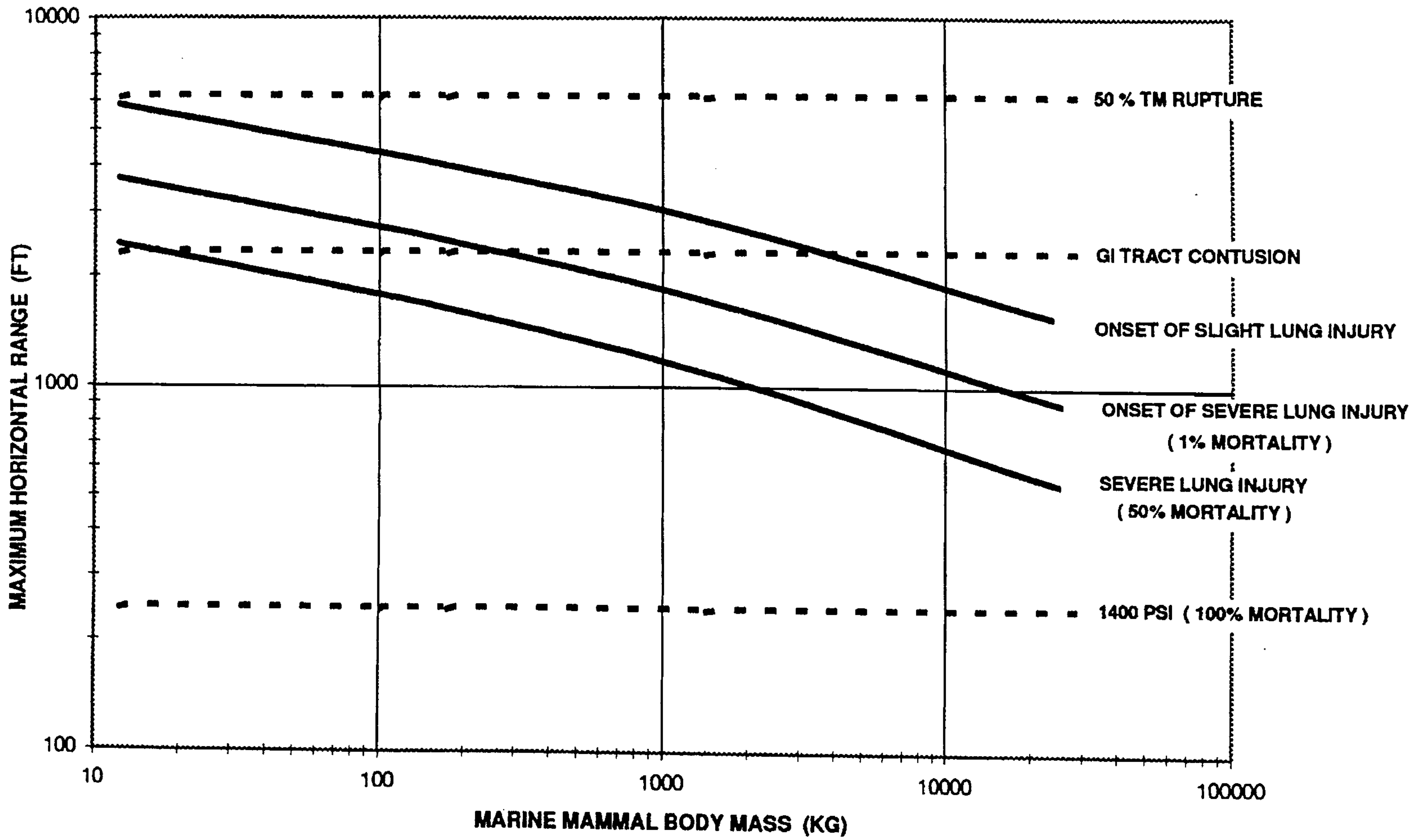


Figure D-7. Maximum calculated ranges for various effects in relation to marine mammal body mass for a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

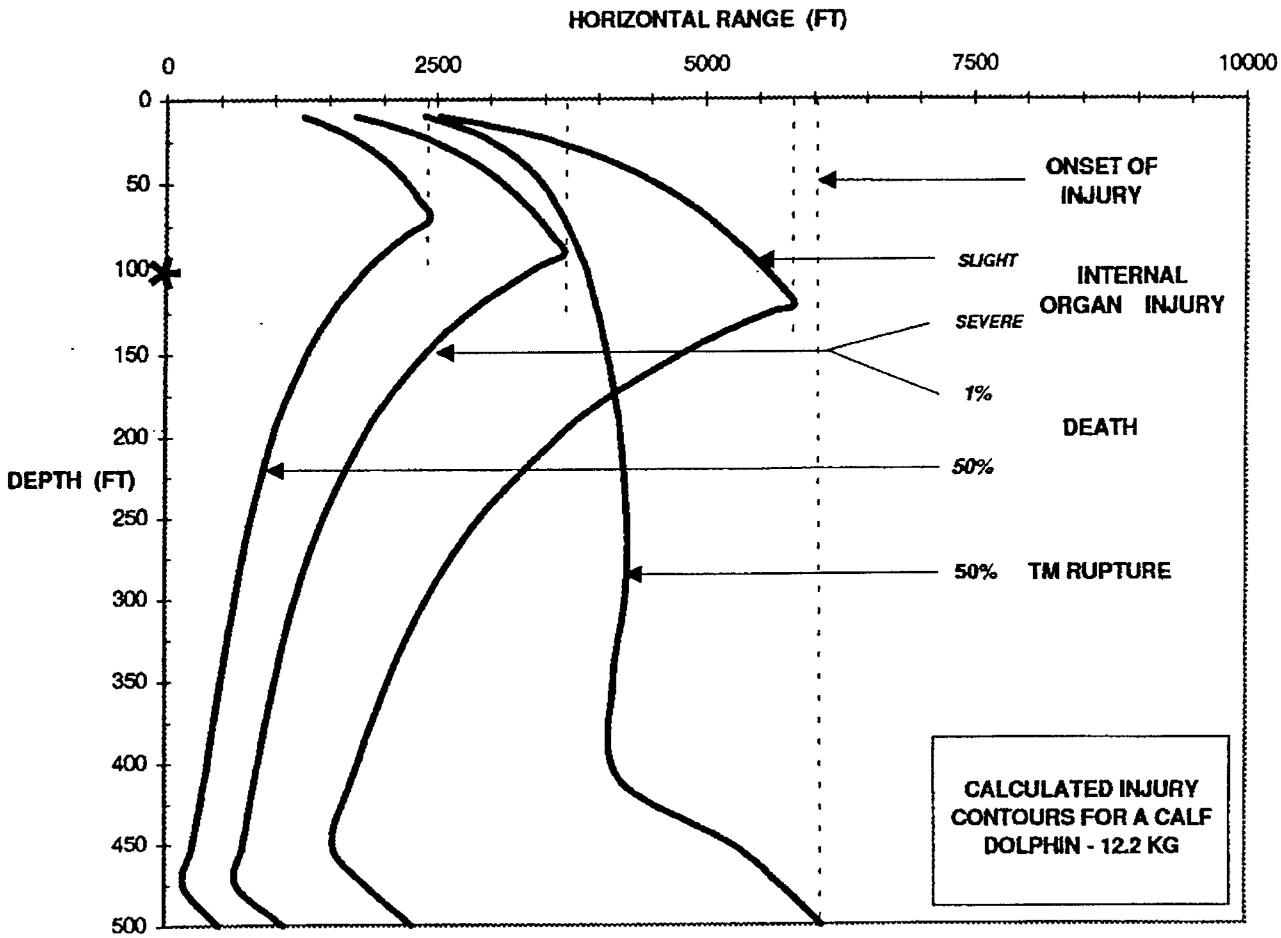


Figure D-8. Calculated injury contours for a calf dolphin (27 lb or 12.2 kg) in relation to a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

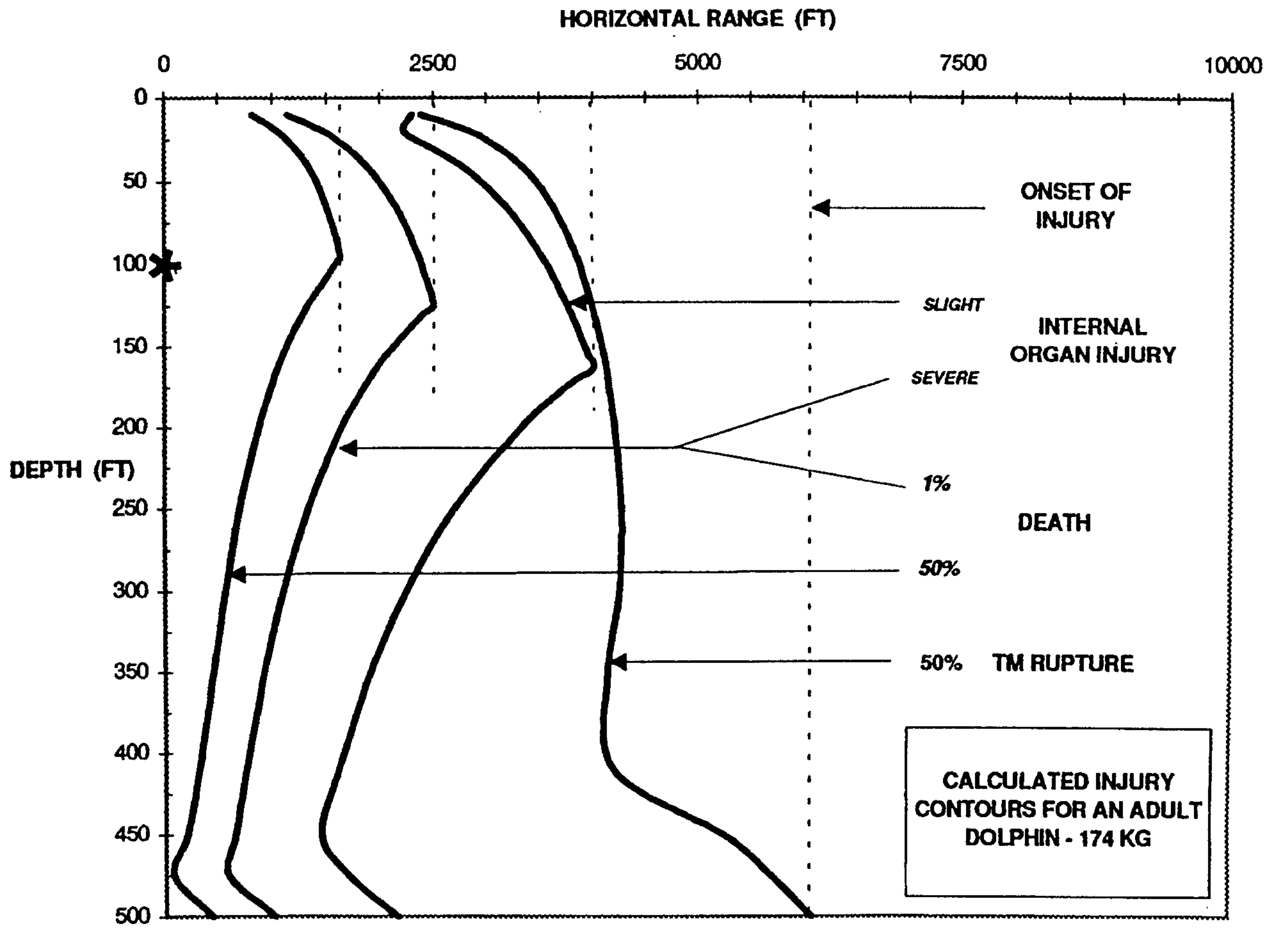


Figure D-9. Calculated injury contours for an adult dolphin (384 lb or 174 kg) in relation to a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

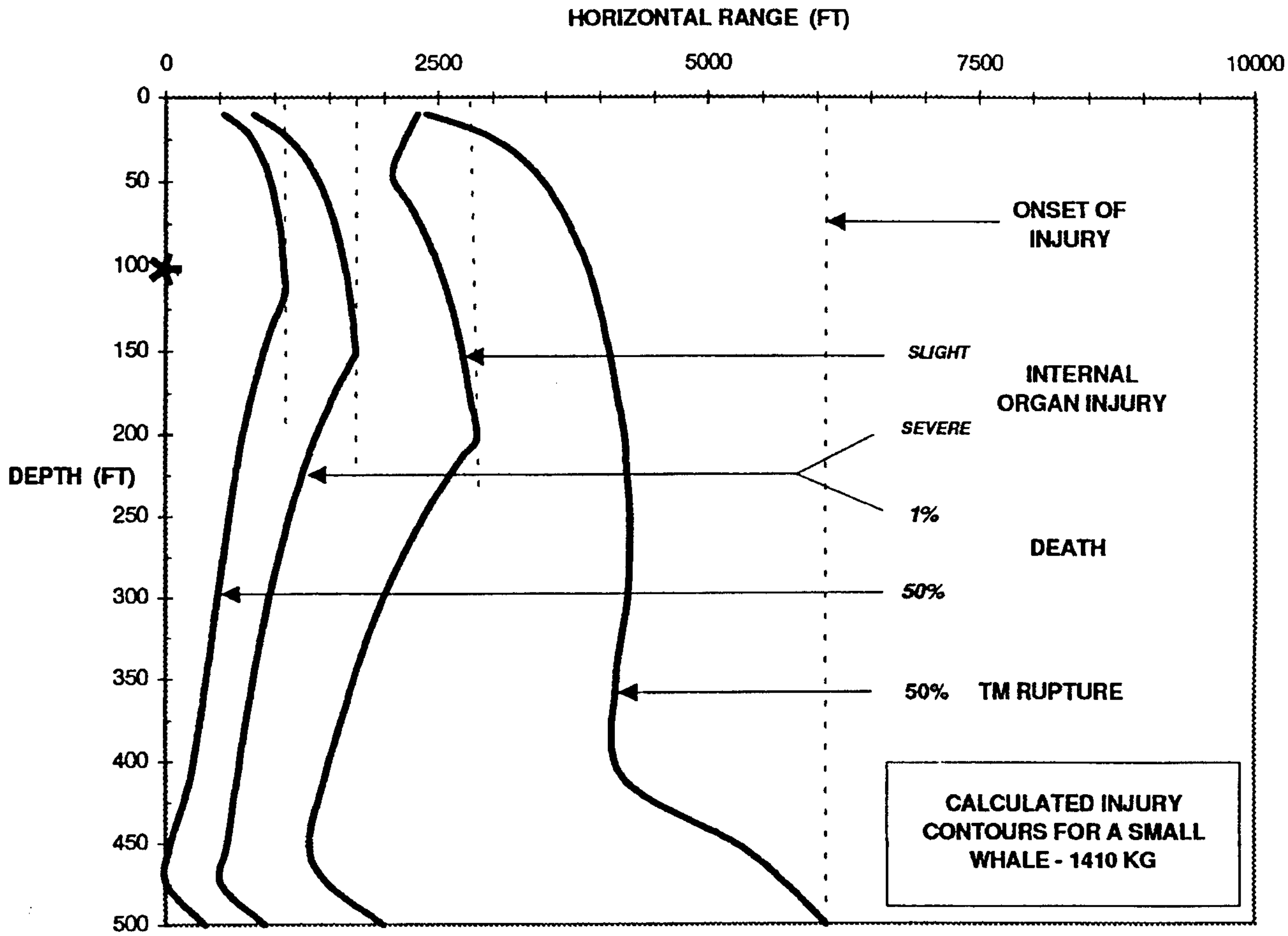


Figure D-10. Calculated injury contours for small whale (3,110 lb or 1,410 kg) in relation to a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

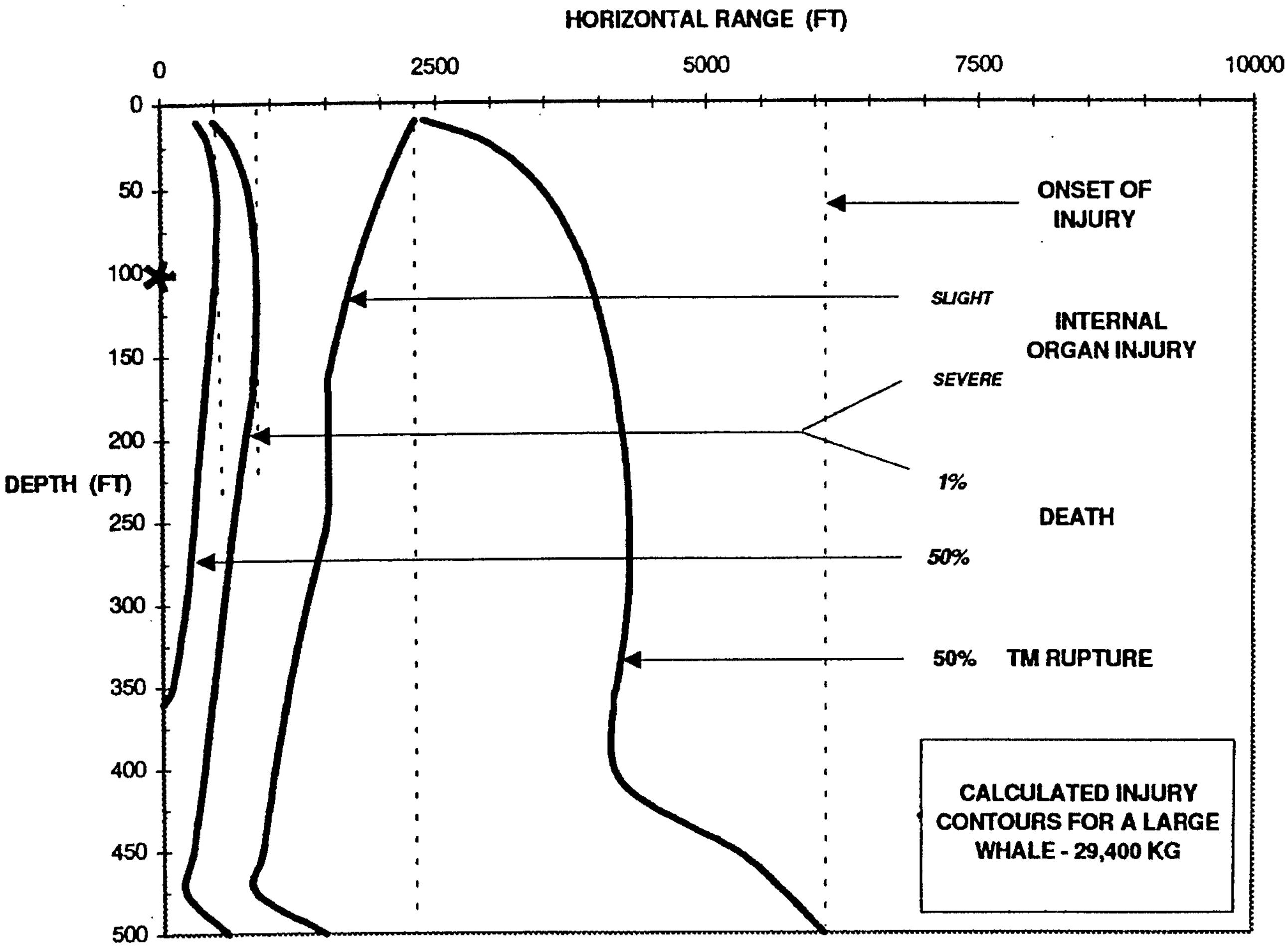


Figure D-11. Calculated injury contours for large whale (64,800 lb or 29,400 kg) in relation to a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).

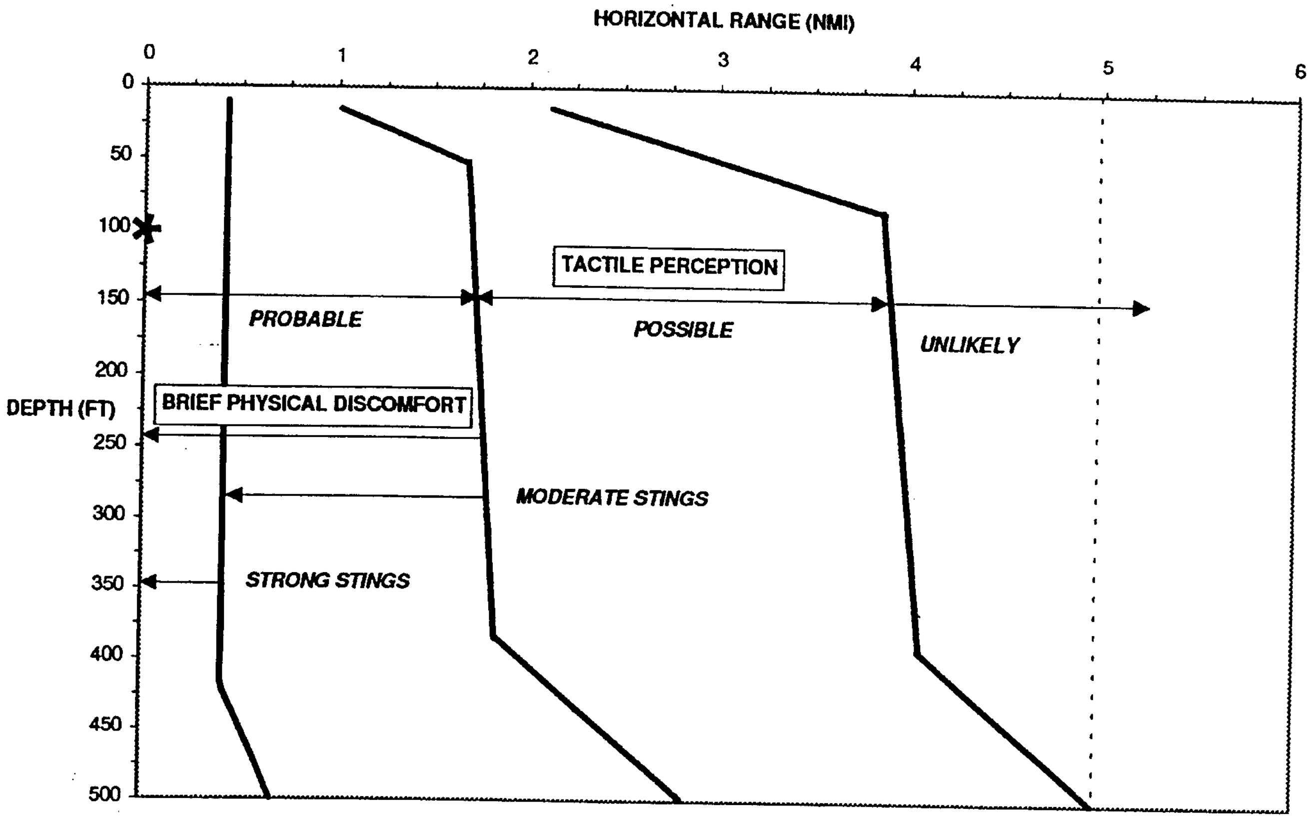
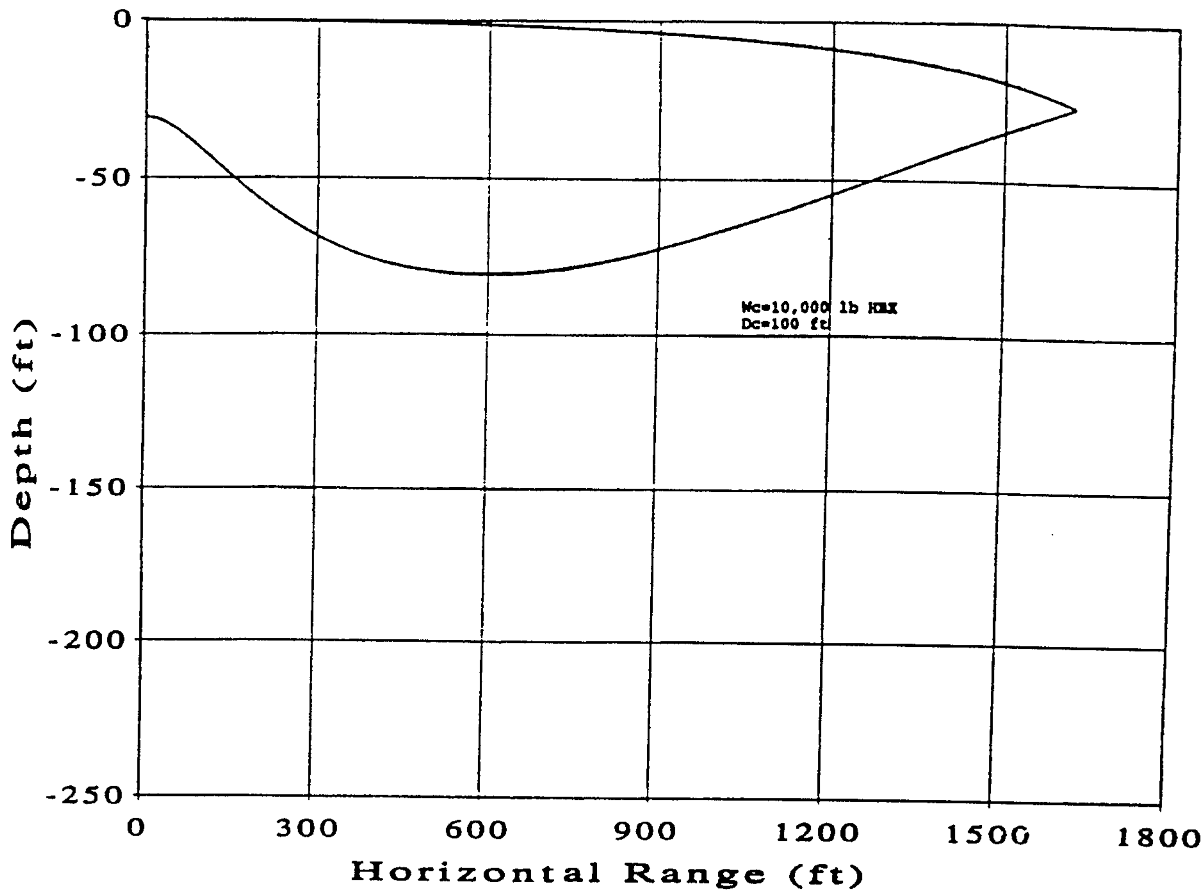


Figure D-12. Calculated contours for brief physical discomfort and tactile perception for a 10,000 lb (4,536 kg) HBX-1 charge detonated at a depth of 100 ft (30 m).



Source: Costanzo and Gordon (1989)

Figure D-13. Bulk cavitation region for a 10,000 lb (3,456 kg) charge detonated at a depth of 100 ft (30 m) (From: Costanzo and Gordon, 1989).

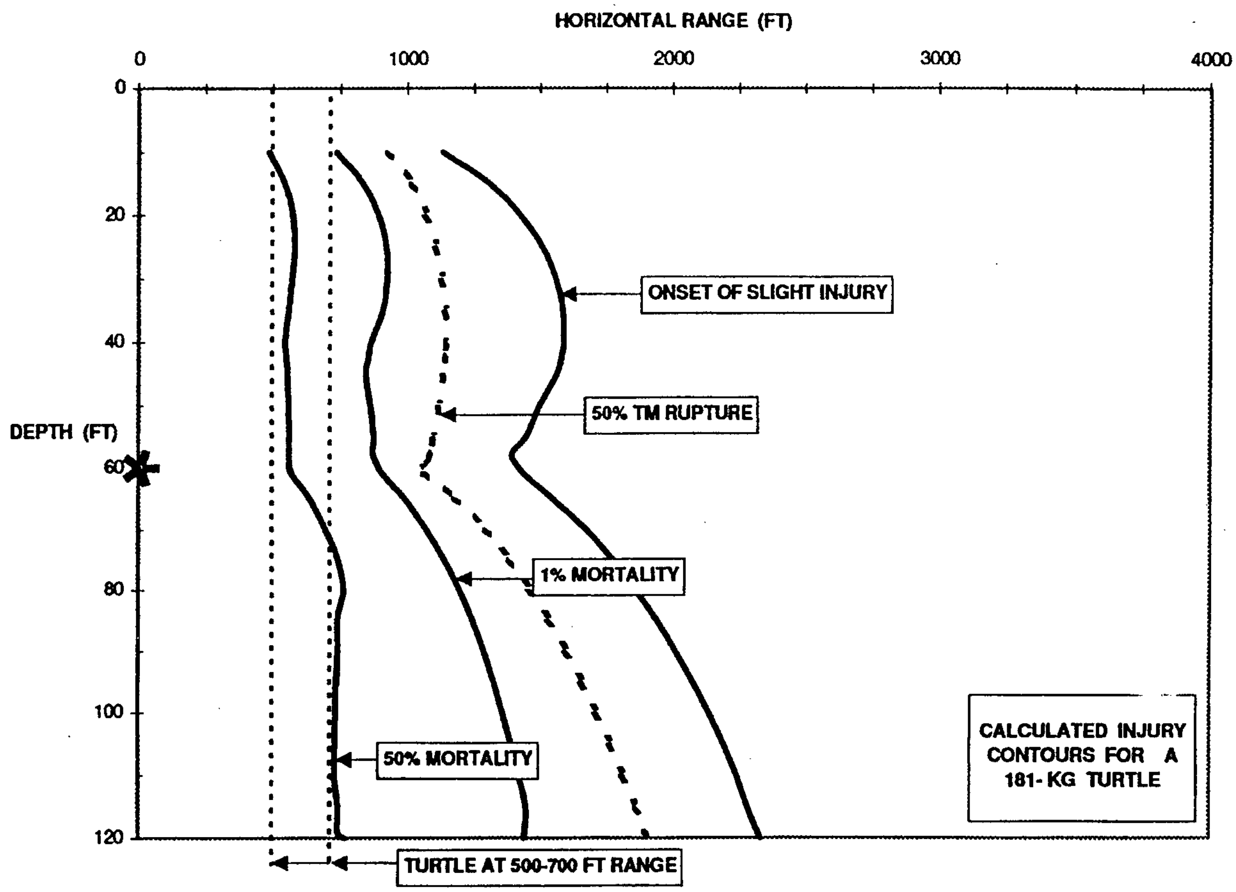


Figure D-14. Calculated injury contours for a sea turtle (400 lb or 181 kg) in relation to a 1,200 lb (544 kg) charge detonated at a depth of 60 ft (18 m). These calculations are to be compared with results reported by O'Keefe and Young (1984). Because turtle depth at time of detonation was unknown, its location is indicated by dashed vertical lines from surface to bottom.

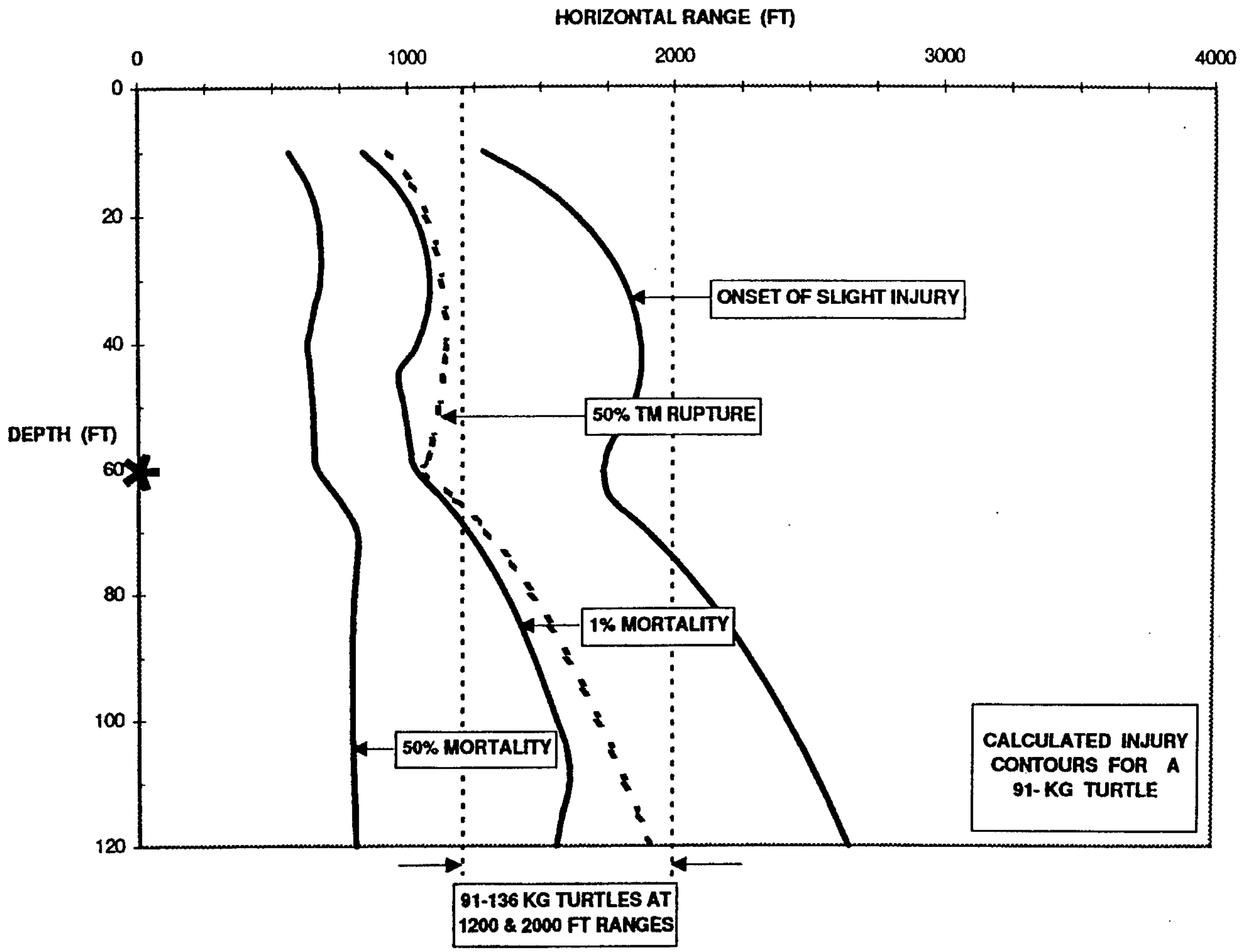


Figure D-15. Calculated injury contours for two sea turtles (200-300 lb or 91-136 kg) in relation to a 1,200 lb (544 kg) charge detonated at a depth of 60 ft (18 m). These calculations are to be compared with results reported by O'Keefe and Young (1984). Because turtle depths at time of detonation were unknown, locations are indicated by dashed vertical lines from surface to bottom.

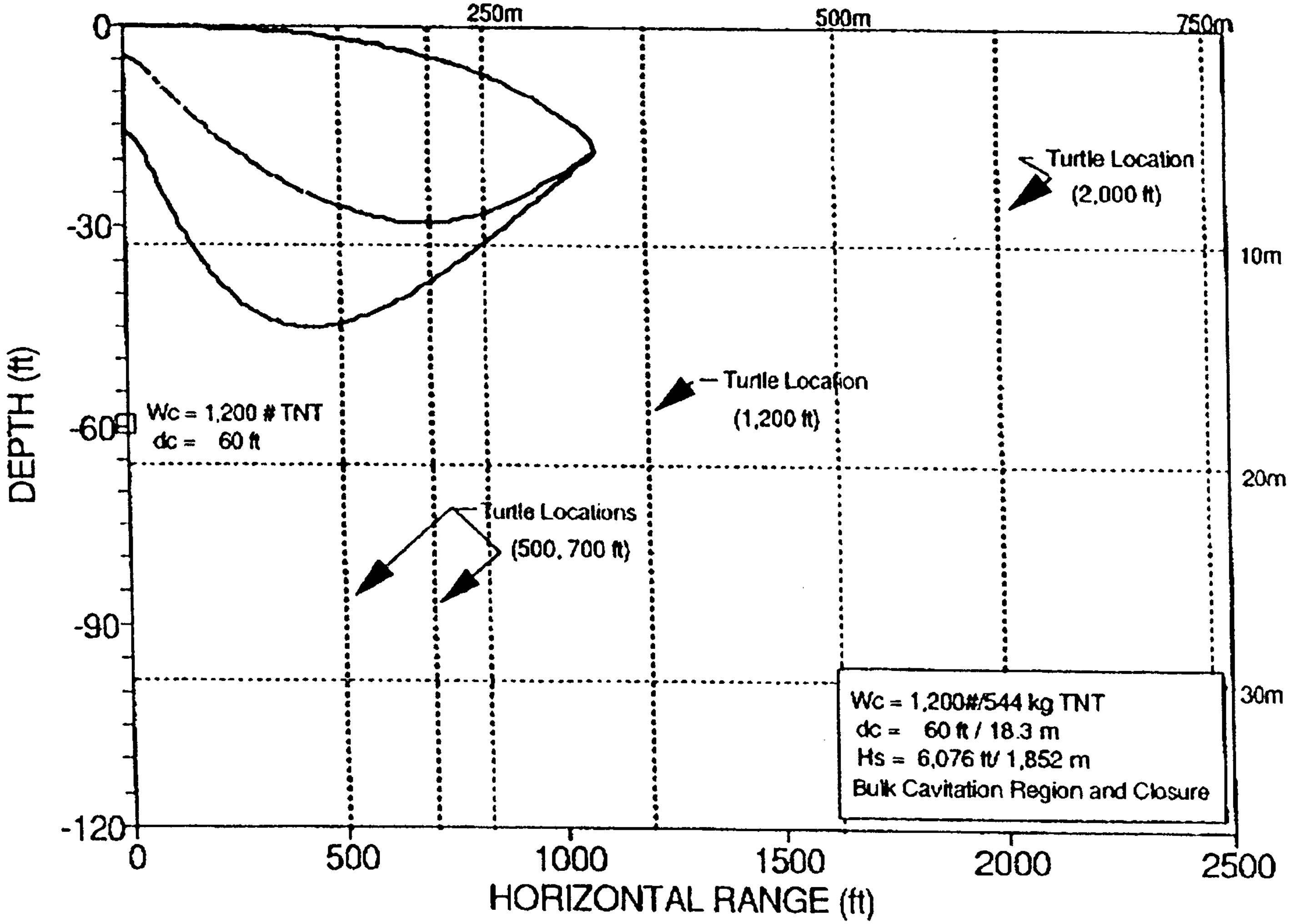


Figure D-16. Calculated bulk cavitation region and closure depth for a 1,200 lb (544 kg) charge detonated at a depth of 60 ft (18 m). These calculations are to be compared with results reported by O'Keefe and Young (1984). Because turtle depths at time of detonation were unknown, locations are indicated by dashed vertical lines from surface to bottom.

APPENDIX E

CRITERIA FOR MARINE MAMMAL AUDITORY THRESHOLD SHIFT

David A. Helweg, Ph.D.
SPAWARSYSCEN SAN DIEGO
Code D351
San Diego, CA 92152-6254

Joel B. Gaspin and Jean A. Goertner (retired)
Underwater Warheads Research and Technology Department
Indian Head Division, Naval Surface Warfare Center
Indian Head, MD 20640-5035

CONTENTS

APPENDIX E

CRITERIA FOR MARINE MAMMAL AUDITORY THRESHOLD SHIFT

E.1 INTRODUCTION

An underwater explosion produces pressure pulses that have the potential for damaging the hearing of sea animals near the explosion. In this appendix, auditory impact criteria are developed for marine mammals and sea turtles exposed to underwater detonations based on experimental data on land and marine mammals, and on what is known about the complex interactions between the physical characteristics of sound and pressure waves and the processes associated with auditory trauma in humans and other species.

Investigators with expertise in underwater-explosion acoustics and marine-mammal hearing have agreed that acoustic criteria for animals exposed to underwater noise should consider the amount of acoustic energy that impinges on the mammal ear (e.g., Clark, 1991; Hamernik et al., 1980; Hamernik & Hsueh, 1991; Henderson et al., 1974; Ketten, 1995; Kryter et al., 1966; Lenhardt, 1986; Luz & Hodge, 1971; Melnick, 1991; Patterson et al., 1986; Price, 1983; Saunders et al., 1985). Energy is proportional to the square of pressure integrated over time, and is commonly discussed in reference to 1/3 octave bands, largely because audiometric data suggest the human cochlea can be modeled as a bank of 1/3 octave filters (Fay, 1988; Green & Swets, 1966).

This is important for issues of threshold shift, because current data indicate that threshold shift is influenced by the combination of exposure duration and peak stimulus amplitude. Hearing threshold, which varies with frequency, is commonly represented as the minimal level in quiet surroundings at which a sound is perceived. Hearing safety limits lie considerably above this minimal hearing threshold. The most conservative limit is the highest sound level that causes no predictable temporary threshold shift (TTS). TTS is a reversible elevation in the level that evokes an auditory response, whereas threshold of discomfort is the minimum effective sound pressure level at which the subject reports pain or discomfort. Between temporary threshold levels and the discomfort level lie the level that can cause a permanent threshold shift (PTS), which is irreversible hearing loss.

A ship shock test is very different from the usual scenario for which auditory criteria are assessed. Damage risk criteria commonly are focused on protecting the hearing of human beings, and are designed to shed light on combinations of amplitude and duration such as might occur in occupational exposure. A great deal of research has focused on determining minimum sound level limits that will induce threshold shift over long-term (e.g., 8-hour workday) exposures. Other research has investigated repeated exposure to impulse-type sounds. Data for lower-amplitude chronic exposure or multiple impulse exposure are only partially relevant to a SEAWOLF ship shock test, which constitutes only a single exposure to possibly intense pressure and sound waves.

The most meaningful criteria for estimating acoustic impact ranges for sea animals would be based on measurements of TTS resulting from exposure to underwater noise. Ideally, for underwater detonations, the criteria should be based on TTS measured for animals exposed to impulsive noise or explosions and, as much as possible, from data on animals exposed to underwater explosions. The reader should understand that explicit, empirical data of this type for marine mammals and other relevant species do not exist. Therefore, we must extrapolate in order to proceed responsibly. Data from land mammals exposed to explosions or impulsive noise are relevant, despite differences in their adaptations for airborne sound because impulsive response, unlike those to continuous sources are, to some extent, media independent.

Appendix D discussed criteria to predict numbers of marine mammals and turtles that may be killed or injured by SEAWOLF detonations. This information was also used to determine the Safety Range for mitigation. In Appendix E, we focus on the wider zone in which impacts decline from injurious levels to negligible or unmeasurable levels. Specifically, the purpose of Appendix E is to estimate the zone in which marine mammals and turtles may experience TTS. This information is used in the FEIS to estimate "harassment."

E.2 METHODS AND TERMINOLOGY

Data describing acoustic effects of sound exposure, such as TTS and PTS, in human and non-human animals, are described in the following section. First, we sketch sources of hearing threshold shifts. Then we describe threshold shift data in human and non-human mammals, limiting our description to studies that have used impulsive stimuli or stimuli with very fast rise times. These data are then used to define a conservative TTS criterion. Lastly, we use the TTS criterion to develop estimates of acoustic impact ranges for marine mammals and sea turtles exposed to an underwater detonation of a 10,000 lb (4,536 kg) explosive charge.

The measurement of sound, and selection of appropriate acoustical comparisons for consideration in this FEIS, requires that audiometric data collected in-air be extrapolated to approximate water equivalents. This requires conversion of audiometric and acoustical measurements to common referents. Sound levels often are measured in decibels (dB), a logarithmic dimensionless unit that is the ratio of the measured level to a reference level. For example, sound *pressure* is converted to decibel equivalent as described in Equation 1. The standard air reference pressure is 20 μPa, as compared to 1 μPa in water, a difference of 26 dB.

[1] $$\text{dB (pressure)} = 20 \times \log_{10}\left(\frac{p_{measured}}{p_{reference}}\right)$$

When comparing sound *intensities*, the acoustic impedance (ρc) of the two media also must be taken into account. The acoustic impedance of air is 42 g/s, as compared to 1530 g/s in water. Equation 2 illustrates the relationship between sound pressure, intensity, and acoustic impedance. By the appropriate calculations we can demonstrate that the intensity of a sound wave in water is about 61.5 dB lower than that of a wave of equivalent pressure in air.

[2] $$\text{Intensity} = \frac{p^2}{\rho \cdot c}, \text{ and dB (intensity)} = 10 \times \log_{10}\left(\frac{I_{measured}}{I_{reference}}\right)$$

Lastly, explosive impulses commonly are described in terms of pressure and *overpressure*, which can be thought of as the amount of pressure beyond the ambient pressure, and is a function of the charge weight and depth. Pressure may be measured in pounds per square inch (psi) or Pascals (Pa), but without conversion to dB. The energy transmitted is equal to intensity integrated over an appropriate time, for example the first positive pressure peak of the shock wave (the A-duration). We use equation 3 to convert dB re 1 μPa to energy in units of $\mu Pa^2 \cdot sec$.

[3] $$\text{dB (energy)} = \text{dB re } 1\ \mu\text{Pa} + \left[10 \times \log_{10}(time_{measured})\right], \text{ where time is in seconds.}$$

To make comparisons between threshold shift effects produced by long duration stimuli and those associated with impulsive stimuli, we may extrapolate using the total energy integrated over the time constant of the ear.

We used conservative criteria in all stages of the extrapolation of acoustic criteria. Consider a hypothetical range of sound pressure levels of 40-60 dB that were shown to induce TTS in a terrestrial mammal. In this example, we would use the 40 dB as the conservative limit range, because this number is the sound pressure level that induced the hypothetical TTS.

An important aspect of our assessment is the reliability of the data on which we based our extrapolation. Data for TTS and PTS are presented for many species and stimulus and exposure configurations. However, the reader should note that it is well accepted by all experts in the field of acoustic trauma that the incidence of PTS is not easily predicted by TTS. There is considerable variability in the onset level and magnitude of TTS and/or PTS across individuals, especially for impulsive stimuli, induced in part by unpredictable factors such the health or response time of the individual ear. Although measurements of eardrum rupture as small as 1% have been reported, the relationship between the acoustic characteristics of the impulse, eardrum rupture, and threshold shift can be highly variable below a level consistent with 50% incidence of PTS. These uncertainties are not often apparent to the casual reader of the scientific literature.

Our primary concern is changes in hearing threshold induced by mechanical pressure and overpressure damage. Our secondary concern is changes in hearing threshold mediated by sensorineural effects, such as metabolic fatigue. The rationale for these priorities is that the pressure event created by the HBX-1 detonation will result in intense overpressures, but the very brief duration of the singular event minimizes likelihood of threshold shifts that are associated with chronic or long-term stimulus durations.

E.3 BACKGROUND ON AUDITORY THRESHOLD SHIFTS

Hearing threshold conventionally means the minimum threshold of audibility, which is experimentally determined as the minimum effective sound pressure level of a signal that evokes an auditory response (Yost, 1994). It is commonly measured in quiet conditions and as a free-field response. Thresholds vary with ambient level and across individuals. To some degree, thresholds reported vary also with the method used to measure them, for example, a behavioral response paradigm in which the subject makes a motor response such as pushing a lever, versus electrophysiological methods in which electrical responses in the auditory nervous system are recorded directly. The better the sensitivity, the lower the threshold (i.e., the lower the sound pressure level required to generate an auditory response).

Temporary threshold shift (TTS) is a reversible decrease in sensitivity and therefore an elevation in the level that evokes an auditory response, whereas threshold of discomfort is the minimum effective sound pressure level at which the subject reports pain or discomfort. Clinical models using small land mammals have been used to determine international standards for industrial damage risk criteria (e.g., Kryter et al., 1966; Lenhardt, 1986; NRC, 1992). These experiments were designed to identify the sound parameters that are central factors in threshold shifts (e.g., Kryter et al., 1966; Lenhardt, 1986; OSHA; Saunders et al., 1985; NRC, 1992). The current consensus is that both intensity and duration are critical factors. Consequently, threshold shifts can be induced by chronic exposure to lower noise levels or brief exposure to high noise levels. These models also indicate previous history and health of the ear as important predictors of threshold shifts, especially shifts from TTS to PTS (Lenhardt, 1986).

Threshold shifts are complex phenomena, and TTS and PTS are not points on a continuum arising from a single damage mechanism (e.g., Lenhardt, 1986; Saunders et al., 1985; Yost, 1994). Threshold shifts and acoustic discomfort may be caused by damage to the transfer functions, the sensorineural mechanisms, or both. Damage to the middle ear ossicles or rupture of the eardrum are examples of damage to mechanical components, which in turn results in compromised transfer functions. Damage to hair cells results in sensorineural loss.

Damage to the auditory system induced by blast overpressures may result in mechanical effects and sensorineural effects, depending on the level of exposure (e.g., Lenhardt, 1986; Liang, 1992; Patterson & Hamernik, 1992; Saunders et al., 1985; NRC, 1992). Mild exposure levels can cause temporary loss by different mechanisms than simple acoustic trauma, although the effects will be similar behaviorally.

Signal rise-time and duration of peak pressure are significant factors in both the degree of TTS and PTS, having potential effects related to both the time and frequency domains (Clark, 1991; Hamernik & Hsueh, 1991; Hamernik et al., 1991; Henderson et al., 1974; Lenhardt, 1986; Liang, 1992; Luz & Hodge, 1971; Melnick, 1991; Patterson & Hamernik, 1992; Price, 1983; Saunders et al., 1985; Smoorenburg, 1992). In all species tested to date, TTS and PTS may result from a range of acoustic stimuli; e.g., either chronic exposure to narrowband sounds or sudden onset of intense sounds. Variables that influence the transition from TTS to PTS may include, for instance, the hearing sensitivity at the range affected, the degree of the shift, and the exposure interval. The criteria for differentiating PTS and TTS zones are both species- and media-dependent and may be strongly influenced by health of the ear (Ketten, 1995).

E.3.1 Threshold Shift in Humans

Human ears, like most terrestrial mammalian ears, are adapted exclusively for sound transduction in air. There are substantial human audiometric data in air for hearing threshold and discomfort levels (Everest, 1994; Edge and Mayes, 1966; Fay, 1988; Yost, 1994). For human subjects with normal hearing [threshold of 0 to 20 dB sound pressure level (SPL) over the 20-20,000 Hz range on average], TTS generally occurs at levels of 80 to 100 dB SPL over threshold and discomfort at approximately 120 dB SPL (OSHA; Yost, 1994).

Humans are the only species for which subjective data, such as reports of discomfort, can be allowed. Humans tend to report discomfort at SPLs of approximately 120 dB (re 20 μPa) regardless of frequency. The discomfort range always lies above SPLs that can induce PTS, for the following reason: Subjects may incur PTS without experiencing uncomfortable or painful SPLs, and PTS may be induced by chronic exposure to nonpainful SPLs. Moreover, the PTS may not be detected until later in life, if ever (Yost, 1994).

Underwater hearing thresholds for humans show a general reduction in sensitivity across all frequencies tested (Al-Masri et al., 1996; Montague and Strickland, 1961), but threshold shifts have been reported underwater. In one study, humans were exposed to a 3500 Hz pure tone for 15 minutes. Two minutes after exposure, a threshold shift (TS) of 30 dB (no damage) was measured (Smith et al., 1970). A second study investigated hearing tolerance levels by exposing hoodless divers to one second duration 1500 Hz tones from a source directly in front of them. The tones were gradually increased in level by 1 dB until the divers requested a halt. An in-air hearing test conducted within 5 minutes of the underwater test showed no threshold shift. Smith and Wojtowicz (1985) reported threshold shifts of 23-55 dB in bare-headed divers exposed to 700, 1400, or 5600 Hz tones for 25 minutes at 141-165 dB (re 20 μPa; equivalent to 167-182 dB re 1 μPa). When exposure duration was shortened to 10 minutes, Smith et al. (1988) reported moderate threshold shifts at sound pressure levels between 125 and 150 dB (re 20 μPa; equivalent to 151-176 dB re 1 μPa). It should be noted that these data are for long exposure to pure tones, and are not directly applicable to the present problem.

Data describing changes in human underwater auditory sensitivity and exposure effects are potentially confounded by the fact that human sound conduction mechanisms are air-adapted rather than water-adapted. The human auditory pathway is adapted for in-air transduction and do not display any of the morphological adaptations to marine environment present in cetacean ears (e.g., Ketten, 1994, 1995). The result is that the hearing mechanisms in the submerged land mammalian ear are unclear and may be abnormal, and therefore the appropriateness of Risk Criteria established from threshold shift measurements on submerged land mammal or human ears is debatable. Moreover, inference of discomfort or intensity tolerance levels using subjective reporting by human divers is questionable for predicting acoustic criteria. Methods that rely on highly subjective phenomena such as discomfort are difficult to calibrate, and results often show high variability both between subjects and within subjects across repeated testing (Green & Swets, 1966). Thus, the potential variability among human subjects based on individual tolerances makes direct extrapolation to marine animals questionable. The human underwater results are included for the sake of completeness but were not used as definitive measure for formation of acoustic impact criteria for marine mammals.

E.3.2 Threshold Shift In Other Terrestrial Mammals

Noise-induced hearing loss has been investigated in a number of mammalian species, particularly rodents and chinchillas, as well as primates and cats (reviewed in Clark, 1991; Hamernik et al., 1980; Kryter et al., 1966). The use of animal models has allowed extensive controlled experimental testing of acoustic parameters related to threshold shifts, coupled with the ability to perform rigorous tests of correlations between noise exposure schedules, behavioral changes, and physical damage to the auditory system.

One common paradigm involves exposing animals to intense (greater than 100 dB SPL) tones and narrow-band noise for "short durations" (less than 6 hours) (Clark, 1991). These durations are considered short because human threshold shift phenomena were first investigated in the context of chronic (i.e., day-long, occupational) exposure to noise. In general, the data show that, with exposure to continuous noise, TTS spreads upward in frequency from the center frequency of the exposure band (e.g., Lenhardt, 1986; Yost, 1994). Upward spread (in terms of frequency) is common to long and short duration exposures that induce TTS. The primary differences in terms of frequency is that the spread is greater for low frequency signals than high frequency, and that is largely because of cochlear tonotopy. High frequencies are represented in the first part of the cochlea close to the middle ear, and are therefore exposed to all intense sound as it is transferred into the cochlea. PTS tends to occur with exposures that produced TTS of 60 dB or more (Clark, 1991). The 60 dB value is for moderate-duration (less than 6 hrs) exposure to 100+ dB (SPL) sounds. Therefore, this relationship does not necessarily hold for an instantaneous, on-off exposure such as a ship shock test. The extent of PTS can be but is not only correlated with extent and location of damage to sensory cells. As noted above, recovery is a function in part of the intensity and duty cycle of the noise.

When the exposure stimulus is impulsive, threshold shifts and auditory trauma may be mediated by different auditory mechanisms than those induced by chronic exposure, in part depending on the levels to which the subject is exposed (e.g., Henderson, Hamernik & Sitler, 1974; Luz & Hodge, 1971; Patterson et al., 1986; Price, 1983). Damage risk criteria developed using data from chronic exposure to noise may not be applicable to impulsive stimuli because the effects of leading edge discontinuity (overpressure) characteristic of impulses are the primary determinants of damage

(Hamernik & Hsueh, 1991; Hamernik et al., 1988; Hamernik et al., 1991; Patterson et al., 1986; Patterson, 1991; Price, 1983; Yiung, 1970).

Luz & Hodge (1971) analyzed the time course of recovery from TTS induced by two impulsive stimuli at 168 dB (re 20 µPa in air; equivalent to 230 dB re 1 µPa in water) in humans and monkeys. TTS in monkeys was measured using a conditioned avoidance paradigm. Threshold was measured for 2 kHz tones within 10 min of exposure, followed by testing at 1, 8 and 14 kHz. This procedure was repeated over a period of hours until recovery was complete. Recovery from TTS induced by long exposure to continuous sound tends to be monotonic, i.e., recovery begins at the end of exposure. In contrast, the results of this study showed that TTS levels induced by impulse noise increased from approximately 20 dB to a peak of approximately 40 to 50 dB over a period of some hours following exposure, after which recovery followed the expected monotonic trend. This suggested the notion that TTS induced by impulse noise was a complex interaction of multiple components of the auditory pathway, rather than, for example, a single variable such as metabolic fatigue.

Hamernik et al (1980) found a rebound effect in recovery from TTS induced by repeated exposure to 155 dBA (A-weighted, re 20 µPa in air, approx. equivalent to 216 dB re 1 µPa in water) impulse noise in chinchillas. TTS was measured using conditioned avoidance or evoked potentials at octave intervals between 0.25 and 8 kHz. At 30 minutes post exposure, TTS was approximately 30 dB, rising to a pooled median peak of 60 dB within 10 hours of exposure. Histological exams of the basilar membrane suggested that loss of inner hair cells (IHC), but not outer hair cells, was correlated with the TTS, but that the degree of correlation was minimal unless there was 100% loss of IHC at some location. Their results are consistent with those of Danielson et al. (1991), Henderson et al. (1974), Patterson (1991), and Ward (1991), whose results do not support models that treat all threshold shifts as a univariate phenomenon, in which the level and timecourse of threshold shift is related only to the total sound energy to which a subject is exposed, in an attempt to integrate data on chronic exposure and impulse exposure.

The role of the distribution of energy across the spectrum of an impulsive stimulus in eliciting auditory threshold shift has been debated (Hamernik et al., 1991; Lenhardt, 1986; NRC, 1992; Price, 1983; Smoorenburg, 1992). As the first positive pressure phase of an impulse lengthens (i.e., the A duration increases), the amount of energy in lower frequencies of the impulse spectrum increases. Hamernik et al. (1991) induced PTS in chinchillas using exposures to 150, 155 or 160 dB impulses (re 20 µPa in air; equivalent to 211 to 221 dB re 1 µPa in water) with peak frequencies that varied from 0.25 to 2 kHz. Exposure was scheduled on a factorial combination of 1X, 10X and 100X repetitions on 10/min, 1/min, and 0.1/min duty cycles. The results suggest that the degree of PTS in chinchillas was frequency dependent, with the degree of PTS proportional to the total energy of the impulses and the auditory sensitivity function. However, the overpressures and broad frequency spectrum associated with the proposed HBX-1 detonations are likely to cause similar damage to most species because impulse and shock wave trauma largely are mechanical in nature. Nevertheless, to acknowledge the potential role of spectral density we will derive two sets of criteria, one for high frequency "specialists" such as odontocetes, and a second for low frequency "specialists" such as baleen whales and sea turtles.

Large inter-subject variability in degree of threshold shift induced by impulsive stimuli has been reported by many researchers working with humans and nonhuman mammals (Hamernik et al., 1980, 1988; Henderson et al., 1974; Hodge & McCommons, 1966; Lenhardt, 1986), thereby making prediction of onset and severity of TTS difficult at best. Moreover, Hamernik et al. (1988) demonstrated that the degree of PTS and sensory cell loss in chinchillas was higher in impulse-induced TTS than TTS induced by chronic exposure. They used avoidance conditioning, testing threshold at octaves from 0.125 to 8 kHz after exposure to multiple 127 to 147 dB (re 20 μPa in air; equivalent to 188 to 208 dB re 1 μPa in water) impulsive stimuli. Average threshold shift ranged from 20 dB upward to a peak of 90 dB approximately 5 hours post exposure, after which threshold recovery was monotonic. However, the transition from TTS to PTS in chinchillas was least predictable when the recovery was typified by the nonmonotonic trend described by Luz & Hodge (1971), a trend characteristic of impulse-induced threshold shift; i.e., there is wider inter-individual variation in the degree of TTS with impulse noise.

In marine mammals, the middle ear appears to contain air and, as such, may be susceptible to mechanical injury (e.g., Ketten, 1995). However, cetacean ears are adapted to the high ambient pressures normally encountered in marine existence. These adaptations include occlusion of the external auditory meatus and thickened membranes (Ketten, 1991, 1992), which may confer increased resilience to pressure-related damage (Ketten, 1995).

E.3.3 TTS in Bottlenose Dolphins

Ridgway et al. (1997) described preliminary results of the first TTS experiments in dolphins. TTS was induced in four bottlenose dolphins using high amplitude 1-sec pure-tone bursts. These stimuli differ from the broadband spectra common to impulsive noise (Hamernik, Ahroon & Hsueh, 1991); however, the amplitude of the TTS stimuli used by Ridgway et al. (1997) rose steeply to the peak amplitude, similar to the timecourse of onset in impulsive waveforms. Because TTS measurements resulting from exposure to impulsive noise are not available, we have used the Ridgway et al. (1997) results as the best available data for predicting explosive effects.

TTS was measured as follows. Masked hearing thresholds were obtained for each dolphin, with masking noise level at 90 dB for 3 kHz, and 100 dB for 20 and 75 kHz 250 msec tone pips. TTS was induced by presenting a super-threshold 1-sec S1 tone, followed immediately by signal detection testing with S2 tone pips at equal and higher frequency. S1 center frequencies were 3, 20, and 75 kHz. Threshold was tested at 3 (4.5 & 6), 20 (30 & 40), and 75 (85 & 100) kHz. TTS was operationally defined as the S1 level in dB re 1 μPa that produced a 6 dB increase in masked hearing threshold of a S2 tone pip at the same frequency within several minutes of S1.

The intensity levels for behavioral responses and for TTS are presented in **Figure E-1**, compared with the masked hearing threshold for each TTS frequency. Agitation by the test subject was observed above 178 dB at 75 kHz, 181 dB at 20 kHz, and 186 dB at 3 kHz (all dB levels re 1 μPa). Temporary threshold shifts were observed above 192-194 dB at 75 kHz, 193-196 at 20 kHz, and 194-201 dB at 3 kHz.

In contrast to findings in other species (e.g., Clark, 1991; Lenhardt, 1986), notice in Figure E-1 that the levels for behavioral responses and TTS were not strongly frequency-dependent. These results are reminiscent of acoustic discomfort curves (Ketten, pers. comm.), and suggest that additional data are required, possibly with shorter stimuli, in order to differentiate between TTS with behavioral responsiveness and TTS alone. However, these data are relevant because they are the first experimental evidence of threshold shift in a marine mammal species, and therefore provide some hard data on which our predictions may be based.

Ridgway et al. (1997) conducted the experiments specifically to address auditory criteria for three SONARs. They recognized the preliminary nature of their findings, citing the need for further investigation in more marine mammal species, replication in more dolphin subjects, and testing across greater frequency ranges, different stimulus durations, onset rise times, and other TTS stimulus configurations. This preliminary study indicates that, for short duration stimuli, dolphins appear to

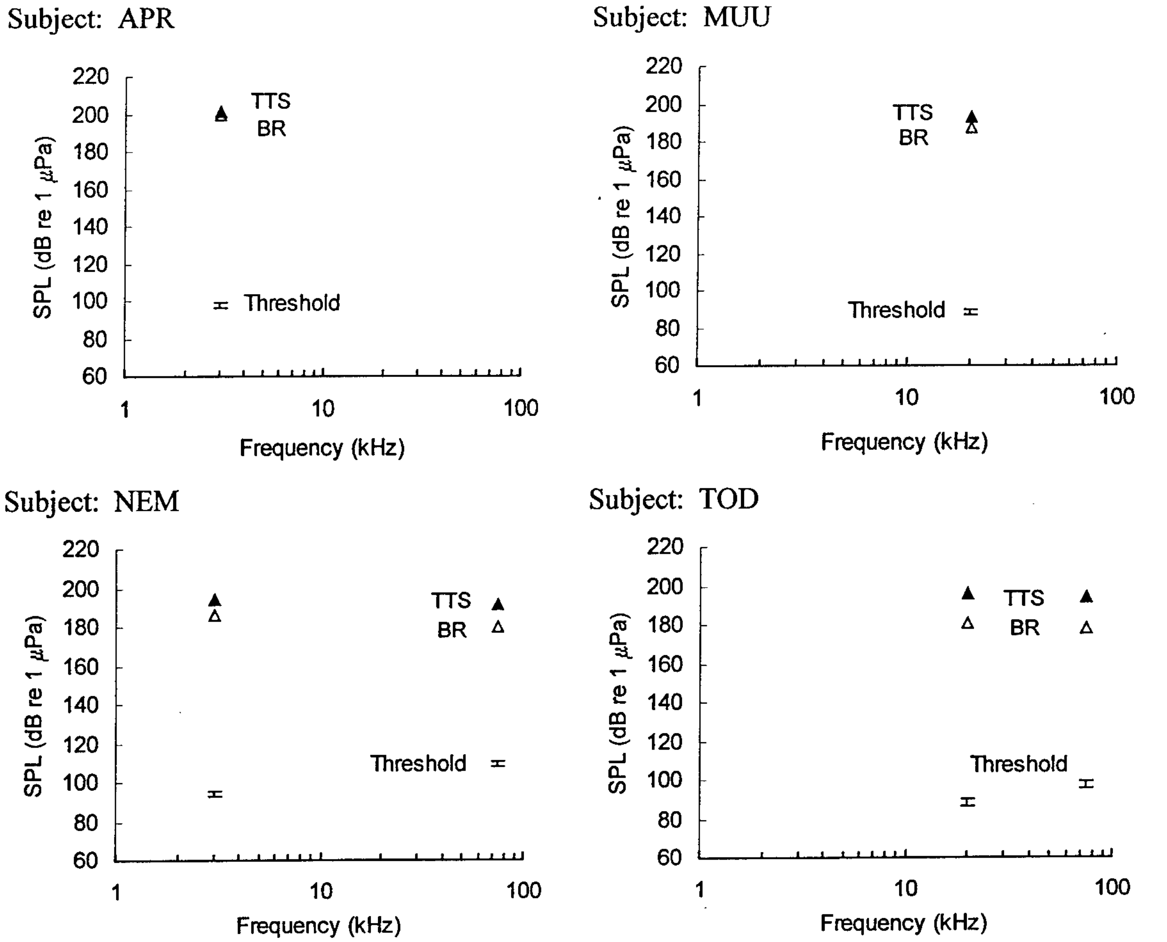


Figure E-1. Masked hearing thresholds (3 dB range), behavioral responses (BR; open triangles) and temporary threshold shifts (TTS; closed triangles) in four bottlenose dolphins (Ridgway et al., 1997). APR was tested at 3 kHz; MUU at 20 kHz; NEM at 3 and 75 kHz; and TOD at 20 and 75 kHz. Masking noise levels were 90 dB at 3 kHz and 100 dB at 20 and 75 kHz. All sound pressure levels (SPL) in dB referenced to 1 μPa at 1 m.

require greater sound pressure levels than do land mammals to report TTS. This is consistent with the intensity equivalents (Ketten, 1995; pers. comm.).

E.4 CRITERIA CONSIDERED

Several themes are common throughout the literature on TTS and PTS associated with impulsive sounds. These themes center on high inter-individual variability in the onset of TTS, the severity of TTS, and the transition from TTS to PTS. In the case of the proposed SEAWOLF shock tests, the relative contribution to TTS of spectral characteristics of the stimulus (Hamernik et al., 1991; Lenhardt, 1986; NRC, 1992; Price, 1983; Smoorenburg, 1992) are slight compared to the contribution by the overpressures caused by the detonation. The shock wave created by HBX-1 detonations has a complex waveform characterized by an essentially instantaneous rise time, high amplitude positive peak lasting approximately 5-10 msec. The overpressures and broad frequency spectrum of the shock wave are likely to cause equivalent damage to all species, making considerations of species-specific frequency-dependent auditory sensitivities unnecessary. No model is available for making predictions about threshold shifts for any specific individual without foreknowledge of the exact acoustic characteristics of the impulses to which an animal may be exposed, and the auditory history and health of each ear in individual animals. Nevertheless, it is incumbent on us to make a prediction for an average ear for potentially impacted species.

We focus our efforts on extrapolation to marine mammals and sea turtles, the animals of greatest concern in the proposed test areas. To acknowledge the potential role of spectral density we will derive two sets of criteria, one for high frequency "specialists" such as odontocetes, and a second for low frequency "specialists" such as baleen whales and sea turtles. There are no data on TTS or PTS in any species of sea turtle, no data on PTS in marine mammal species, and only preliminary data on TTS in one species of marine mammal, the bottlenose dolphin. Three possible acoustic criteria evaluated in this section are (a) extrapolation of human PTS criteria to marine mammals as suggested by Richardson et al. (1995); (b) acoustic criteria developed for marine mammals by Ketten (1995); and (c) recent data from Ridgway et al. (1997) for TTS in bottlenose dolphins.

E.4.1 Extrapolation of PTS using Human DRC (Richardson et al. 1995)

Richardson et al. (1995) extrapolated possible damage risk criteria (DRC) for marine mammals using DRC standards for humans exposed to impulsive stimuli in air coupled with limited data for cetacean auditory thresholds. The human PTS DRC were extrapolated from in-air estimates of TS (Ward, 1968). The DRC are expressed in terms of levels of PTS induced by 100 impulses, in dB re 20 μPa (air standard), that are adjusted according to pulse duration, number of impulses, and deviation from normal incident grazing angle (Richardson et al., 1995). For a single brief exposure, Richardson et al. (1995) speculate a range of 214-244 dB, based on a baseline of 164 dB re 20 μPa for a 25 μsec impulse, plus 10 dB for the 100-fold decrease in number of exposures, plus an apparent 40-70 dB in threshold difference between humans and bottlenose dolphins.

Although Richardson et al. (1995) make clear that their analysis is speculative, they appear to have overlooked the critical fact that sound pressure levels measured in-air cannot be directly compared to sound pressure levels measured in-water. As described in Section E.2, comparisons must be made in terms of sound intensity or power, which takes into account the differences in acoustic impedance of the different media. Therefore, for the purpose of explication we recalculate here the range for a PTS transition zone using numbers appropriate for in-water measurement plus our knowledge of HBX-1, using logic similar to that of Richardson et al. (1995).

We start with 152 dB for a pulse duration of 1.5 msec. We add 10 dB for the 100-fold decrease in the number of impulses (from 100 to 1), which results in a baseline estimate of 162 dB re 1 μPa. At 3 kHz, the dolphin in-water threshold is approximately 42 dB compared to 18dB for humans in air, using the proper comparative units of intensity (re 10^{-16} W/cm^2). We add 24 dB, making the baseline 186 dB after "converting" human to dolphin audiometry. Finally, we add 61 dB, which converts the in-air level to its in-water equivalent, thereby yielding an estimate of 247 dB re 1 μPa peak pressure in water for a single 1.5 msec duration pulse.

To apply this criterion to the HBX-1 shock wave, we need to subtract 2 dB per doubling of duration to account for the actual pulse duration. The duration of the direct shock wave is a function of the charge and animal depths and the slant distance between them. This calculation was done assuming straight line propagation (probably accurate for the short distances involved in PTS). For an assumed animal depth and horizontal range, we calculated the shock wave duration. We then subtracted 2 dB per doubling of duration relative to 1.5 msec to the 247 dB criterion [(Log(duration in msec)-Log(1.5))/Log (2)]. Using this pressure level, and the well known similitude equation for HBX-1 peak pressure as a function of distance (Price, 1979), we calculated the slant distance at which this peak pressure would be observed. This was then compared to the assumed slant distance. This process was carried out iteratively until the calculated and assumed slant distances were within 0.1%. This process was repeated for a number of depths, and yielded the results shown in **Table E-1**.

Table E-1. PTS criteria for marine mammals based on extrapolation of human DRC as suggested by Richardson et al. (1995). Calculations assume a 10,000 lb charge detonated at a depth of 30 m (100 ft).

Animal Depth ft (m)	Horizontal Range ft (m)	Peak Pressure (dB re 1 μPa)	Duration (msec)
10 (3)	680 (207)	250	0.6
50 (15)	983 (300)	246	2.1
100 (30)	1150 (350)	245	3.5
200 (61)	1340 (408)	243	6.0
300 (91)	1457 (444)	242	8.2
500 (152)	1638 (499)	241	11.9

Thus, the extrapolated DRCs suggest that a marine mammal at a depth of 10 ft (3 m) exposed to any single impulse with peak pressure exceeding 250 dB (re 1 μPa) would have a very high probability of experiencing PTS. For an animal at a depth of 500 ft (152 m), a high probability of PTS would be associated with exposure to any single pulse with peak pressure exceeding 241 dB re 1 μPa.

The reader should note that the criterion under consideration in this Appendix is TTS, not PTS. We have included the above discussion of the Richardson et al. (1995) PTS methodology for the sake of completeness, and to illustrate that one must be extremely careful in applying methods derived for in-air terrestrial safety limits to water-adapted marine species.

E.4.2 Cetacean Acoustic Criteria (Ketten, 1995)

Ketten (1995) provided a theoretical model of zones of potential trauma to aquatic ears (e.g., fracture of ossicles) induced by underwater detonations. Her model is derived from comparisons of in-air versus in-water trauma studies in the comparative literature for TTS and PTS induced by impulsive stimuli, plus models of how the pressure and overpressures associated with blast exposures affect mammalian ear structure.

Ketten identified 5 to 15 psi as the range within which an outer limit for TTS may be predicted to occur. A 10,000 lb (4,536 kg) HBX-1 detonation in deep water produces maximum pressures ranging from approx. 76.8 psi at 1,000 m range down to approx. 5.4 psi at 10,000 m range (Table 2 in Ketten, 1995). From the decrement in pressure with distance, Ketten estimated that an outer limit for minimal TTS was 5 km, which was associated with a peak pressure of 12 psi.

Ketten's model is limited to an "ideal" condition in which she has assumed the detonation occurred in deep water with the charge placed below 100 m in depth, and that the bottom depth is at least 20 times the detonation depth. Moreover, she has assumed that the bottom substrate is thick, flat sediment. In contrast, the proposed shock tests will occur in shallow water (approx. 500 ft or 152 m), and the detonation depth is only 100 ft (30 m). For this reason, the ranges calculated by Ketten are not directly applicable to the SEAWOLF shock test conditions, but Ketten's 12psi criterion can be used to calculate an effect range as discussed in Section E.5.

E.4.3 TTS in Bottlenose Dolphins (Ridgway et al., 1997)

Ridgway et al. (1997) provided the first-ever behavioral data on TTS in marine mammals. They measured TTS and associated behavioral effects in bottlenose dolphins at 3, 20 and 75 kHz. Three kHz is a clinical standard used in reference to human hearing sensitivity (e.g., Lenhardt, 1986) and is also a common standard used in auditory research with animals. Very little energy in frequencies above approximately 1 kHz generated by the HBX-1 detonation will propagate beyond the first few hundred meters. However, we consider all of the Ridgway et al. (1997) data because the high frequency end of the cochlea is closest to the middle ear and therefore is potentially susceptible to trauma from any intense stimuli regardless of spectral structure, as described previously. Ridgway et al. (1997) reported that TTS occurred in the range of 194-201 dB (re 1 μPa) at 3 kHz, 193-196 dB at 20 kHz, and 192-194 dB at 75 kHz. Thus, a conservative bound for sound pressure levels for medium-sized odontocetes would be 192 dB, which was the lowest level needed to induce TTS.

The measured time constant of the bottlenose dolphin ear was approximately 100 to 200 msec for brief tonal stimuli (Johnson, 1968). Using 100 msec is most conservative. Thus, we estimate the energy that induced TTS in bottlenose dolphins within the 100 msec integration time to be 182 dB $\mu Pa^2 \cdot sec$ [$192\ dB + (10 \times \log(0.1 sec))$]. This energy level will result in a conservative TTS range, because the distance established using 75 kHz TTS data will extend farther than that which would be predicted for 3 kHz.

Ridgway et al. (1997) described behavioral events that occurred at lower exposure levels than TTS in some trials. However, these reports were anecdotal and the relationship between behavior and TTS remains unquantified. Moreover, the appearance of these behaviors was not consistent, and there was no way to rule out other possible causes of the behavior, such as interactions among neighboring dolphins. Therefore, we elected to use the most consistent, quantifiable indicator of acoustic harassment, the TTS values.

E.5 METHOD OF CALCULATING TTS IMPACT ZONES

In this and the following sections we will determine the critical distances from the explosion for TTS in marine mammals (and by extrapolation, sea turtles). The critical distance is the shortest distance at which no TTS is expected to occur. We will use two criteria based on the preceding discussion. At a given position in the water column, TTS would not be expected to occur if (1) the peak pressure is less than 12 psi (Section E.4.2) and (2) the energy density in all 1/3 octave bands is less than 182 dB re 1 $\mu Pa^2 \cdot sec$ (Section E.4.3). The PTS criterion extrapolated from human DRC as suggested by Richardson et al. (1995) (Section E.4.1) is not used because it would be a less conservative criterion (PTS is a more severe effect than TTS, and the effect range would be much less).

In calculating the range for the energy-based TTS criterion, different frequency ranges will be considered for odontocetes and mysticetes due to their differences in low frequency hearing sensitivity. For small- and medium-sized odontocetes, whose range of best hearing is above 10,000 Hz, the frequency range considered will be 100 Hz and up. At 100 Hz, the sensitivity of bottlenose dolphin hearing is down by more than 70 dB from the peak sensitivity (Richardson et al., 1995). Extension to lower frequencies was not deemed necessary.

Although audiograms have been measured for some odontocetes, the only information available for baleen whales is based on vocalization recordings, anatomical models of hearing ranges, and playback experiments (Clark, 1990; Ketten, 1991,1992, 1994; Richardson et al., 1995). The majority of sound energy produced by baleen whales lies between approximately 15 to 1,000 Hz (Richardson et al., 1995; Clark, 1990). In the light of this, and to be conservative, we will extend the frequency range considered for the energy criterion for mysticetes down to 10 Hz.

The pulse train from an underwater explosion in relatively shallow water consists of the direct shock wave followed by companion surface-reflected and bottom reflected waveforms. There will generally be a series of higher order reflections: bottom-surface, surface-bottom, bottom-surface-bottom, etc. There may be significant energy which travels largely through the bottom. In addition, at the ranges of interest for sea mammal TTS, the arrivals will generally be modified by refraction due to the variation of sound speed with depth in the water column. All these transmission paths must be considered to produce an accurate model of the pressure vs. time signature at locations of interest.

For these calculations the contribution of the bubble pulse can be ignored. The bubble pulse period for a 10,000 lb HBX-1 charge at a depth of 100 ft (30 m) is about 1.7 sec, which corresponds to a bubble pulse frequency of 0.6 Hz. Since the effect of the bubble pulse on the spectrum is minimal at frequencies above ten times the bubble pulse frequency (Weston, 1960), it would have negligible effects in this application. Note that for other situations, involving smaller explosions, the bubble pulse effect on the spectrum may have to be taken into account.

The procedure for calculating the critical distance for TTS is as follows:

1. At a given assumed animal position in the water, for a particular sound speed profile, calculate the pressure vs. time waveform expected at that position.
2. Note the peak pressure in that waveform and compare with the 12-psi criterion for TTS.
3. Calculate the energy density spectrum for the waveform.
4. Integrate the spectrum in 1/3 octave bands.
5. Determine if the energy density in any 1/3-octave band exceeds 182 dB re 1 μPa^2.sec (considering frequency ranges of $\geq$100 Hz for odontocetes and $\geq$10 Hz for mysticetes).
6. By performing a large number of calculations at different positions for different sound speed profiles, determine the shortest distance at which neither criterion is exceeded.

The pressure-time waveforms were calculated using the REFMS computer model for shock wave transmission (Britt et al., 1991). Validation studies of this model are listed at the end of this appendix. The model includes the effects of multiple surface and bottom reflections of the shock wave, as well as refraction effects. Although this is largely an acoustic model, non-linear effects on shock wave transmission near the charge are included. The explosive charge weight, type of explosive and charge depth are input into the calculation. A sound speed profile in the water is required for the calculation, as are bottom depth and properties. For a given range, waveforms were calculated at assumed animal depths of 50 to 400 ft (15 to 122 m). Energy spectra were obtained from the pressure-time waveforms by standard methods.

For the SEAWOLF calculations, archival sound speed profiles for both the Mayport and Norfolk sites were used. To be conservative, the complete calculated pulse train was used to compute the spectrum, even if it contained pulses separated by more than 0.1 sec, the integration time of the dolphin ear for brief tone pips.

Using the limited number of archival sound speed profiles available for the two proposed test sites, calculations were made of the acoustic environment to which sea mammals might be exposed as a result of detonating a 10,000 lb (4,536 kg) charge of HBX-1 at a depth of 100 ft (30 m). Only profiles measured in spring and summer were used. The water depth was assumed to be 500 ft (152 m). The effect of bottom slope was not considered, as previous experience has indicated that it would have only a minor effect on the results.

Although the water column in the Mayport area seems to have a rather stable sound speed structure, there are very few archival profiles available. Profiles in the Norfolk area are quite variable. However, in both areas, vortices from the Gulf Stream can cause major swings in sound speed profiles in as little as 24 hours. For both areas, the archival profiles can give only an indication of the situation one might expect during a given time period.

E.6 RESULTS

The cases considered are for profiles most representative of the variability to be expected from April to August in the two areas. **Figures E-2 through E-4** show selected energy spectra for the Norfolk test area. **Figures E-5 through E-7** show selected energy spectrum plots for the Mayport area. Each of these figures shows the calculated energy spectrum, in 1/3-octave bands, for animal depths of 100, 200, 300 and 400 ft (30, 61, 91, and 122 m). **Figures E-8 through E-10** and **Figures E-11 through E-13** show a selection of calculated pressure vs. time waveforms for the respective test sites. In each of these figures, the x-axis has been shifted by 10 psi between charge depths to allow the traces to be separated for clarity.

Based on the detailed calculations, general guidance may be drawn as to the critical distance for TTS at each proposed test site. **Figure E-14** shows the calculated peak pressure as a function of distance for the Norfolk area. **Figures E-15 and E-16** show the calculated maximum energy density as a function of distance for odontocetes and mysticetes. In each case, the maximum values obtained at each distance are plotted, without regard to the depth at which the maximum occurred. **FiguresE-17 through E-19** show the same data for the Mayport area. For each of these plots, the maximum distance at which the criterion was reached was taken as indicative of the critical distance. The distances obtained from the energy criterion were compared with those for the peak pressure criterion, and the greater taken as the critical distance for TTS. In no case was the 12 psi peak pressure criterion the determining factor, as the distances at which this pressure level was reached were less than those indicated by the energy criterion. From these results, the critical TTS distances for each test site for odontocetes and baleen whales were determined. These distances are summarized in **Table E-2**.

Table E-2. Maximum estimated ranges for TTS at the Mayport and Norfolk areas, based on the 182 dB energy criterion.

	Norfolk	Mayport
Odontocetes	7.0 nmi (13.0 km)	8.5 nmi (15.7 km)
Mysticetes	12.0 nmi (22.2 km)	12.7 nmi (23.5 km)

E.7 CONCLUSIONS

The most meaningful criteria for estimating acoustic impact ranges for marine mammals and turtles would be based on measurements of TTS resulting from exposure to impulsive noise (ideally, underwater explosions). However, these data do not exist. Therefore, we have developed acoustic criteria based on the best available data. This includes results from the first TTS study of a marine mammal – the Ridgway et al. (1997) experiment with bottlenose dolphins. In addition, acoustic impact zones developed for marine mammals by Ketten (1995) provide a basis for an acoustic criterion.

In this Appendix, a dual criterion has been developed: (1) an energy-based TTS criterion of 182 dB re 1 $\mu Pa^2 \cdot sec$ derived from the Ridgway et al. (1997) bottlenose dolphin data; and (2) 12 psi peak pressure, cited by Ketten (1995) as associated with an "outer limit for the 10,000 lb charge for minimal, recoverable auditory trauma." The effect range is the minimum distance at which neither criterion is exceeded. The same TTS criterion is used for both odontocetes and mysticetes, a reasonable approach based on the best available data. However, different frequencies were used to calculate TTS ranges based on their differing sensitivity to low frequencies. For odontocetes, we included all frequencies greater than or equal to 100 Hz. For mysticetes, we included all frequencies greater than or equal to 10 Hz. These are highly conservative lower frequency bounds, especially for odontocetes. For the Mayport area, the maximum TTS range is predicted to be 8.5 nmi (15.7 km) for odontocetes and 12.7 nmi (23.5 km) for mysticetes. Corresponding TTS ranges at Norfolk are 7 nmi (13 km) for odontocetes and 12 nmi (22.2 km) for mysticetes. In no case was the 12 psi peak pressure criterion the determining factor, as the distances at which this pressure level was reached were less than those indicated by the 182 dB energy criterion.

There are no data for TTS or PTS in sea turtles. Ridgway et al. (1969) reported maximal sensitivity for green sea turtles occurred at 300 to 400 Hz, with a rapid decline in sensitivity for lower and higher tones. Similarly, Moein et al. (1994) reported a hearing range of about 250 to 1,000 Hz for loggerhead sea turtles, and Lenhardt (1994) stated that maximal sensitivity in sea turtles generally occurs in the range from 100 to 800 Hz. Calculated in-water hearing thresholds within the useful range appear to be high (e.g., about 160 to 200 dB re 1 μPa; Lenhardt, 1994). Based on this information, the TTS distance predicted for odontocetes using frequencies $\geq$100 Hz [i.e., 8.5 nmi (15.7 km) at Mayport and 7 nmi (13 km) at Norfolk] should be conservative for sea turtles. It should be noted that, in contrast to marine mammals, little is known about the role of sound and hearing in sea turtle survival.

Finally, it should be noted that calculations made using archival information provide only an estimate of what may occur. The actual acoustic field on any given day will depend on the sound-velocity structure at that time and on the actual bottom sediment and structure in the area. *In situ* profile measurements and calculations made on site during shock testing will improve future model predictions.

E.8 ADDITIONAL INFORMATION

Commenters on the Draft Environmental Impact Statement (DEIS) requested additional information on sound source properties. Some examples of this type of information are provided at the end of this appendix.

An example REFMS waveform for one set of conditions is attached as **Figure E-20**. This plot does not show the bubble pulse, but does include reflections from the surface and bottom and takes into account the velocity structure of the water column.

An example of a pressure-time history calculated by the NSWC bubble code is also attached as **Figure E-21** (not for the same conditions as the previous example). This calculation is for a 10,000 lb (4,536 kg) TNT charge at 300 ft (91 m) depth, with a gauge at the same depth at a range of 300 ft (91 m) in a water depth of 500 ft (152 m). The water is taken to be isovelocity in this calculation, as the sound-speed profile has little effect this close to the charge. The plot shows not only the shock wave, but also the first bubble pulse; it does not include surface and bottom reflections.

Figure E-22 and E-23 show pressure pulses at various depths at ranges of 4 nmi (7.4 km) and 6 nmi (11.1 km) from a detonation at the Mayport area. The corresponding energy spectra for the 6 nmi (11.1 km) range have been shown in Figure E-5.

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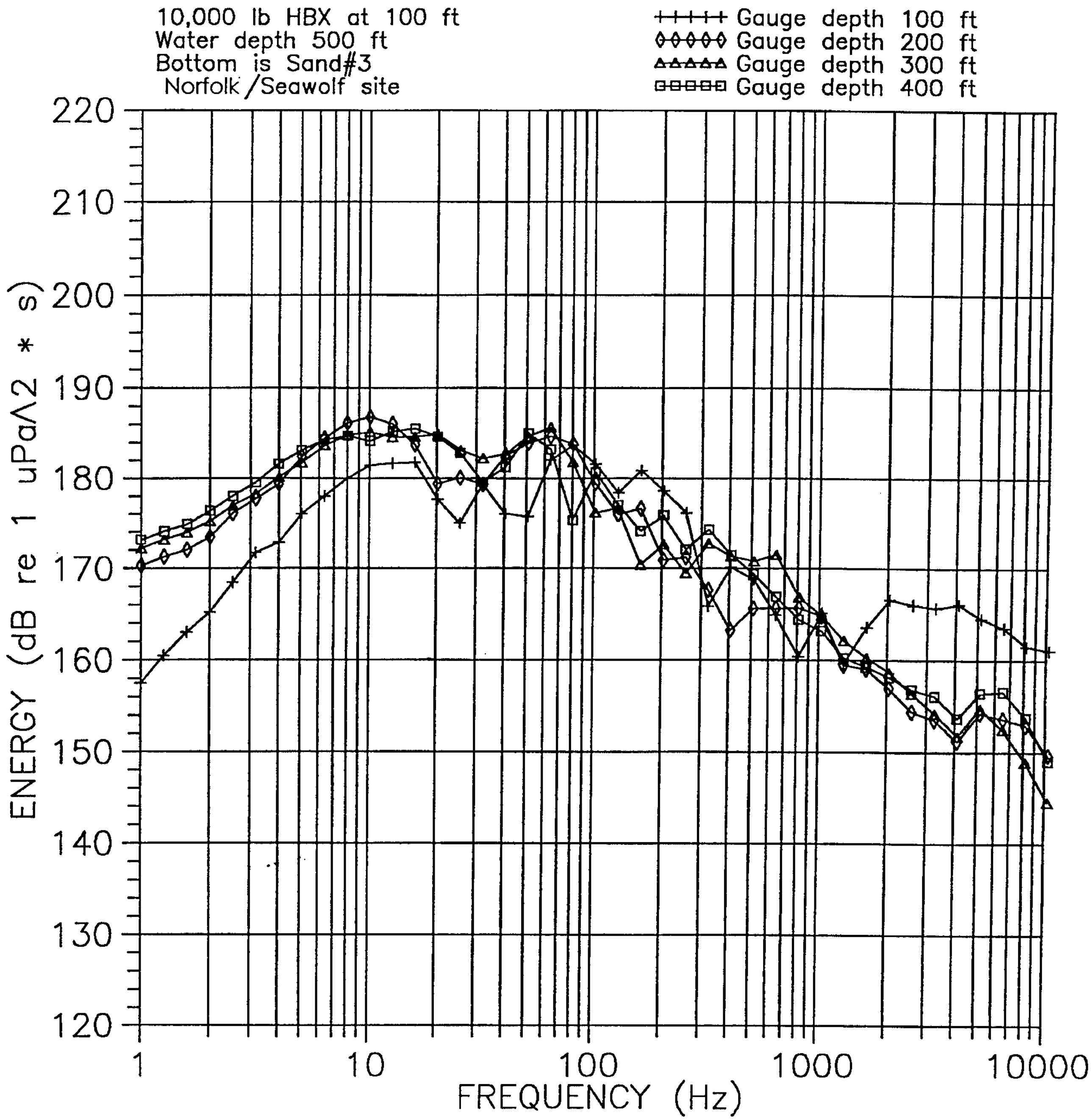


Figure E-2. Calculated 1/3-octave band energy, Norfolk Area, range = 6 nmi.

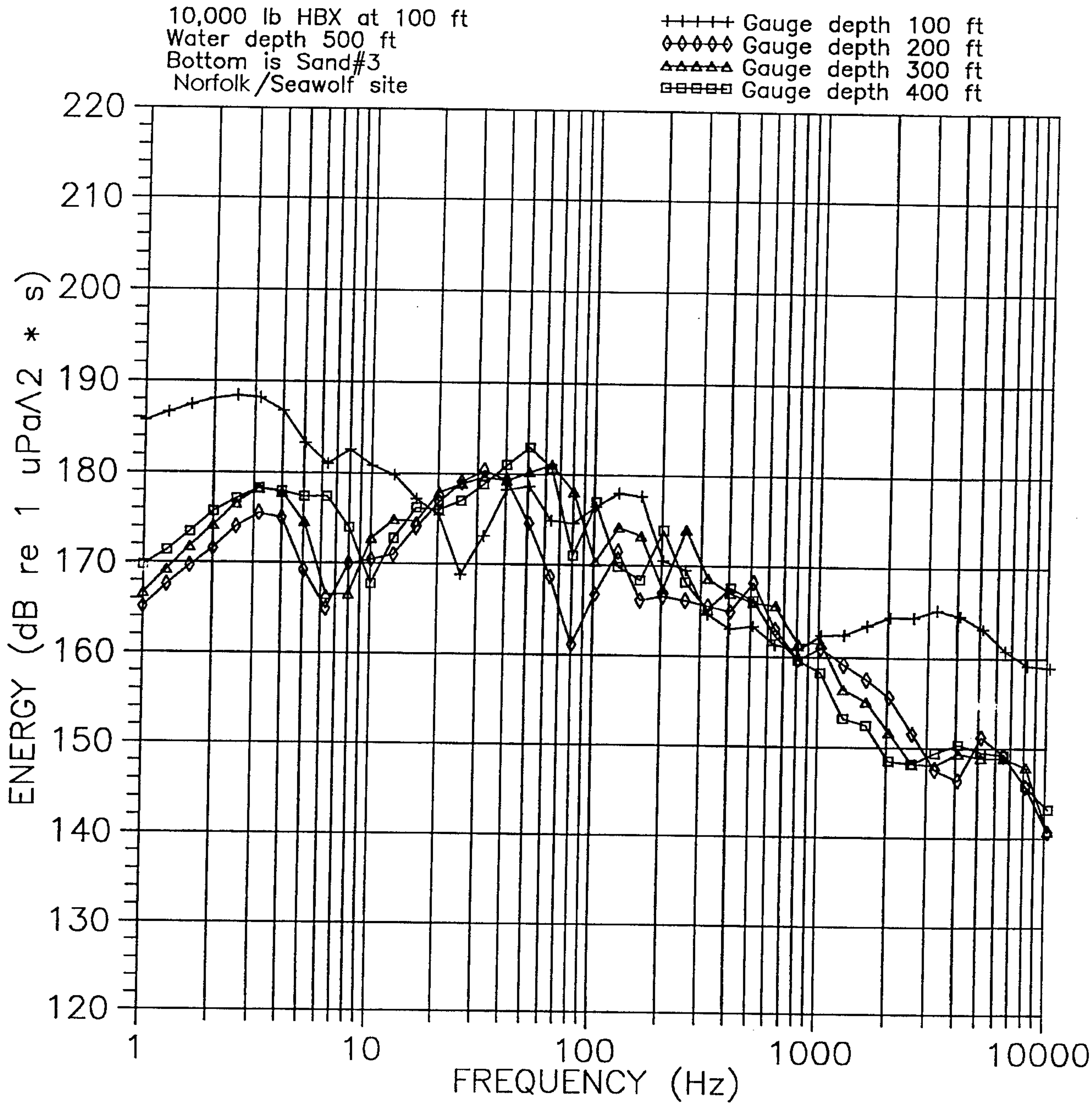


Figure E-3. Calculated 1/3-octave band energy, Norfolk Area, range = 8 nmi.

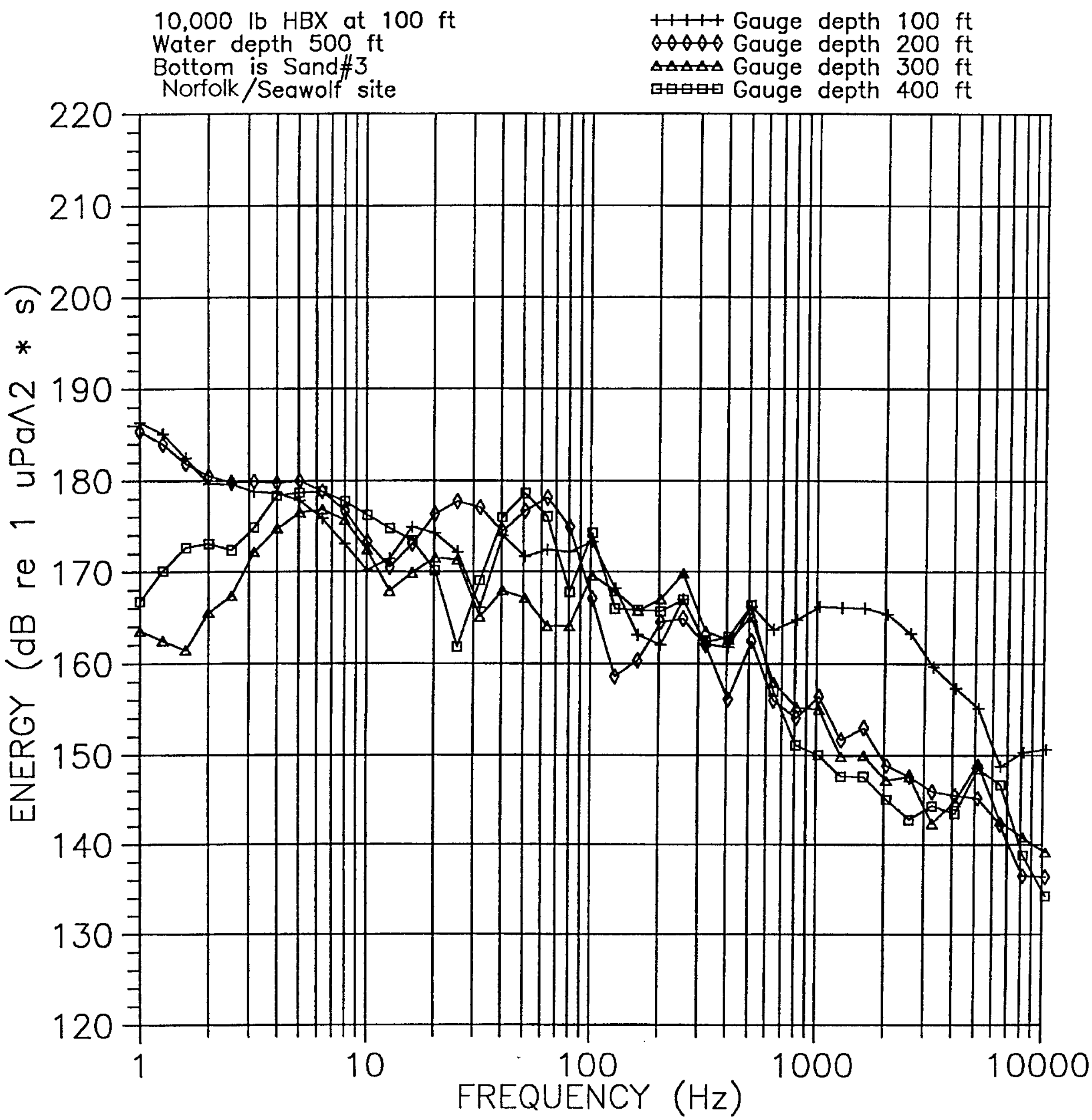


Figure E-4. Calculated 1/3-octave band energy, Norfolk Area, range = 12 nmi.

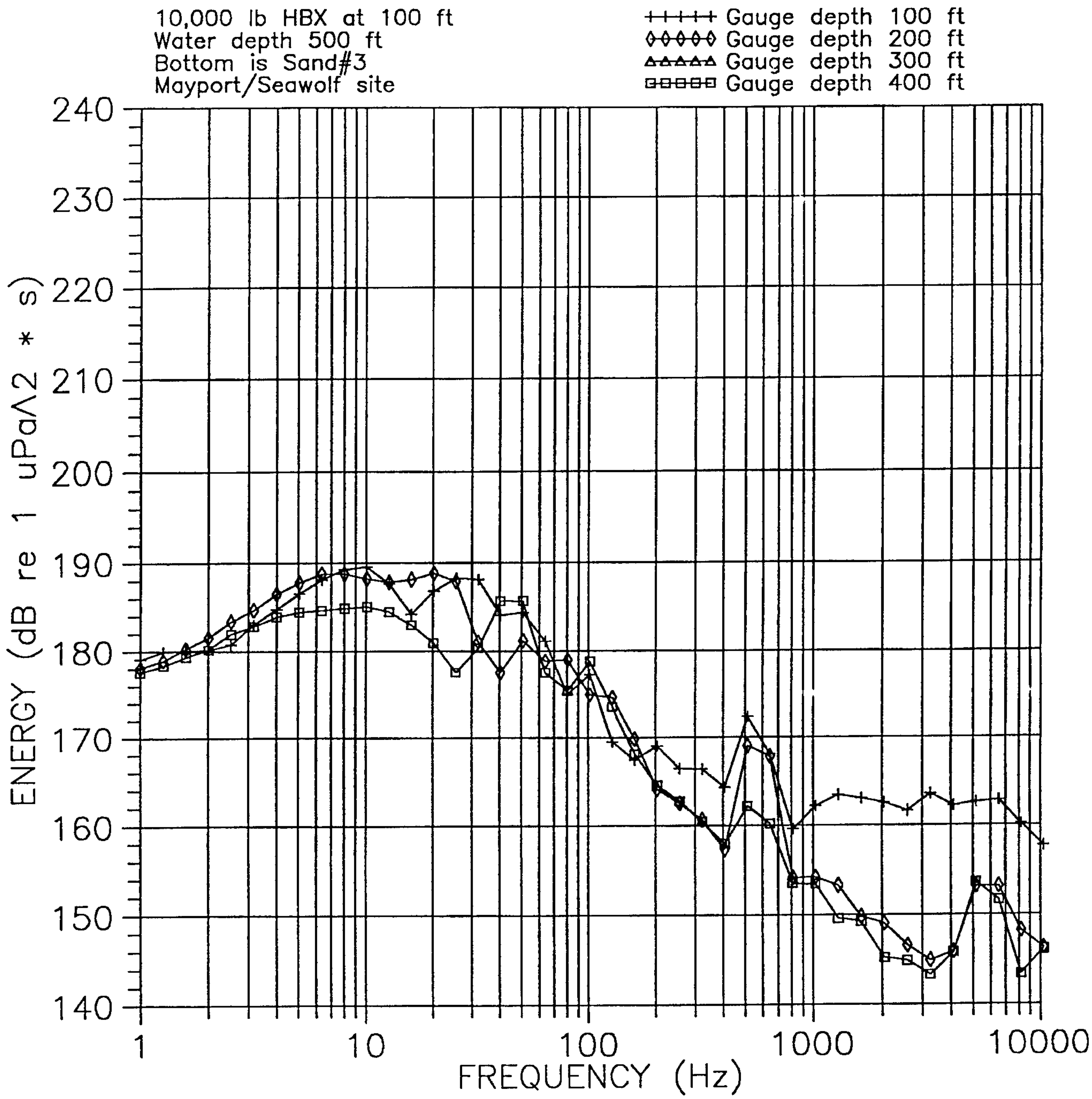


Figure E-5. Calculated 1/3-octave band energy, Mayport Area, range = 6 nmi.

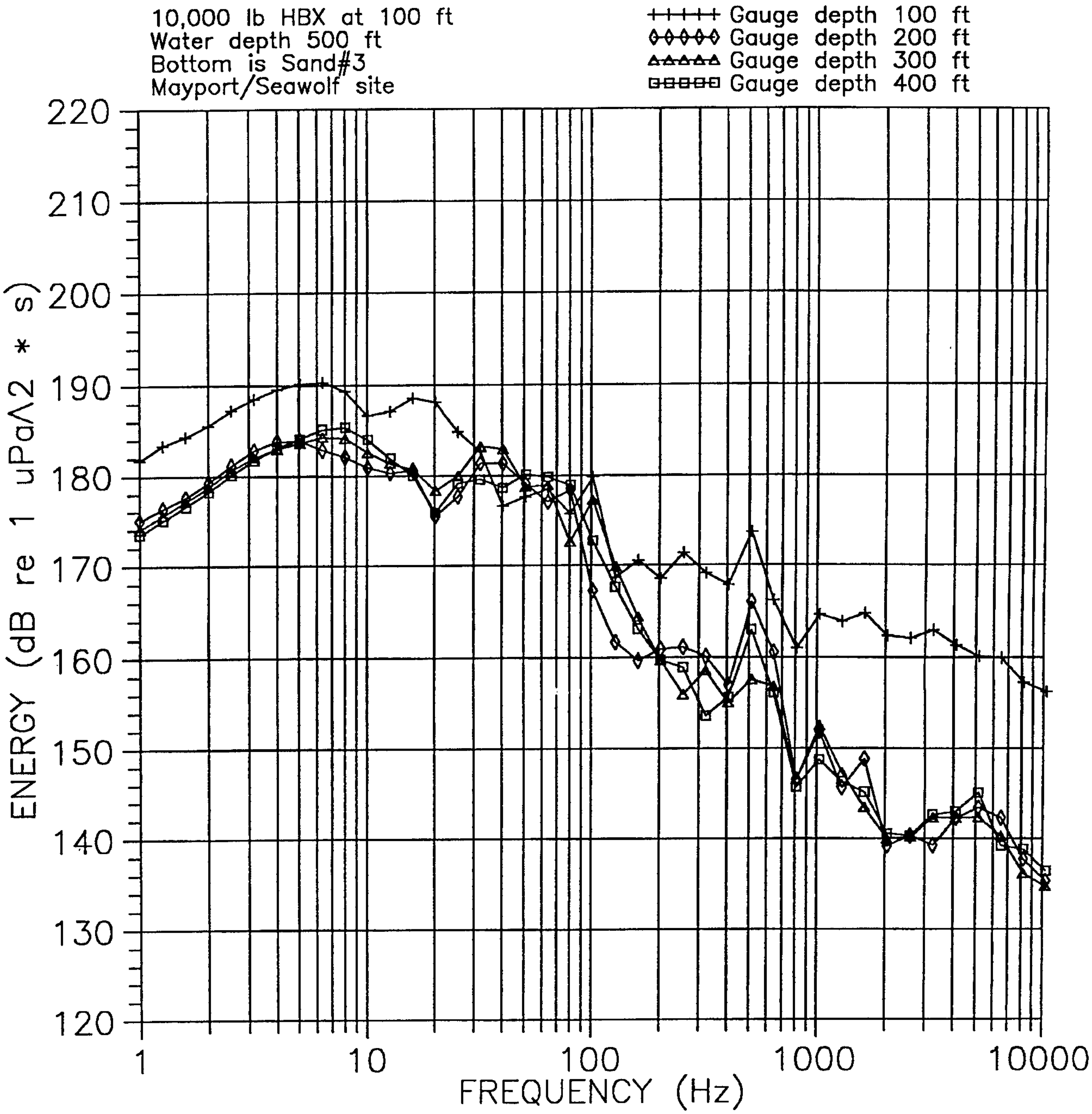


Figure E-6. Calculated 1/3-octave band energy, Mayport Area, range = 8 nmi.

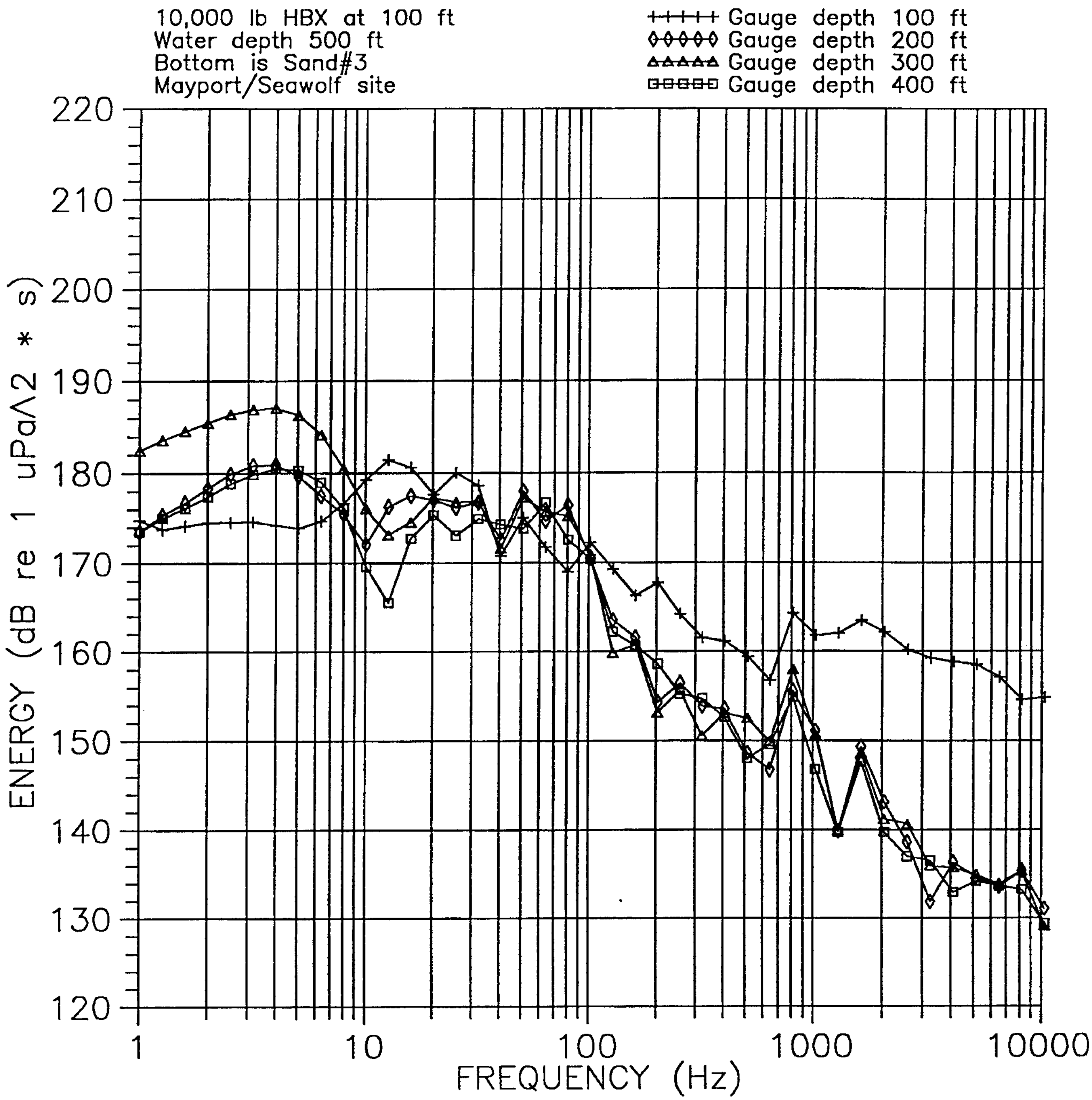


Figure E-7. Calculated 1/3-octave band energy, Mayport Area, range = 12 nmi.

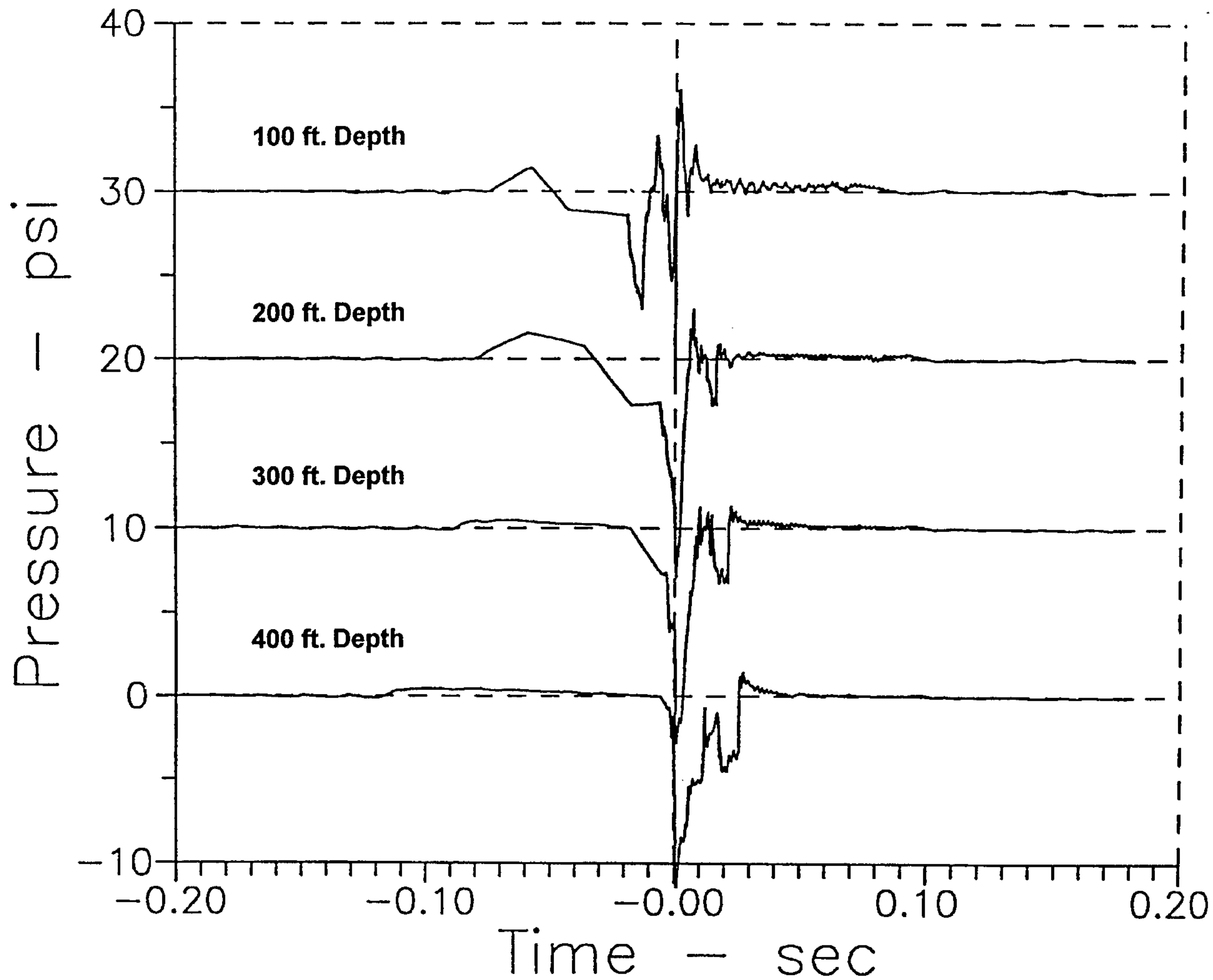


Figure E-8. Calculated pressure vs. time, Norfolk Area, range = 6 nmi.

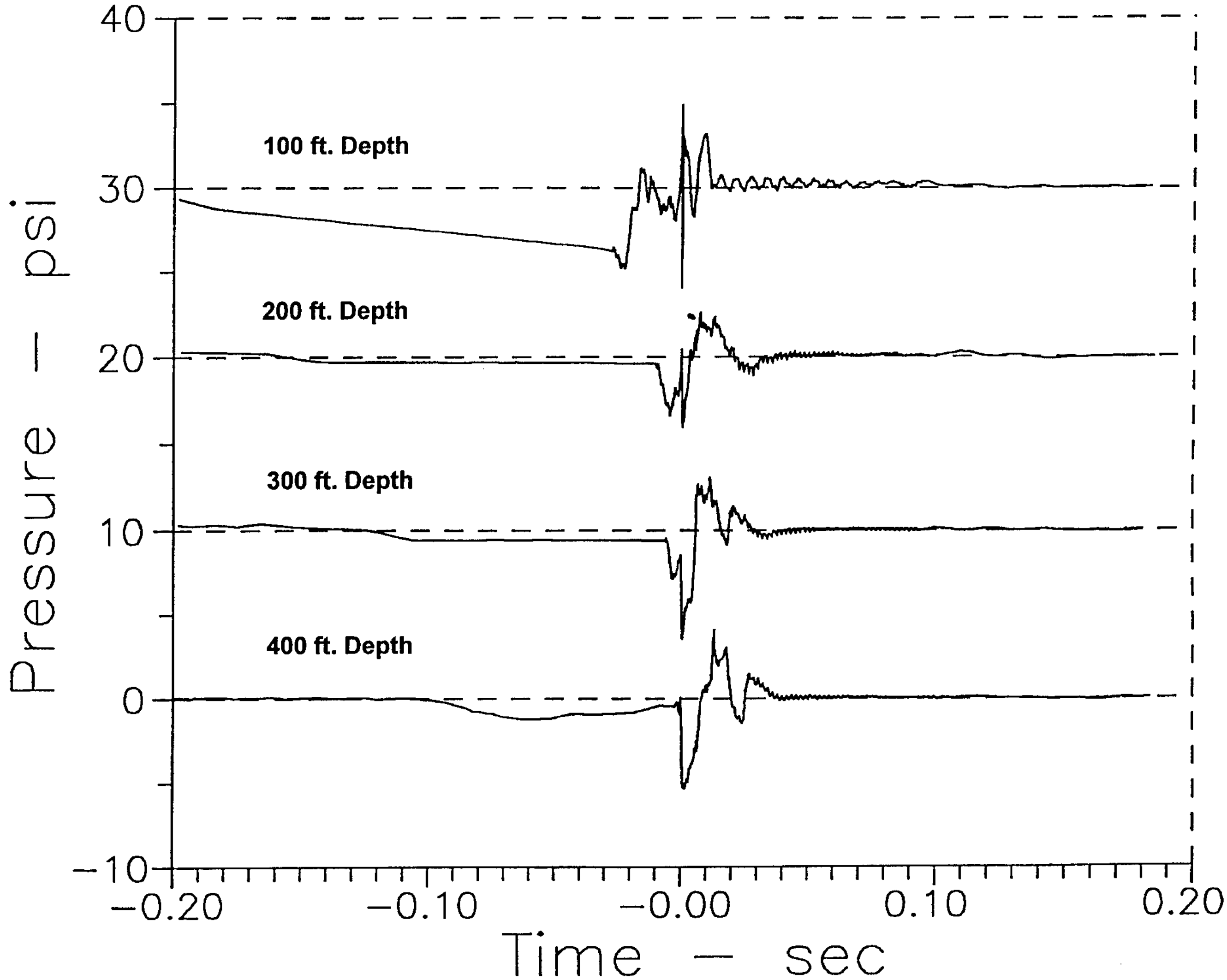


Figure E-9. Calculated pressure vs. time, Norfolk Area, range = 8 nmi.

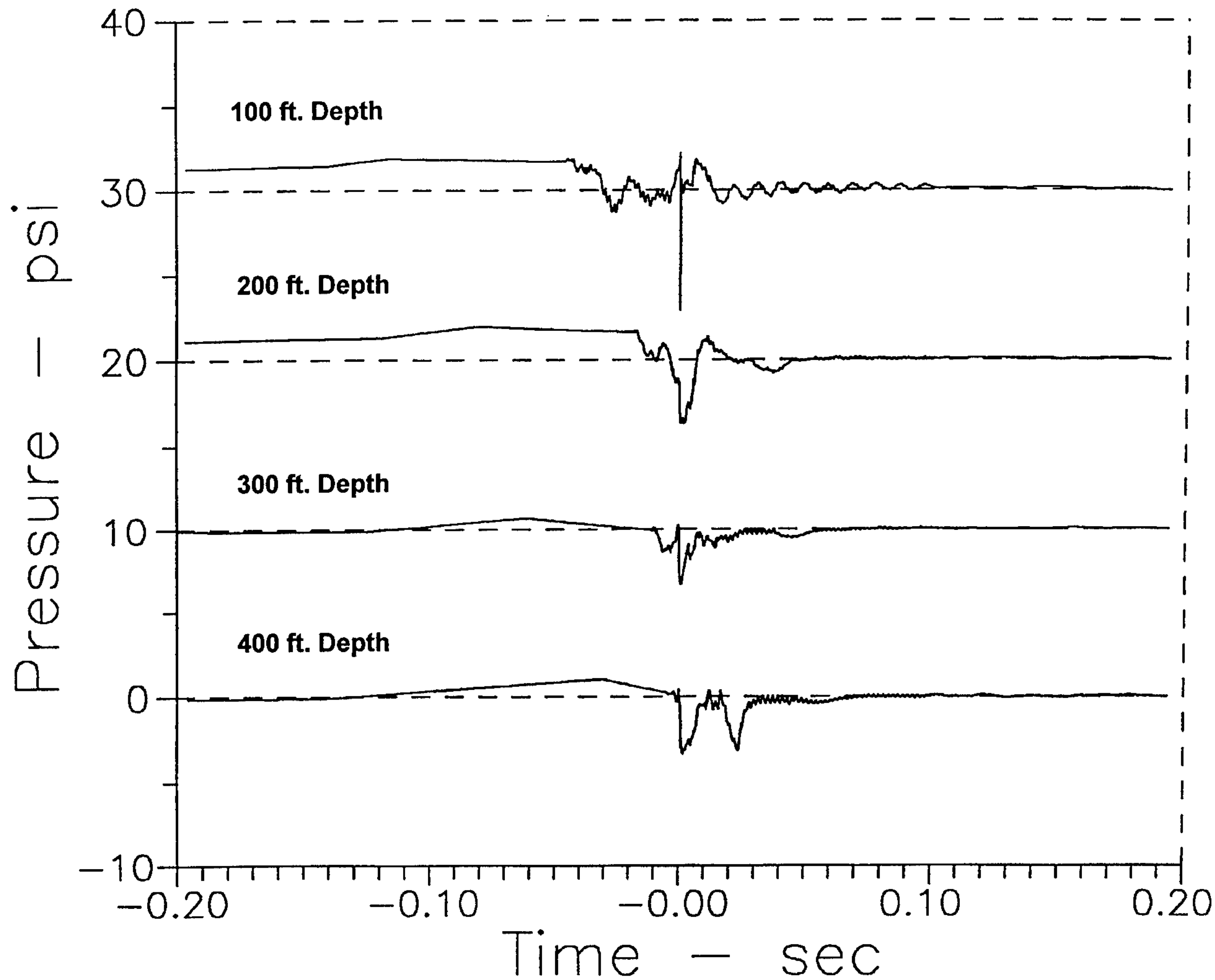


Figure E-10. Calculated pressure vs. time, Norfolk Area, range = 12 nmi.

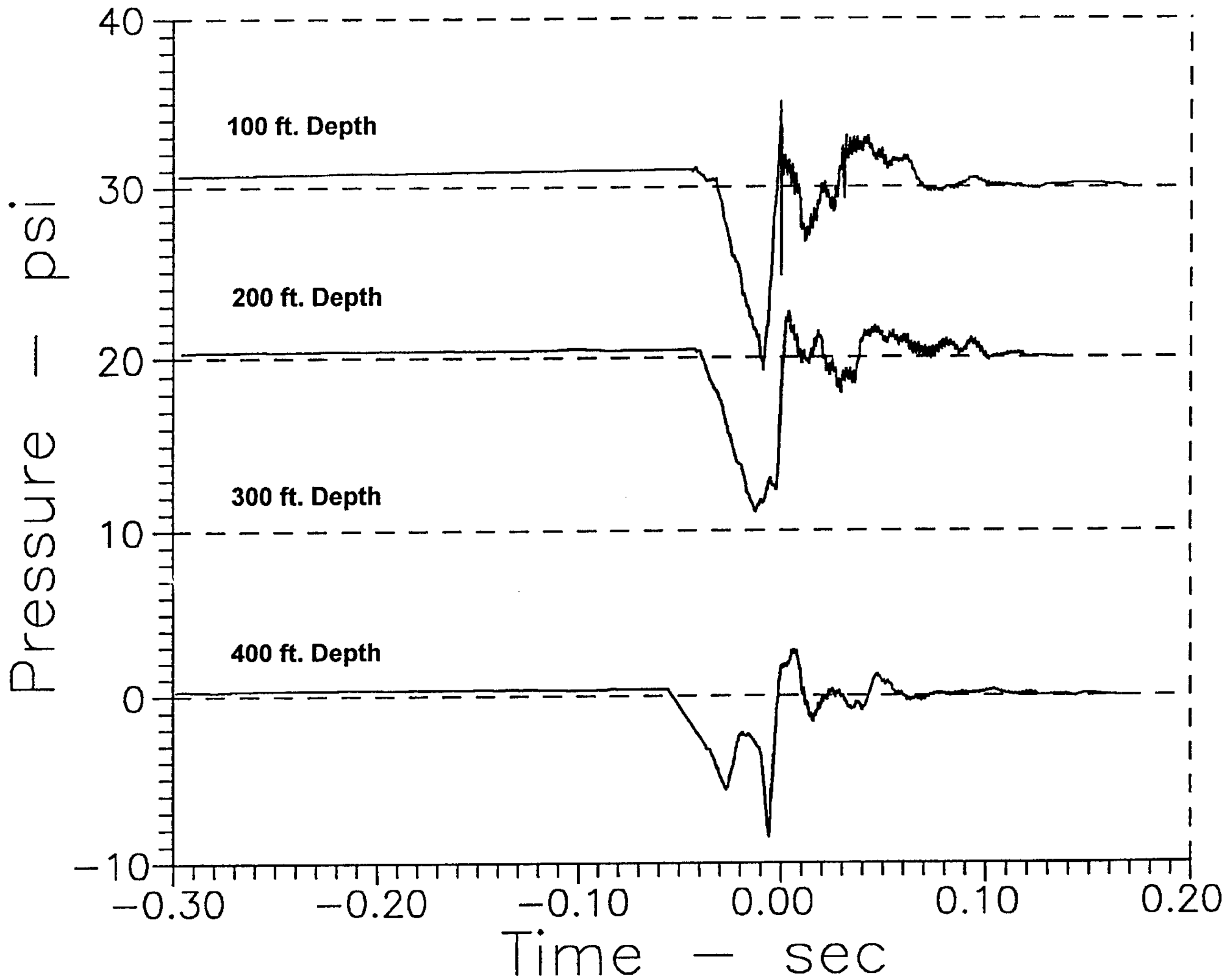


Figure E-11. Calculated pressure vs. time, Mayport Area, range = 6 nmi.

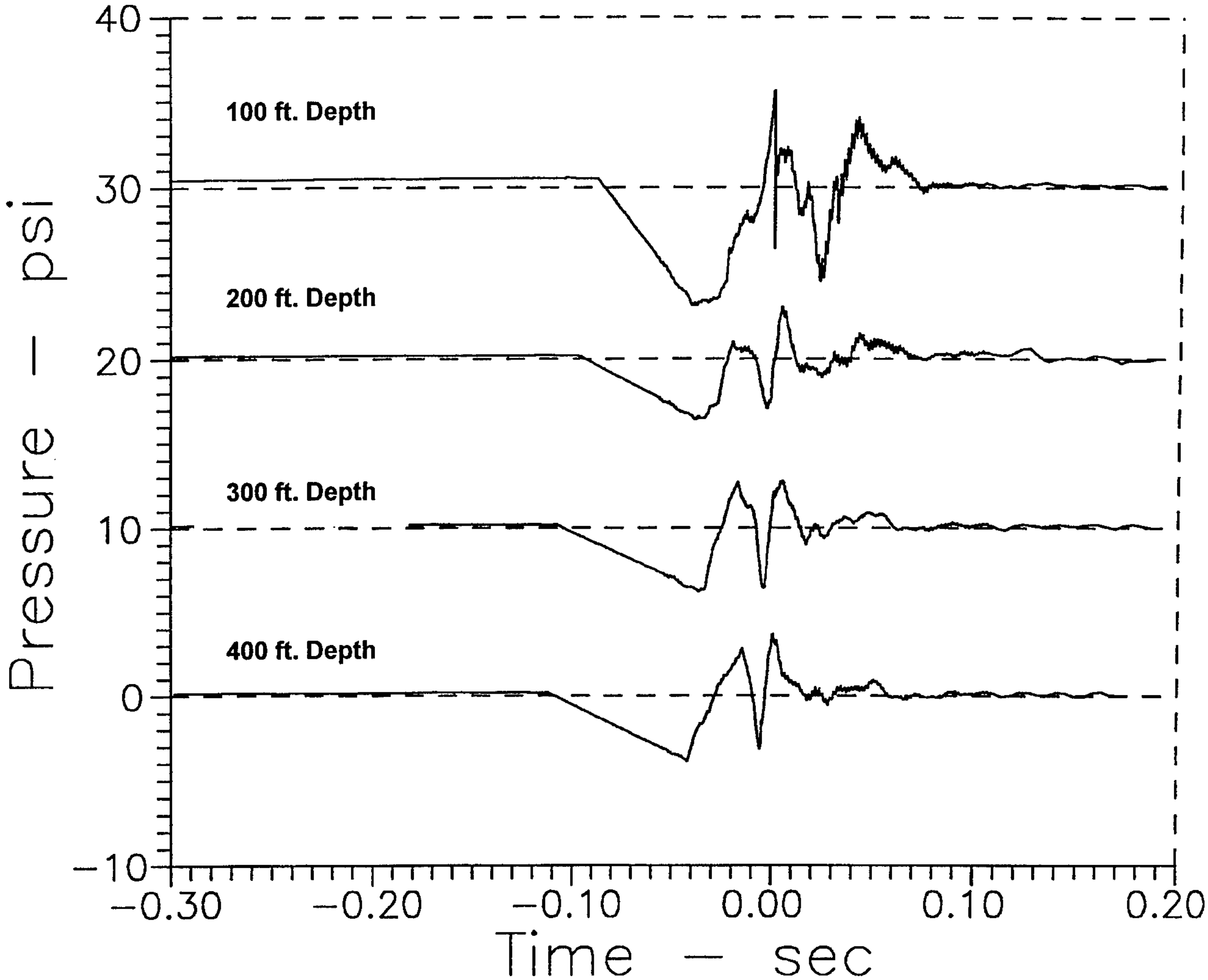


Figure E-12. Calculated pressure vs. time, Mayport Area, range = 8 nmi.

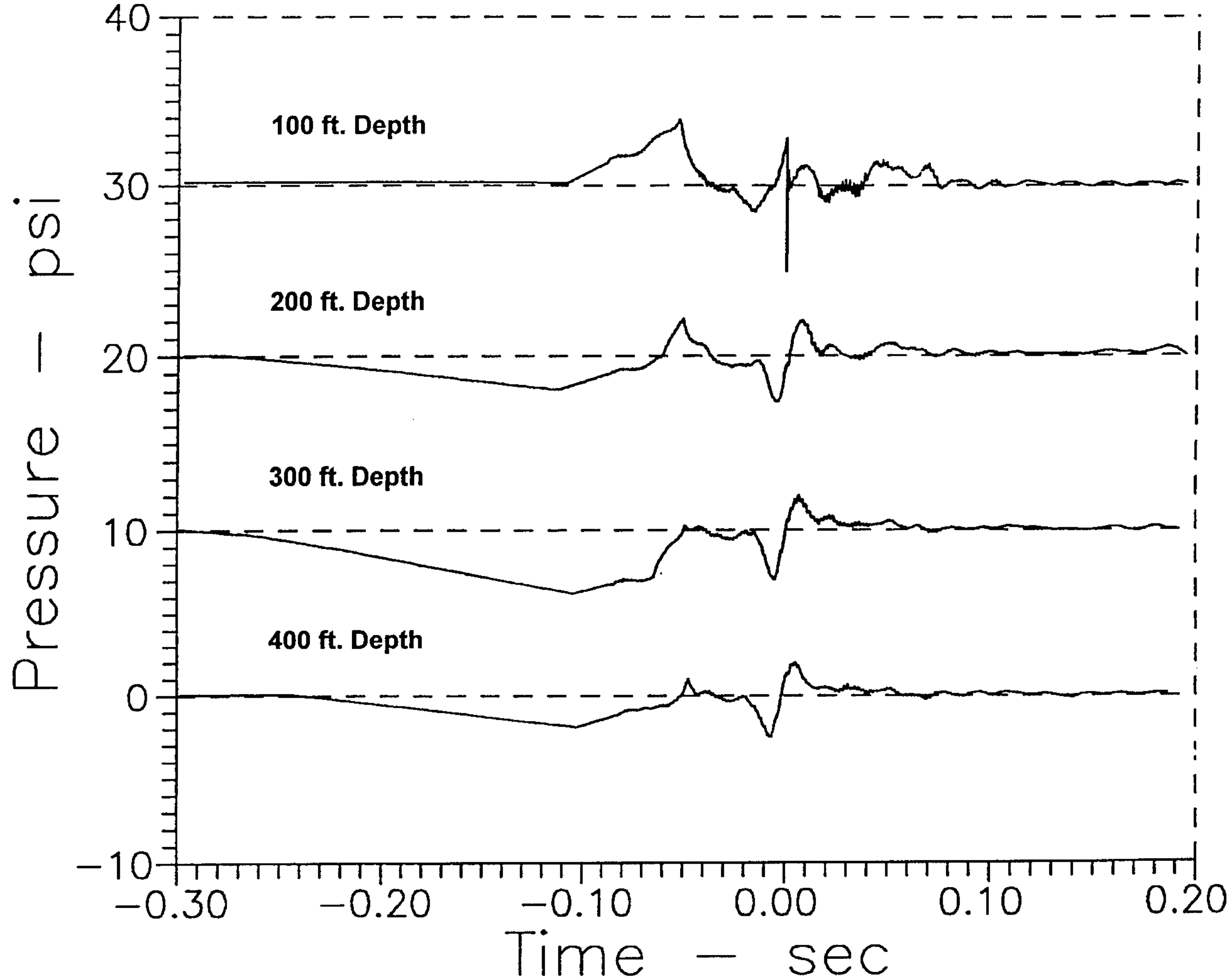


Figure E-13. Calculated pressure vs. time, Mayport Area, range = 12 nmi.

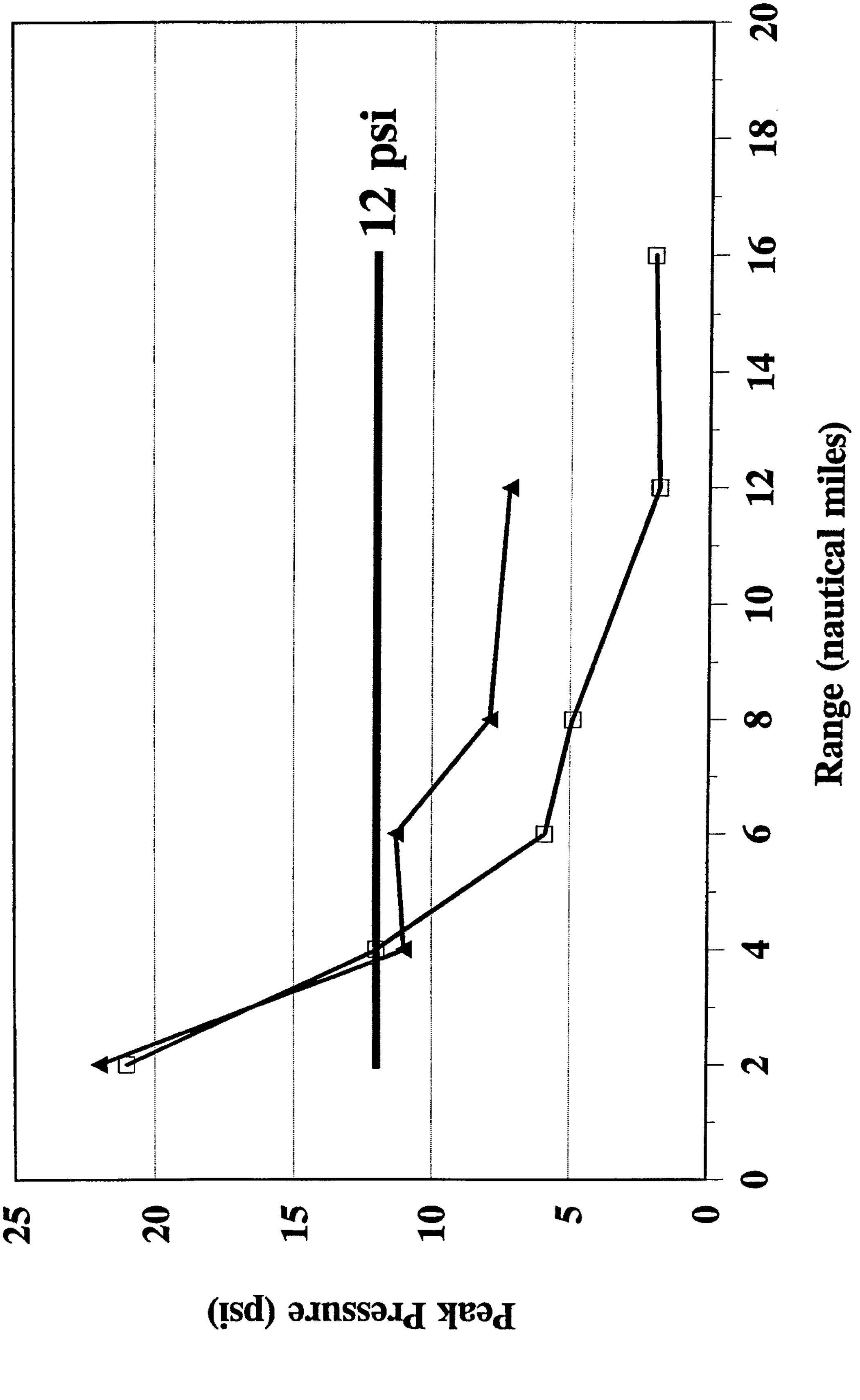


Figure E-14. Calculated peak pressures, Norfolk Area.

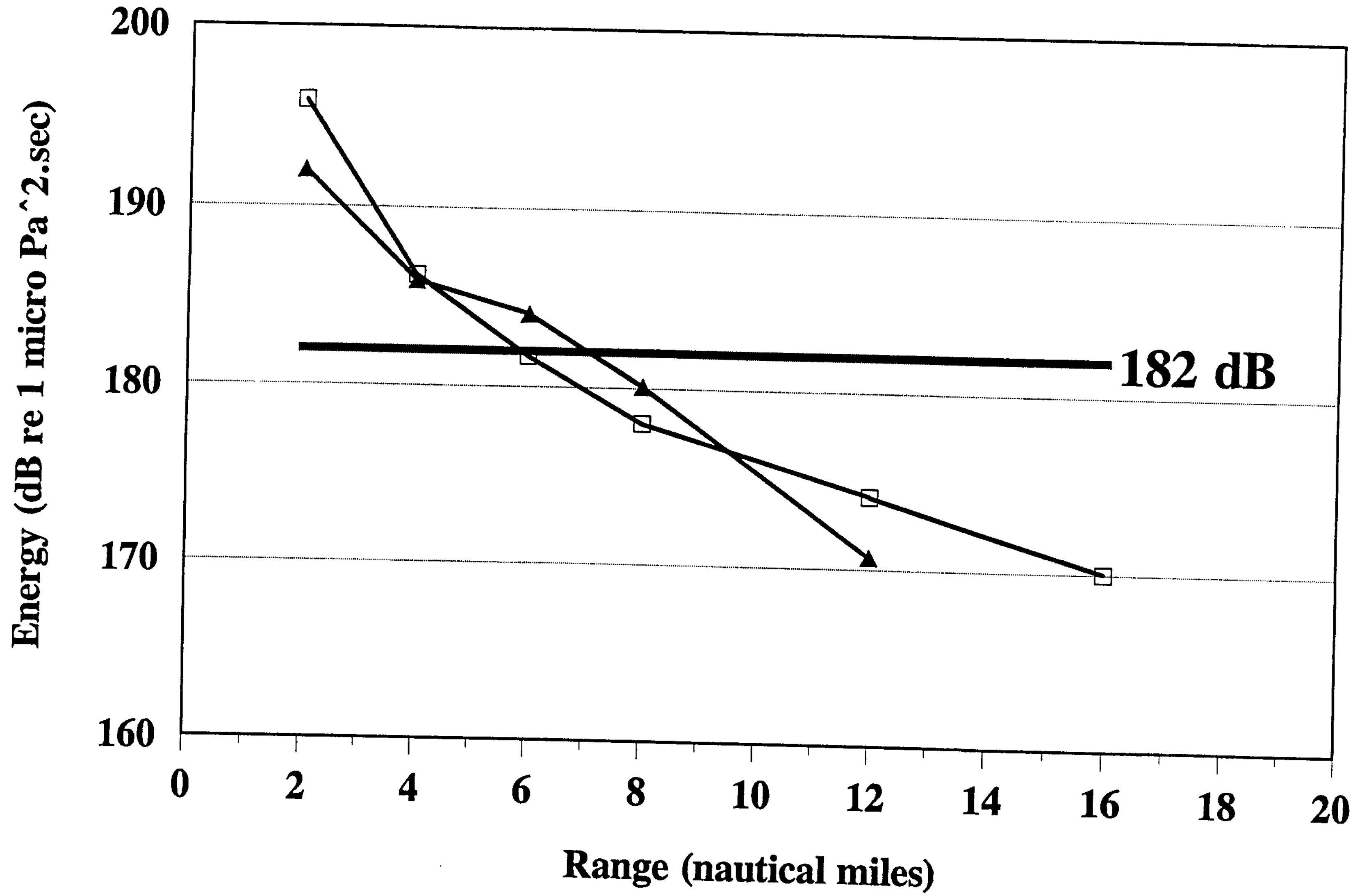


Figure E-15. Calculated maximum energy density - odontocetes, Norfolk Area.

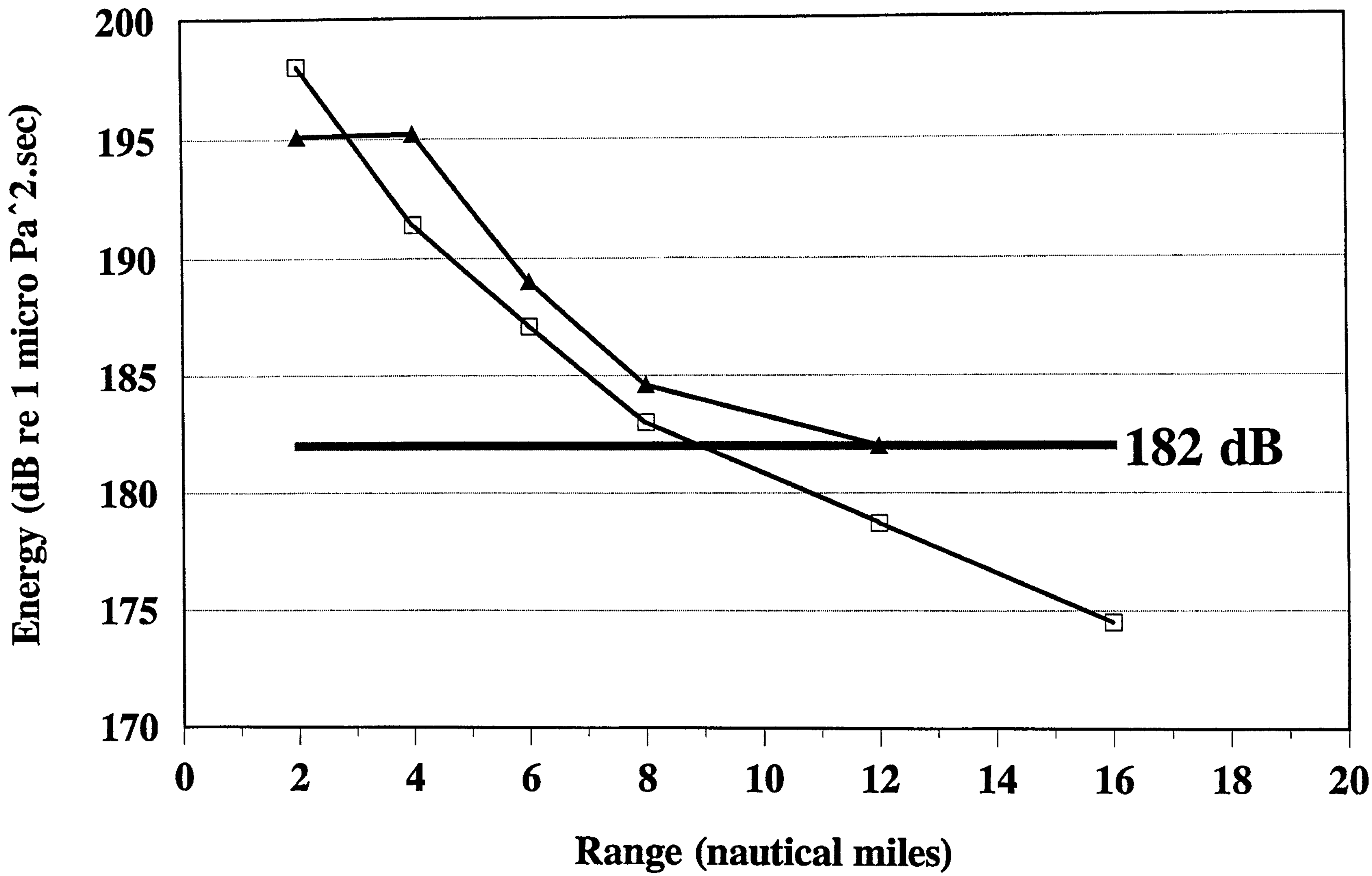


Figure E-16. Calculated maximum energy density - baleen whales, Norfolk Area.

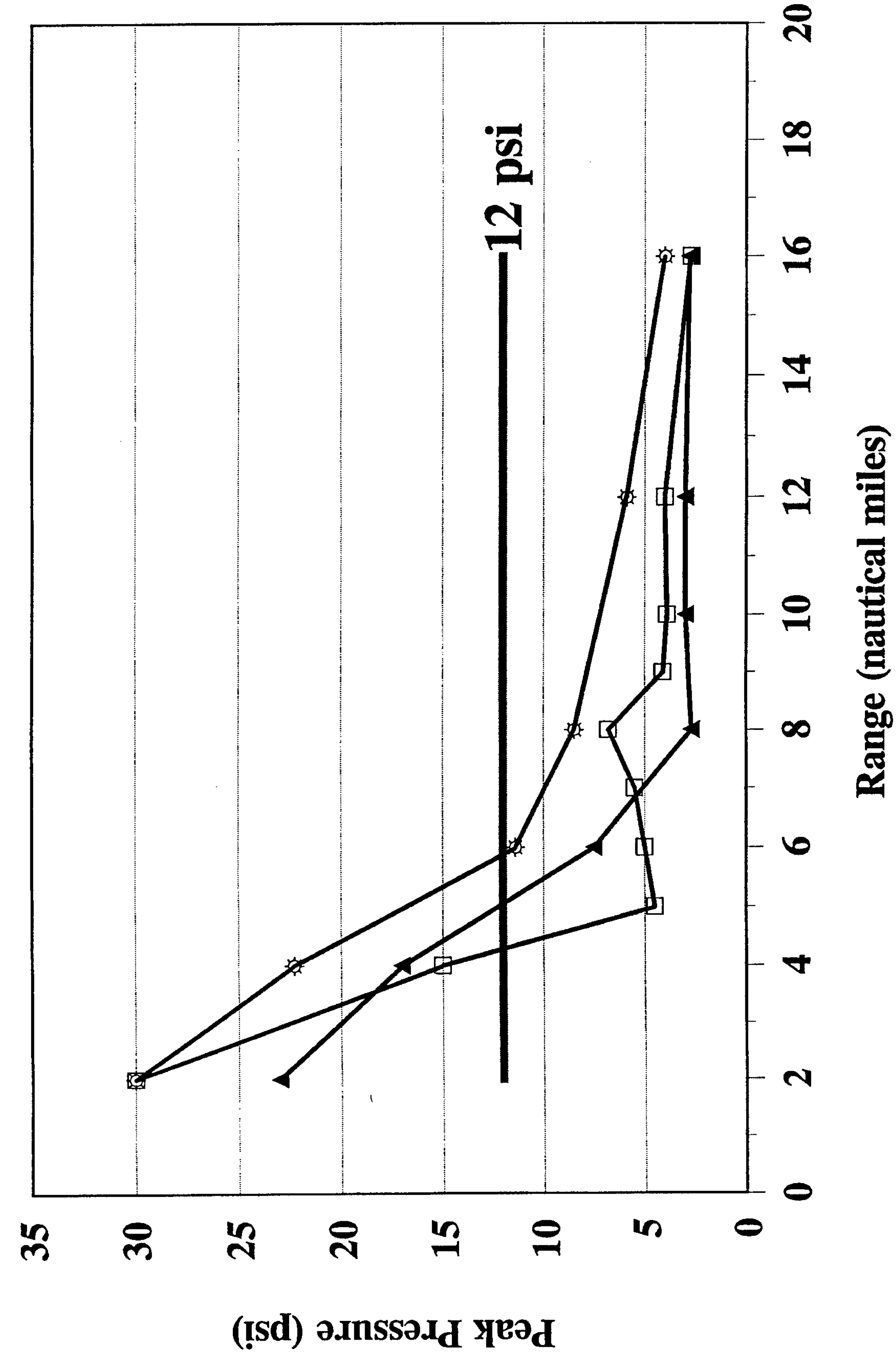


Figure E-17. Calculated peak pressures, Mayport Area.

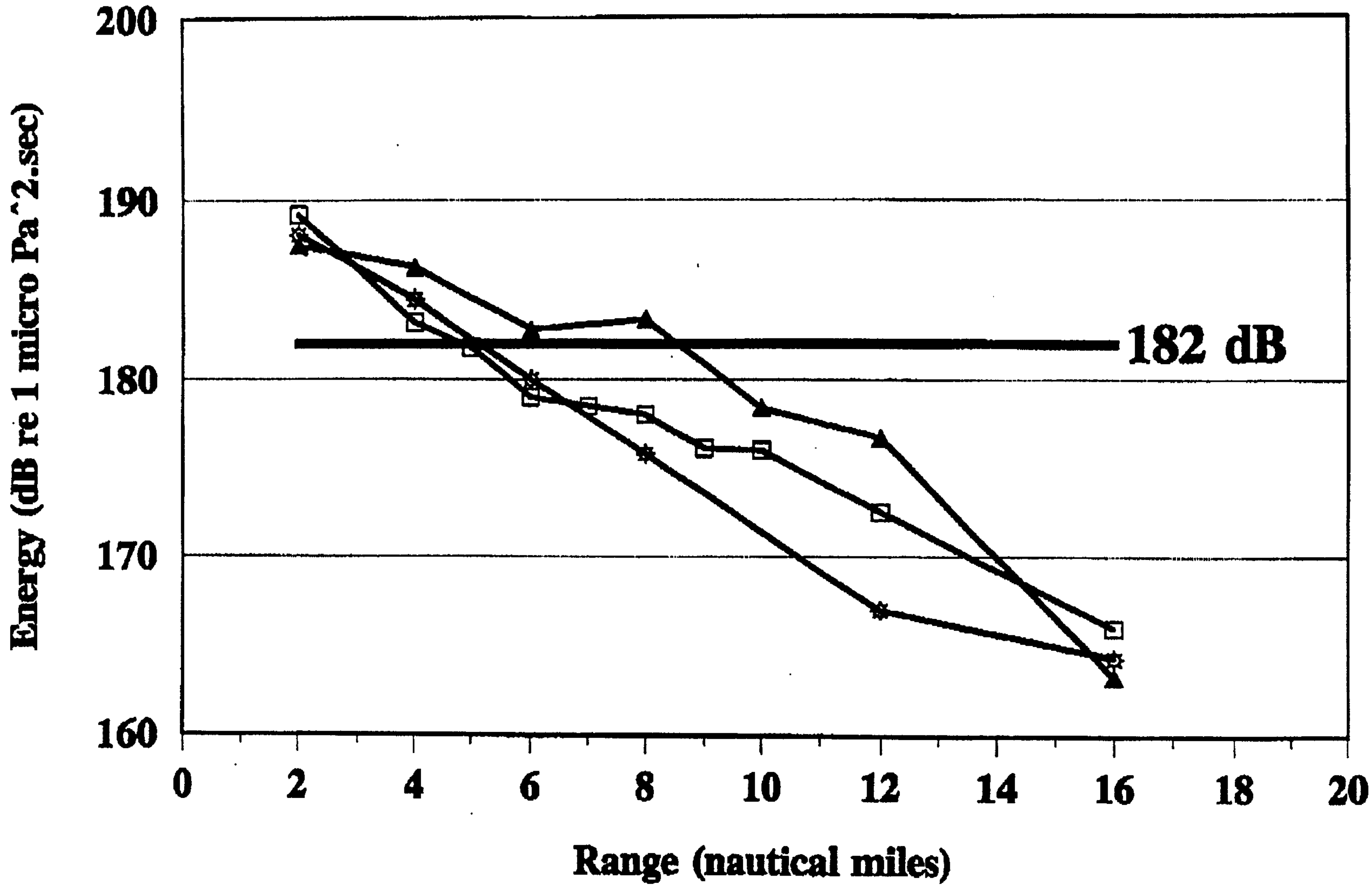


Figure E-18. Calculated maximum energy density - odontocetes, Mayport Area.

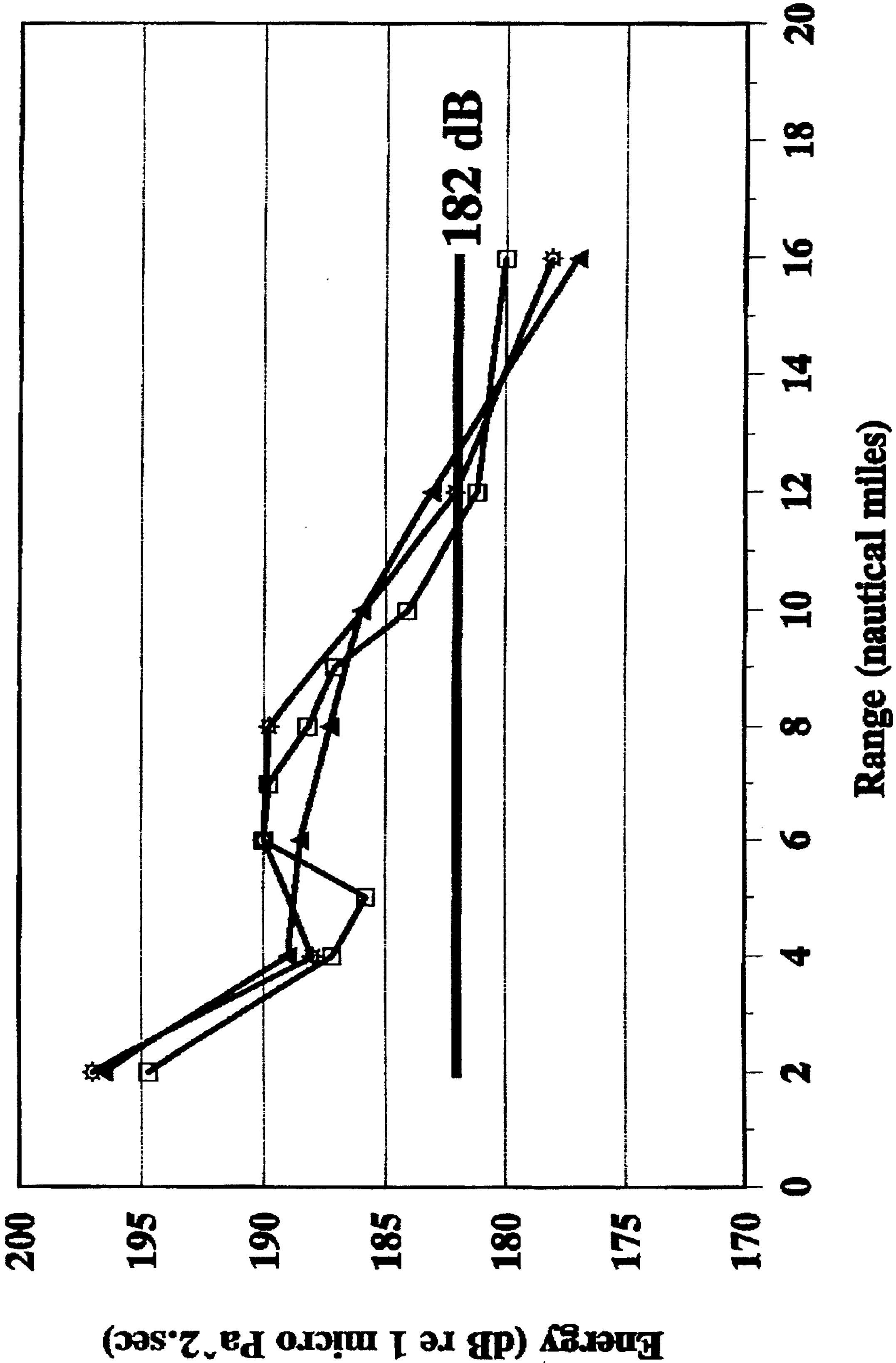
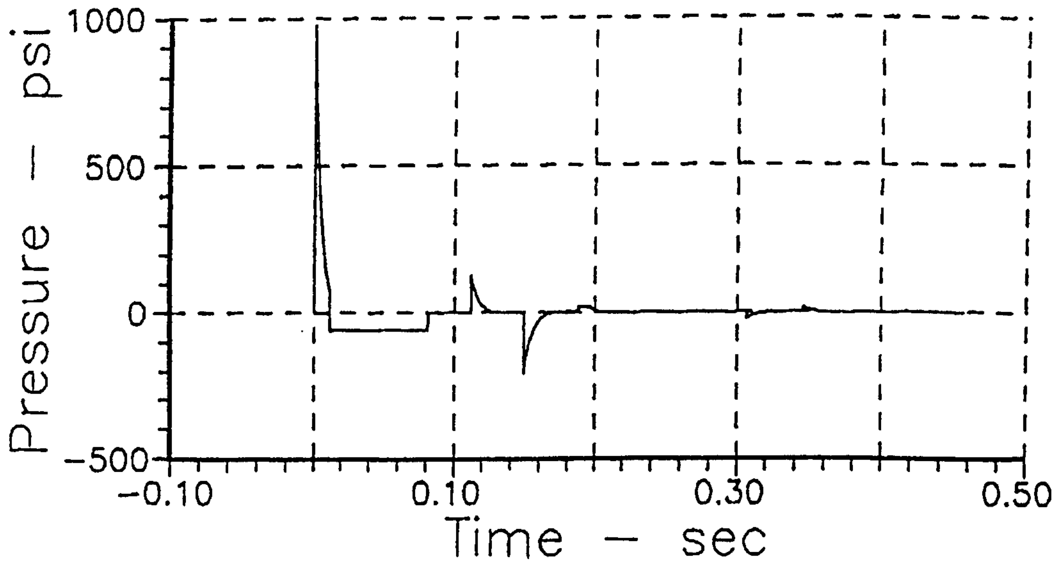


Figure E-19. Calculated maximum energy density - baleen whales, Mayport Area.

REFMS PLOT OF CLOSE-IN WAVEFORM

Conditions:

Mayport Profile D011
10,000 pounds HBX-1
Detonation at 100-ft depth in 500 feet of water
Gage at 100-ft at 300-ft range



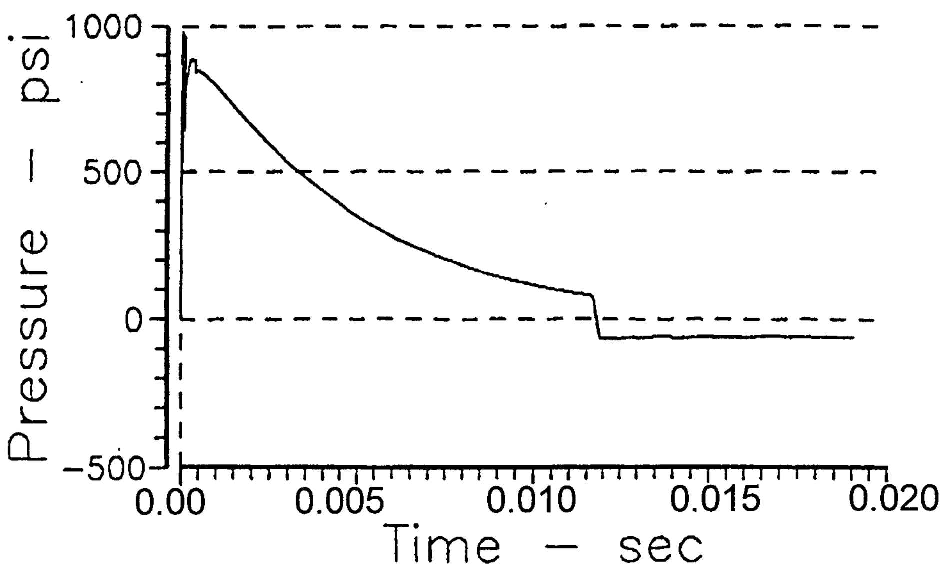


Figure E-20. REFMS plot of close-in waveform.

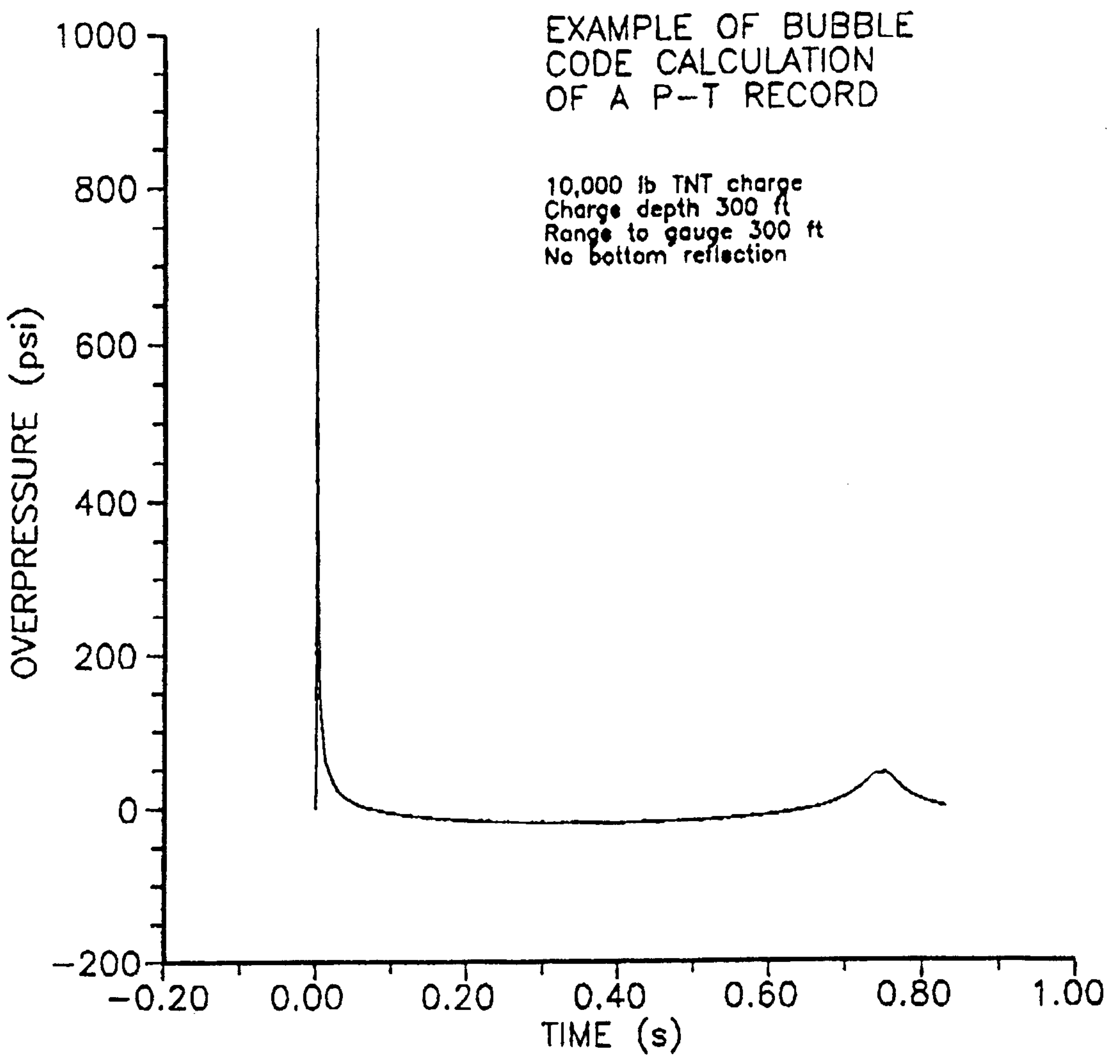


Figure E-21. Example of bubble code calculation of a pressure vs. time record.

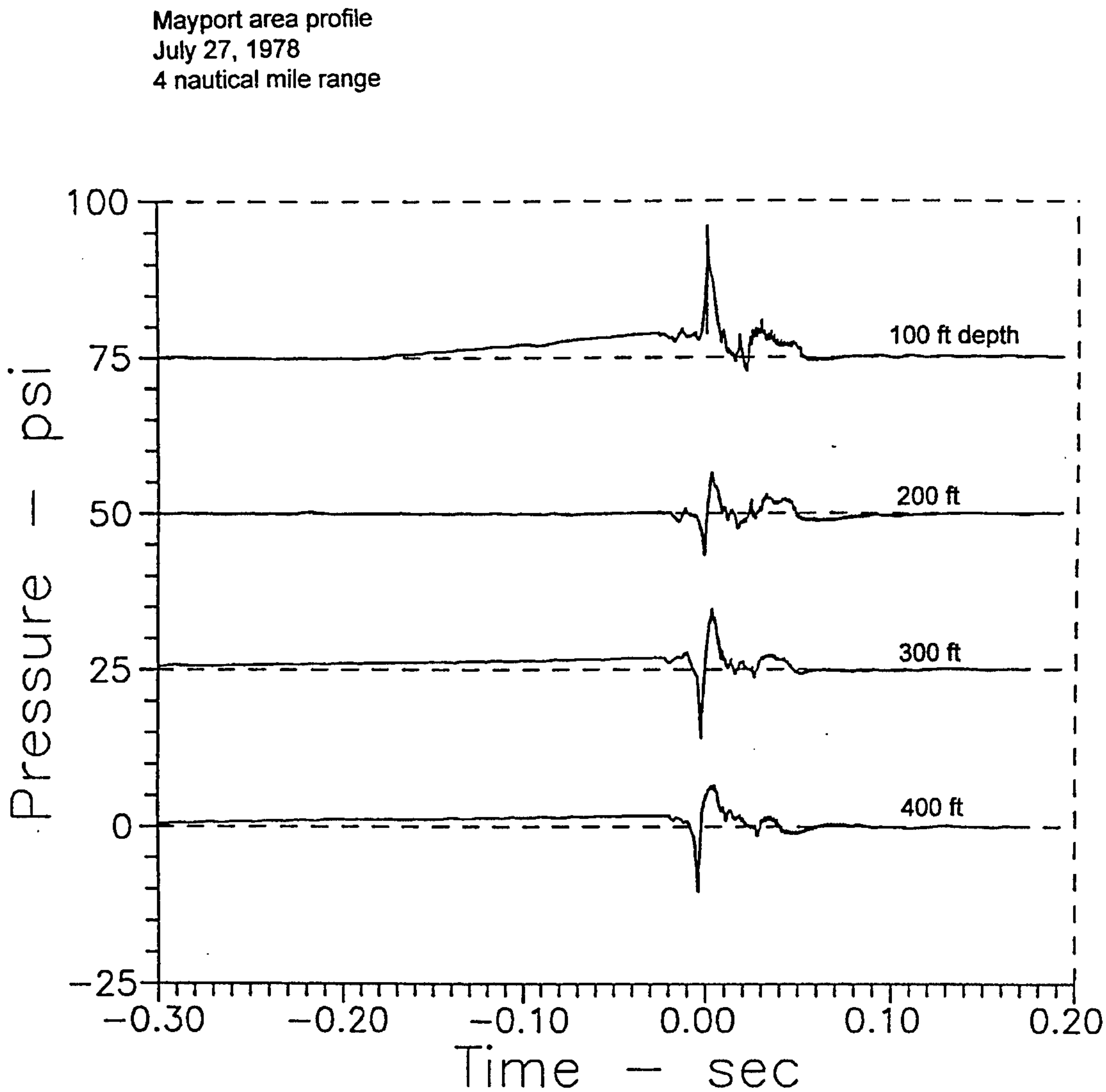


Figure E-22. An example of calculated pressure pulses at various depths in the water column at a range of 4 nmi from the detonation point.

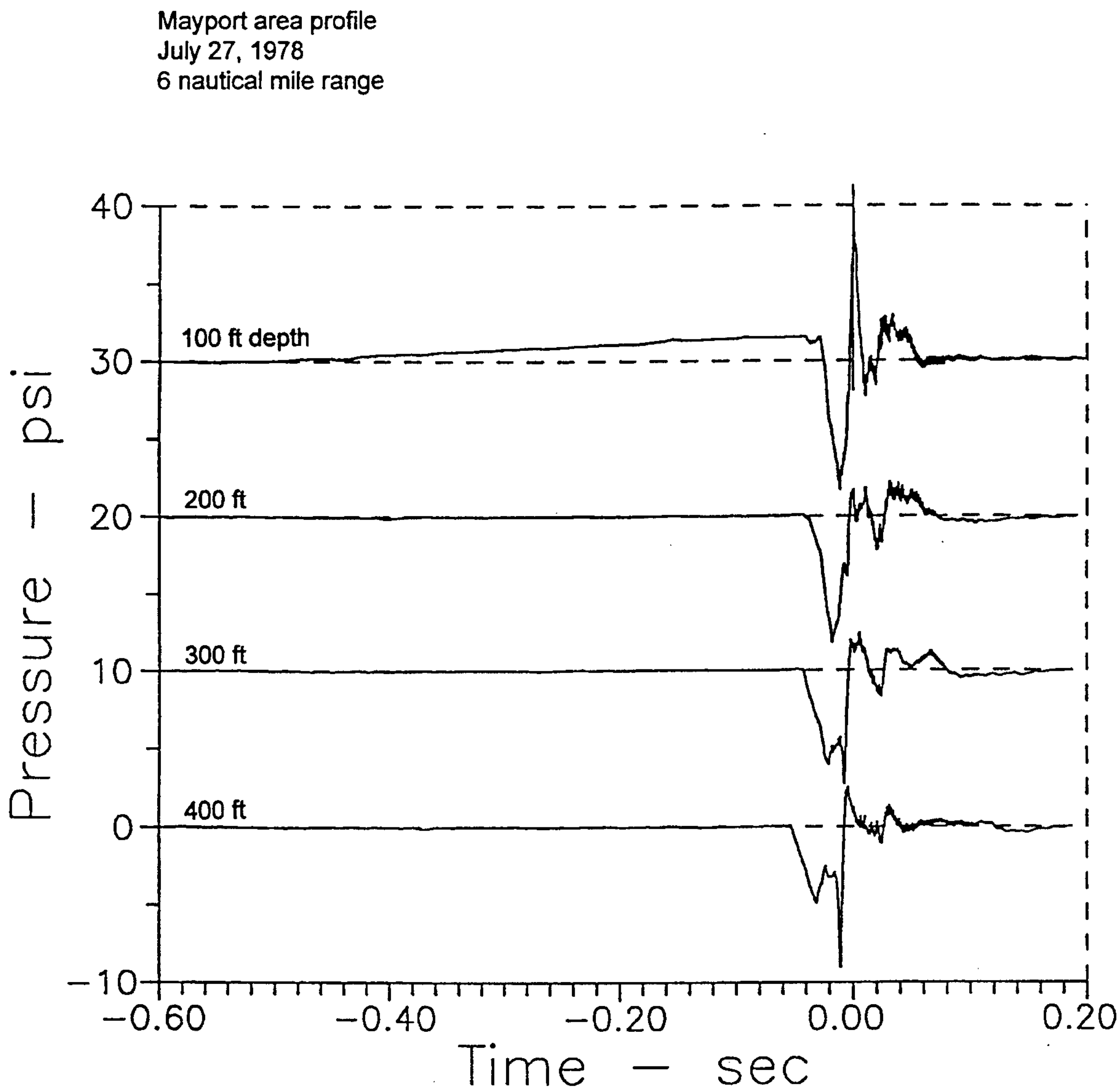


Figure E-23. An example of calculated pressure pulses at various depths in the water column at a range of 6 nmi from the detonation point.

APPENDIX F

NUCLEAR SAFETY

NUCLEAR SAFETY

This section evaluates the radiological environmental effects from shock testing SEAWOLF class submarines and provides relevant information on the Naval Nuclear Propulsion Program which, pursuant to federal law, regulates nuclear safety and radioactivity associated with nuclear propulsion work.

This section has been developed making full use of the extensive body of unclassified environmental and technical information available on nuclear propulsion matters. This information includes detailed annual reports published over three decades; independent environmental surveys performed by the Environmental Protection Agency, by states in which Naval Nuclear Propulsion facilities are located and by some foreign countries; and a thorough independent review performed by the Government Accounting Office in 1991.

1 Introduction

1.1 History and Mission of the Program

In 1946, at the conclusion of World War II, Congress passed the Atomic Energy Act, which established the Atomic Energy Commission (AEC) to succeed the wartime Manhattan Project, and gave it sole responsibility for developing atomic energy. At that time, then-Captain (later Admiral) Hyman G. Rickover was assigned to the Navy Bureau of Ships, the organization responsible for Naval ship design. Rickover recognized the military implications of successfully harnessing atomic power for submarine propulsion, and that it would be necessary for the Navy to work with the AEC to develop such a program. By 1949, Rickover had forged an arrangement between the AEC and the Navy that led to the formation of the Naval Nuclear Propulsion Program. In 1954, the nuclear submarine USS NAUTILUS put to sea and demonstrated the basis for all subsequent U.S. nuclear-powered warship designs. In the 1970's, government restructuring moved the Naval Nuclear Propulsion Program from the AEC (which was disestablished) to what became the Department of Energy. As the Naval Nuclear Propulsion Program grew in size and scope over the years, it retained its dual responsibilities within the Department of Energy and the Department of the Navy, and its basic organization, responsibilities, and technical discipline have remained as it was when first established.

Today, the Naval Nuclear Propulsion Program continues as a joint Navy/Department of Energy (DOE) organization responsible for all matters pertaining to Naval nuclear propulsion pursuant to Presidential Executive Order 12344, permanently enacted as Public Law 98-525 (42 USC 7158). The Program is responsible for:

1. The nuclear propulsion plants aboard 107 ships (including 1 research vessel) powered by Naval nuclear

reactors.

2. Two Moored Training Ships located in Charleston, South Carolina used for Naval nuclear propulsion plant operator training.

3. Nuclear work performed at eight shipyards (six public, including two currently being closed, and two private).

4. Two DOE government-owned, contractor-operated laboratories devoted solely to Naval nuclear propulsion research, development, and design work.

5. Land-based prototype Naval nuclear reactors used for research and development work and training of Naval nuclear propulsion plant operators.

The Naval Nuclear Propulsion Program's conservative design practices and stringent operating procedures have resulted in the demonstrated safety record of Naval nuclear propulsion plants. U.S. Naval reactors have accumulated over 4,600 reactor years of operation and have steamed over 100 million miles without a reactor accident or any significant radiological effect on the environment.

The following sections provide a brief discussion of the Naval Nuclear Propulsion Program. For further information on this subject see references 1, 2 and/or 3.

1.2 Nuclear Propulsion for Navy Submarines

Before the advent of nuclear power, the submarine was, in reality, a small surface ship that could submerge for only short periods of time. As it required oxygen as well as fossil fuel to operate its diesel engines, the submarine had to draw in air and exhaust combustion products. This required the submarine either to be on the surface, or close enough to the surface to use a snorkel, which made the ship susceptible to detection. To avoid detection, the ship had to submerge fully and rely on electric batteries which depleted within several hours. The ship would then have to surface again to start the diesel and recharge the batteries. By eliminating altogether the need for oxygen for propulsion, nuclear power offered a way to drive a submerged submarine at high speeds without concern for fuel consumption; to operate fully capable sensors and weapons systems during extended deployments; and to support a safe and comfortable living environment for the crew. Only a nuclear-powered submarine can operate anywhere in the world's oceans, including under the polar ice, undetected and at maximum capability for extended periods.

The U.S. Navy's nuclear powered ships have an unparalleled record of safety and reliability. Today, Naval nuclear powered ships operate in and out of major U.S. ports and have visited over 150 foreign ports in over 50 countries and territories.

1.3 Philosophy of the Program

Since radioactive material is an inherent by-product of the nuclear fission process, its control has been a central concern for the Naval Nuclear Propulsion Program from the Program's inception. Radiation levels and releases of radioactivity have historically been controlled well below those permitted by national and international standards. All features of design, construction, operation, maintenance, and personnel selection, training and qualification have been oriented toward minimizing environmental effects and ensuring the health and safety of workers, ships crew members, and the general public. Conservative reactor safety design has, from the beginning, been a hallmark of the Naval Nuclear Propulsion Program. The stringent radiological control practices used in the Naval Nuclear Propulsion Program are documented in reference 4.

1.4 Safe Operational Record of the Program

The history of safe operation of the Navy's nuclear powered ships and their support facilities is a matter of public record. This record shows a long and extensive history of the Program's activities having no significant effect on the environment. Detailed environmental monitoring results published yearly provide a comprehensive description of environmental performance for all Naval Nuclear Propulsion Program facilities. Report NT-95-1 (reference 5) is the latest report for all the ships, bases, and shipyards. This record confirms that the procedures used by the Naval Nuclear Propulsion Program to control radioactivity from U.S. Naval nuclear powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public and has been independently corroborated by the Environmental Protection Agency.

The Naval Nuclear Propulsion Program has obtained independent evaluations from the Nuclear Regulatory Commission (NRC) and the Advisory Committee on Reactor Safeguards (ACRS) on naval reactor designs. These reviews were conducted as a means to provide independent confirmation and added assurance that nuclear propulsion plant design, operations and maintenance pose no significant risk to public health and safety.

In addition, the General Accounting Office (GAO), a Congressional investigative organization, in 1991 completed a thorough fourteen month review of DOE sites under the cognizance of the Naval Nuclear Propulsion Program (reference 6). This review included full access to classified documents. The GAO investigators also made visits to the DOE laboratory and naval reactor prototype sites supporting the Naval Nuclear Propulsion Program, which operate to the same stringent standards imposed on Navy facilities and activities. The GAO review concentrated on environmental, health and safety matters, including reactor safety. In congressional testimony on April 25, 1991, the GAO stated in part:

> "In the past we have testified many times before this committee regarding problems in the Department of Energy (DOE). It is a pleasure to be here today to discuss a positive program in DOE. In summary, Mr. Chairman, we have reviewed the environmental, health, and safety practices at the Naval Reactors laboratories and sites and have found no significant deficiencies."

2 Naval Nuclear Powered Ships

2.1 Background

The source of energy for Naval nuclear powered ships originates from fissioning uranium atoms contained within pressurized water reactor cores. Since the fission process also produces radiation, shielding is placed around the reactor to protect the crew. U.S. Naval nuclear propulsion plants, including SEAWOLF class submarines, use a pressurized water reactor design which has two basic systems: the primary system and the secondary system. The arrangement is shown schematically in Figure 1. The primary system circulates ordinary demineralized water in an all-welded, closed loop consisting of the reactor vessel, piping, pumps and steam generators. The heat produced in the reactor core is transferred to the water, which is kept under pressure to prevent boiling. The heated water passes through the steam generators where it transfers its energy. The primary water is then pumped back to the reactor to be heated again.

Inside the steam generators, the heat from the primary system is transferred across a water-tight boundary to the water in the secondary system, also a closed loop. The secondary water, which is at a relatively low pressure, boils, creating steam. Isolation of the secondary system from the primary system prevents water in the two systems from intermixing, keeping radioactivity out of the secondary water.

In the secondary system, steam flows from the steam generators to drive the main propulsion turbines, which turn the ship's propellers, and the turbine generators, which supply the ship with electricity. After passing through the turbines, the steam is condensed back into water and feed pumps return it to the steam generators for reuse. Thus, the primary and secondary systems are separate, closed systems in which constantly circulating water transforms energy produced in the nuclear chain reaction into useful work.

The reactor core is installed in a heavy-walled pressure vessel within a primary shield. This shield limits exposure from gamma and neutron radiation produced when the reactor is at power. Reactor plant piping systems are installed primarily inside a reactor compartment, which is surrounded by a secondary shield. Because of these two shields, the resulting radiation outside the propulsion plant spaces during reactor plant operation is generally not any greater than background radiation (references 1 and 5).

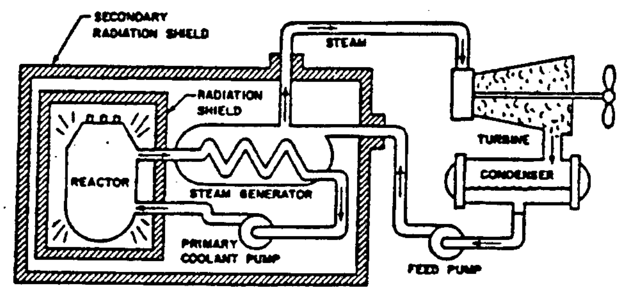


Figure 1: Pressurized Water Reactor

2.2 Reactor Design and Operation

U.S. nuclear-powered warships and their reactors are designed to exacting and rigorous standards. For submarines, this includes the ability to submerge to substantial depths. They must be able to survive battle shock well in excess of the forces that will be experienced during the shock test and protect crews in combat. Naval reactors include redundant systems and means of auxiliary propulsion, and are operated by highly trained crews using rigorously applied procedures.

The nuclear fuel in Naval nuclear propulsion reactor cores uses highly corrosion-resistant and highly radiation-resistant materials. The resistance to corrosion is such that the reactor core could remain submerged in seawater indefinitely without releasing fission products while the radioactivity decays, since the corrosion rate of the protective cladding on the fuel elements is negligible. As a result, the fuel is very strong and has very high integrity. The fuel is designed, built, and tested to ensure that the radioactive fission products during normal reactor operations or adverse conditions will be contained. Naval nuclear fuel can withstand combat shock loads that are well in excess of 50 times the force of gravity and over twice the forces that would be experienced in a ship shock test. Naval nuclear fuel routinely operates with rapid changes in power level since Naval ships must be able to change speed quickly in operational situations. Naval nuclear fuel consists of solid components which are non-explosive, non-flammable, and non-corrosive.

Strict adherence to conservative principles of design and operation of Naval reactors was discussed on May 24, 1979, by the Director of Naval Nuclear Propulsion (then Admiral H. G. Rickover) in Congressional testimony following the accident at Three Mile Island. Rickover emphasized that ensuring reactor safety is the responsibility of all personnel who work on Naval nuclear propulsion plants and that each Program element from training, to design, to construction, and to operation must be properly carried out in a coordinated fashion to achieve the goal of safe performance. A more thorough discussion of this topic can be found in *Rickover and the Nuclear Navy: The Discipline of Technology* (Duncan 1990).

3 Impacts of Normal Operations

Nearly all (greater than 99%) of the radioactive atoms in a nuclear reactor are found in two forms: the uranium fuel itself or fission products created by the nuclear chain reaction. As discussed above, the fuel elements in Naval propulsion reactor cores are designed and built with high fuel integrity to retain this radioactivity. This high fuel integrity has been confirmed by operating experience. Such integrity is a necessity for sailors who must live in the enclosed atmosphere of a submarine. High integrity fuel is also used for nuclear powered surface ships.

The quantity (less than 1%) of remaining radioactive atoms present in a Naval nuclear reactor are encountered in two forms. The majority (99.9%) of the remaining (1%) radioactive atoms form an integral part of the structural alloys of the reactor plant piping and components, created by neutron activation of the iron and alloying elements during operation of the reactor plant. The balance (0.1%) is in the form of finely divided radioactive corrosion and wear products originating from metal surfaces in contact with reactor coolant. These corrosion and wear products are transported in the reactor coolant through the nuclear fuel region where they are activated by neutrons, and then deposited on piping system internal surfaces. Most of these corrosion products tightly adhere to piping system internal surfaces. The small amount which does not adhere is the source of potential radioactive contamination encountered during work on Naval nuclear reactor plants. Stringent controls are used to keep this material contained when working on system internals. Moreover, naval reactor plants have systems which continuously purify the reactor coolant and remove such contamination.

4 Radiological Environmental Monitoring Program

Radiological environmental monitoring is conducted by the U.S. Navy in U.S. harbors frequented by Naval nuclear powered ships, including comprehensive marine, air, and land-based environmental contamination and radiation sampling. The Navy issues an annual report which describes the Navy's policies and practices regarding such things as disposal of radioactive liquid, transportation and disposal of radioactive materials and solid wastes, and monitoring of the environment to determine the effect of nuclear-powered warship operations (reference 5). This report is provided to Congress and to cognizant Federal, State, and local officials in areas frequented by nuclear-powered ships. Reference 5 reports that the total amount of long-lived gamma radioactivity released into harbors and seas within twelve miles of shore for all Navy nuclear powered ships has been less than 0.002 curies during each of the last twenty-three years. The Code of Federal Regulations (10CFR20) lists water concentration limits for discharge of radioactivity for commercial nuclear facilities in effluents based on limiting the dose of members of the public from continuous ingestion of the activitv discharged to 50 millirem per year. This limit is given for information only. Navy policy is to reuse radioactive water. As a result, the control of radioactive liquid discharges at Navy facilities is much more stringent than at facilities such as commercial nuclear power plants which comply with the limits of 10CFR20. The amount of radioactivity (less than 0.002 curies) discharged from all Navy nuclear powered vessels annually within 12 miles of shore combined is less than one hundredth of the amount of radioactivity released by a single typical commercial nuclear power plant under its Nuclear Regulatory Commission license. To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity in the volume of harbor water occupied by a single naval nuclear powered submarine.

As a measure of the significance of this data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in any of the last twenty-three years by U.S. nuclear powered warships and support facilities, that person would not exceed the annual radiation exposure permitted for an individual worker by the U.S. Nuclear Regulatory Commission.

Environmental samples from each harbor monitored are also independently checked at least annually by a U.S. Department of Energy laboratory to ensure that analytical procedures are correct and standardized. Additionally, the U.S. Environmental Protection Agency has conducted independent surveys in U.S. harbors; reference 5 lists each report issued by the EPA on their surveys. The results are consistent with Navy monitoring results. These surveys have confirmed that U.S. Naval nuclear powered ships and their support facilities have had no significant impact on the radioactivity of the marine or terrestrial environment.

5 Occupational Radiation Exposure

The Naval Nuclear Propulsion Program invokes stringent controls on occupational radiation exposure. As discussed in reference 4, the Program's policy is to reduce to as low as reasonably achievable the exposure to personnel from ionizing radiation associated with Naval nuclear propulsion plants. These stringent controls on occupational radiation exposure have been successful. No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal accumulated radiation exposure limit which allows 5 roentgen-equivalent-man (rem) exposure for each year beyond age 18. Since 1967, no person has exceeded the Federal limit which allows up to 3 rem per quarter year, nor in this period has anyone exceeded the limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants (Note: the Navy has used a self-imposed limit of 5 rem/year since 1967; the NRC established 5 rem/year as a Federal Annual Radiation Exposure limit on January 1, 1994 (10CFR20)). No person in the Naval Nuclear Propulsion Program has received greater than two rem in a year since 1980. In recent years, the average occupational exposure of each person monitored at all shipyards is 0.12 rem per year. For comparison, the amount of radiation exposure a typical person in the United States receives each year from natural background radiation is 0.300 rem. The average lifetime accumulated radiation exposure from radiation associated with Naval nuclear propulsion plants for all shipyard personnel is 1.2 rem.

In reference 7 the National Council on Radiation Protection and Measurements reviewed the exposures to the U.S. working population from occupational exposures. This included a review of the occupational exposures to personnel from the Naval Nuclear Propulsion Program. Based on this review, the National Council on radiation Protection and Measurements concluded:

> "These small values (of occupational exposure) reflect the success of the Navy's efforts to keep doses as low as reasonably achievable (ALARA)."

The propulsion spaces and crew of SEAWOLF class submarines are approximately the same size as those of LOS ANGELES class submarines. The radiation exposure due to operation and maintenance of SEAWOLF class submarines would also be similar to those of LOS ANGELES class submarines, thus, occupational exposure from SEAWOLF class submarines will not impose any additional risk beyond that already accepted for previous submarine classes.

6 Naval Nuclear Propulsion Plant Safety

The safety record of United States naval nuclear propulsion plants aboard nuclear-powered warships is well known; there has never been a reactor accident since the first naval reactor began operation, comprising over 4,600 reactor years of experience. As cited earlier, U.S. Navy nuclear-powered warships have steamed over 100 million miles since 1955. A number of reasons why the design and operation of Naval nuclear powered ships result in minimal risk of accidents, and why the consequences would be small should a problem occur are briefly discussed below.

Critical to safety are the officers and sailors who operate the naval nuclear propulsion plants aboard nuclear powered warships. Since the 1950's, over 91,000 officers and enlisted technicians have been trained for this purpose. The officer selection process accepts only applicants who have high standing at colleges and universities. All personnel receive one to two years of training in theoretical knowledge and practical experience on operating reactors that are like the reactors used on ships. Even after completing this training, before manning a nuclear propulsion plant watch station, the personnel must spend about six months qualifying on the ship to which they are assigned. Despite the extensive training and qualification program, multiple layers of supervision and inspection are employed to ensure a high state of readiness and compliance with safety standards. When a ship's reactor is in operation at sea, there are, in addition to the enlisted technicians, four officers on duty, with an average total of 40 years of experience in naval nuclear propulsion.

As discussed earlier, all U.S. nuclear-powered warships use pressurized water reactors. The radioactive fission products are contained within high-integrity fuel elements that can withstand battle shock well in excess of 50 times the force of gravity which is over twice the forces that would be experienced during a shock test. The fuel is designed to preclude release of fission products to the primary coolant. Only limited radioactivity is found in the pure water used in the all-welded primary coolant system. The reactor compartment forms a container and shields the crew from radiation. This compartment is radiologically clean so that it can be entered without any protective clothing within minutes of shutting down the reactor.

As discussed in section 7, all previous Naval nuclear propulsion plants that have been shock tested have performed as designed resulting in no release of fission products from Naval reactor cores to the environment. Even in the highly improbable event that the ship should sink and flood as a result of the shock test (note that since the test is conducted in relatively shallow water (500 feet) the hull would not be crushed due to sea pressure), substantial data exist verifying the high integrity of U.S. Naval reactor designs. Two nuclear-powered submarines (USS THRESHER and USS SCORPION) sank during operations at sea in the 1960's. Neither was lost due to a reactor accident, but both losses resulted in the ship exceeding crush depth and the hull being crushed inward by tremendous sea pressure, events producing far more damage to the ships than would occur at the shallow depth in which the shock test would be performed. Radiological surveys of the debris sites have been performed on several occasions over the past three decades and confirm that, despite the catastrophic manner in which these ships were lost, no detectable radioactive fission products have been released into the environment. The only radioactivity found at these sites was from corrosion products from the primary coolant system. The amount of radioactivity found in the surveys was less than the naturally occurring radioactivity in the seabed sediment. These data are reported in detail in separate publicly available reports (references 8 and 9). Likewise, if SEAWOLF were to rest on the sea floor intact, there would be sufficient time to place the reactor plant in a long term stable condition without impacting the surrounding environment.

In addition to the many safety considerations referred to above, there are several other factors that enhance naval reactor safety. Naval reactors include many redundant systems and means of auxiliary power. Naval reactors are smaller and lower in power rating than typical commercial plants. They also normally operate at power levels well below their rated power. Thus, the amount of radioactivity potentially available for release typically is less than one hundredth of that for a commercial reactor. The plant is designed to withstand a wide variety of casualty conditions without damage to the reactor core or release of significant amounts of radioactivity.

In addition, consistent with past practice, the SEAWOLF Class nuclear propulsion plant design was independently reviewed by the Nuclear Regulatory Commission (NRC) and the Advisory Committee on Reactor Safeguards (ACRS). Both reviews concluded that the SEAWOLF Class reactors could be operated without undue risk to the health and safety of the public.

7 Previous Shock Tests of Nuclear Powered Warships

All U.S. warships are designed to withstand extreme shock from underwater explosions. For most structure and equipment, the shock design loads result in stronger, more robust structure and equipment than would be required to satisfy other design requirements, such as mechanical, pressure or thermal loads. Similarly for electrical and electronic equipment, shock hardened designs are less susceptible to signal or power disruption. In a non-shock environment, such shock hardened equipment provides increased margin to degradation and failure.

The shock capability of individual equipment is confirmed by testing individual equipment at design shock loads. The primary focus of a shock test of the entire ship is not to test equipment at or near or its breaking point. Rather, the purpose is to carefully measure, record, and analyze the reaction of equipment in actual shipboard condition to shock impulses, and to compare these results to analytical predictions made before the test. Five nuclear submarines (USS SKATE (SSN 578), USS SKIPJACK (SSN 585), USS THRESHER (SSN 593), USS OMAHA (SSN 692) and USS JACKSONVILLE (SSN 699)) and two nuclear surface ships (USS ARKANSAS (CGN 41) and USS THEODORE ROOSEVELT (CVN 71)) have been subjected to underwater explosion shock tests similar to that proposed for SEAWOLF. The maximum severity of the shock tests were less than 2/3 of the shock design requirements for shipboard equipment. As expected, in none of these tests was the safety of the nuclear reactor jeopardized, and no radiological problems were experienced. The maximum severity of the proposed ship shock test for SEAWOLF will be 1/2 of the shock design requirements.

The design and testing of SEAWOLF equipment and structures for shock is more thorough than for any previous submarine class. Lessons from previous equipment shock tests, and previous submarine shock tests have been factored into the SEAWOLF design. For the nuclear propulsion plant, this not only includes the reactor core and reactor coolant pressure containing boundary, but all essential auxiliary equipment which supports, monitors, and controls the propulsion plant. Based on past successful shock test performance and the enhanced design features of the SEAWOLF submarine, no radiological impacts are expected as a result of completing the shock test.

8 Conclusions

The Naval Nuclear Propulsion Program provides comprehensive technical management of all aspects of Naval nuclear propulsion plant design, construction and operation including careful consideration of reactor safety, radiological, and environmental concerns. Past operations, including previous shock tests, have resulted in no significant radiological environmental impacts and demonstrated the Program's effectiveness of this management philosophy. Continued application of the environmental practices which are standard throughout the Program will ensure the absence of any radiological environmental effect as a result of shock testing or operating the SEAWOLF submarine.

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3. *The Nuclear Navy, 1946-1962*, The University of Chicago Press, R.G. Hewlett and F. Duncan (1974)

4. U.S. Navy Report NT-95-2, *Occupational Radiation Exposure from U.S. Naval Nuclear Plants and Their Support Facilities,* March 1995.

5. U.S. Navy Report NT-95-1, *Environmental Monitoring and disposal of Radioactive Wastes From U.S. Naval Nuclear Powered Ships and Their Support Facilities,* March, 1995.

6. United States General Accounting Office Report GAO/RCED-91-157, *Nuclear Health and Safety; Environmental, Health, and Safety Practices at Naval Reactors Facilities;* August 1991.

7. National Council on Radiation Protection and Measurements Report 101, *Exposure of the U. S. Population From Occupational Radiation,* June 1, 1989

8. Knolls Atomic Power Laboratory KAPL-4749, *Deep Sea Radiological Environmental Monitoring Conducted at the Site of the Nuclear-Powered Submarine SCORPION Sinking,* R.B. Sheldon and J.D. Michne, October, 1993.

9. Knolls Atomic Power Laboratory KAPL-4748, *Deep Sea Radiological Environmental Monitoring Conducted at the Site of the Nuclear-Powered Submarine THRESHER Sinking,* R.B. Sheldon and J.D. Michne, October, 1993.

10. Code of Federal Regulations, Title 10 (Nuclear Regulatory Commission), Part 20, *Standards for Protection Against Radiation.*

APPENDIX G

ENDANGERED SPECIES ACT CONSULTATION

(G.1 CONSULTATION LETTERS
G.2 BIOLOGICAL OPINION)

G.1 CONSULTATION LETTERS

Section G.1 contains copies of the consultation letters prepared in accordance with Section 7 of the Endangered Species Act. There are 10 letters in all. The first letter from the Department of the Navy is an example of letters sent requesting informal consultation; similar letters were sent to various offices of the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). Next are three response letters from the NMFS and four response letters from the USFWS. Based on the response letters, no formal consultation with the USFWS was required because the USFWS determined that there are no endangered and threatened species or critical habitats under its jurisdiction that could be affected by the proposed action. The Navy subsequently requested initiation of formal consultation with the NMFS as indicated by the final two letters. The Biological Opinion prepared by the NMFS is presented separately in Section G.2.

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
P.O. BOX 190010
2155 EAGLE DRIVE
NORTH CHARLESTON, S.C. 29419-9010

11000
064WS
23 May 95

Dr. Andrew Kemmerer
Regional Director
National Marine Fisheries Service
9721 Executive Center Drive North
St. Petersburg, Florida 33702

Dear Dr. Kemmerer:

We are in the process of producing an Environmental Impact Statement (EIS) for "shock testing" the SEAWOLF Submarine at a site to be located off the east coast of the United States. To assist us in this process, we have hired the firm Continental Shelf Associates, Inc. (CSA). Pursuant to 40 CFR 1501.6, the National Marine Fisheries Service (NMFS) will be a cooperating agency in the preparation and development of the EIS. The EIS will also provide requisite information under 50 CFR A 228.4 for the application of a Letter of Authorization from the NMFS for small takes of marine mammals under Section 101(a)(5) of the Marine Mammal Protection Act of 1972, and for a biological assessment to fulfill requirements listed in the Endangered Species Act of 1973 for the incidental take of listed species (50 CFR 402.12). To assist in the completion of these objectives, the Navy would like to initiate informal consultation with the NMFS for information necessary for the preparation of the EIS.

The SEAWOLF is a new class of submarine. Each new class of ships constructed for the Navy must undergo sea trials to ensure seaworthiness, safety, and combat readiness. Typically, one of the first ships of each class is shock tested to assess the survivability of the hull, all ship systems, and the crew. A shock test consists of a series of underwater detonations that are used to propagate a shock wave through a ship's hull, thus simulating underwater detonations which are similar to those encountered in combat. To approximate actual conditions and provide the best information, ship shock testing is conducted in offshore waters by exploding underwater charges and measuring the effects on the ship. The test provides important information which is used to improve the initial design and enhance the effectiveness and overall survivability of the crew and ship. These improvements are applied to follow-on ships of the same class. Each shock test will involve the detonation of a 10,000-pound charge at an approximate depth of 100 feet below the water surface. An operations vessel will moor at the test site and assemble and deploy a 1-mile long test array. The array will consist of the explosive charge, marker buoys, instrumentation, connecting ropes, and the "gate" which is a small diameter rope that the submarine breaks as it passes through the array. For each test, the submarine will submerge just below the surface, about 65 feet, and navigate in the direction of the prevailing current toward the marker buoys located on each side of the gate. As the submarine passes through the gate, detonation of the explosive will be initiated from the operations vessel on verbal command. After an initial inspection for damage, the submarine will surface and then travel back to the shore facility for detailed post-test inspections and preparations for the next test. For each subsequent test, the gate will be moved closer to the explosive so the submarine will experience a more severe shock level. The program is planned for one detonation per week over a five-week period.

Candidate shock test areas that would be considered are off the coast of Norfolk, Virginia and Jacksonville, Florida, due to the proximity of supporting naval bases (**Figure 1**). An important logistical consideration for shock tests includes closeness of a naval base with a drydock capable of handling a submarine the size of SEAWOLF in case the vessel is damaged during the shock testing. A maximum water depth of 500 feet is required to ensure that bottom conditions do not affect the shock tests, to facilitate test operations, and to ensure the safety of the crew. For the areas being considered, a water depth of 500 feet ranges from 70 to 100 miles offshore. The Norfolk, Virginia test area lies along the continental shelf edge from the southern boundary of the proposed Norfolk Canyon National Marine Sanctuary at latitude 36°56.00' N to latitude 35°41.00' N. The Mayport, Florida test area lies along the approximate position of the west wall of the Gulf Stream, from latitude 31°25.00' N to 36°07.00' N.

The operational area within the selected test site is planned to be a 1 nautical mile diameter zone centered on the explosive charge. An exclusion zone of 5 nautical miles will be established around the test site to exclude all non-test ship, submarine, and aircraft traffic. This zone will be maintained free of radio communications and other electromagnetic interferences. Any traffic within a 10 nautical mile radius will be warned to alter course or will be escorted from the area. A Notice to Airmen and Mariners will be published in advance of the first test.

The SEAWOLF submarine will be ready for shock testing between April and October 1997. Shock testing must be completed by October 1997 due to the decrease in favorable weather conditions which occurs after this month.

CSA is presently conducting a systematic aerial survey program to assess spatial and temporal surface densities of marine mammals and sea turtles in the two candidate test areas (**Figures 2** and 3). These surveys will be conducted monthly between April and September 1995. Results of the surveys will be incorporated into the Draft EIS (DEIS) and will be used to propose the most appropriate area for the shock test. In addition, a thorough review of the existing literature and data of marine mammal, sea turtle, and marine bird populations in the candidate test areas will be presented in the Existing Environment Section of the DEIS. A plan for mitigating and monitoring potentially adverse effects from the shock test will also be described in the DEIS. Elements of this plan include the selection of a test site, or sites, which would minimize the likelihood of encountering marine mammals and sea turtles, and a program involving extensive aerial and shipboard surveillance for species of concern which could be conducted prior to and after detonation. Pre-detonation surveillance, or monitoring, would delay shock testing if a marine mammal or sea turtle is within the predetermined safety zone of the shock test site. The DEIS will also discuss additional specific mitigation measures.

For this stage of the project and the development of the prerequisite DEIS, the Navy would like to request initial background information which includes the following items:

- A listing of listed, proposed, and candidate species of concern for the proposed action, including known temporal and spatial movements; and
- A listing of designated or proposed critical habitats for the above listed species.

This information would provide a basis for descriptions of the existing environment with respect to federally protected and listed species. The Navy, assisted by CSA, would like to further consult with the NMFS regarding additional information on the existing environment, the development of the environmental consequences (or impacts) section for species or critical habitats of concern, and mitigation/monitoring associated with this project. Your assistance in expediting this request is greatly appreciated.

Sincerely,

L. M. PITTS
Head, Environmental Planning
By direction of
the Commanding Officer

Encl:
(1) Figure 1 - Candidate site aerial survey areas
(2) Figure 2 - Location of aerial survey area showing survey blocks and transects off Norfolk, Virginia
(3) Figure 3 - Location of aerial survey area showing survey blocks and transects off Mayport, Florida

copy to:
National Marine Fisheries Service, Gloucester, Massachusetts (Dr. Jon Rittgers)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Dr. N.
St. Petersburg, FL 33702

JUN 26 1995 F/SEO13:KRW:jbm

Mr. L. M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division, Naval
Facilities Engineering Command
P.O. Box 190010
North Charleston, NC 29419-9010

Dear Mr. Pitts:

This letter is in response to your May 23, 1995 request to initiate informal consultation under the Endangered Species Act on proposed ship shock testing of the Navy SEAWOLF submarines. You requested information on 1) a listing of listed, proposed, and candidate species of concern for the proposed action, including known temporal and spatial movements; and 2) a listing of designated or proposed critical habitats for the above-listed species.

With respect to marine mammals, the answers to most of your questions are contained in the enclosed draft copy of the *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments*. This document lists the marine mammal species to be found in the area, describes their status, and provides a description of their geographic range, including information on temporal and seasonal movements (if available). This document also cites numerous references which would be useful to you in preparing your DEIS. When the final Atlantic Stock Assessment reports are published, we will forward them to you, as some of the numbers in the draft will be changed in the final version. Of the many marine mammal species present in the proposed ship shock test area off Jacksonville, only six are listed (all as endangered). These include the northern right whale, *Eubalaena glacialis*, the humpback whale, *Megaptera novaeangliae*, the sperm whale, *Physeter macrocephalus*, the blue whale, *Balaenoptera musculus*, the fin whale, *B. physalus*, and the sei whale, *B. borealis*.

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One additional marine mammal, the harbor porpoise, *Phocoena phocoena*, has been proposed for listing as a threatened species. This species occurs in the proposed site off Norfolk, Virginia. Harbor porpoise strandings have been recorded from as far south as Florida in winter (Polacheck, Wenzel and Early, 1991); but the southern end of the species' normal range is believed to extend only to North Carolina (Marine Mammals Investigation, 1992).

Critical habitat has been established for only one of the above marine mammal species: the northern right whale. A copy of the regulations defining this area is enclosed, as the proposed ship shock test site near Mayport, Florida is within this critical habitat area. Right whales have been sighted in this area between the months of October and May (Mead, 1986), although they are most prevalent between late November and March, with fewer numbers sometimes lingering through April (Kraus et *al.*, 1993). A copy of the Northern Right Whale Recovery Plan is enclosed for your information.

With respect to listed sea turtles, there are five species which may occur in the proposed area off Mayport. These include loggerheads, *Caretta caretta* (threatened), green turtles, *Chelonia mydas* (the breeding population off Florida is listed as endangered; otherwise, this species is considered threatened), leatherbacks, *Dermochelys coriacea* (endangered), hawksbills, *Eretmochelys imbricata* (endangered), and Kemp's ridleys, *Lepidochelys kempii* (also endangered). Enclosed you will find copies of sea turtle recovery plans and a number of scientific papers which provide information on sea turtle distribution and movement patterns, as you requested. No critical habitat has been designated for sea turtles within or near the proposed shock trial sites. Also enclosed are documents which provide background information on fish resources in the area.

The above documents should all be useful in preparing the affected environment section of your DEIS. Your letter indicates that you would also appreciate additional information for use in preparing the environmental consequences and mitigative measures sections of the DEIS. References, which should assist you with the former, are included in the enclosed list. A list of experts who would be good contacts regarding information on the effects of sound on marine organisms is also enclosed. The draft EISs prepared for the proposed ATOC experiments (both for California and Hawaii) contain a brief literature review of the effects of sound on various marine animals, as well as an extensive discussion of this topic. An address where copies of the ATOC EISs may be obtained is enclosed. These resources should be reviewed, as well as other NEPA documentation previously prepared for similar Navy activities.

In brief, the DEIS should address the hearing capabilities of marine mammals and sea turtles, the characteristics of the sounds (e.g., intensity, frequency, duration, properties of spreading, etc.) that will be produced by the explosions and other noises associated with the ship shock tests, the levels of received sounds from these sources at various distances from the source, "zones of influence" upon any potentially affected marine mammal, sea turtle, or prey species (e.g., fish and squid), including at what distances the blasts or associated shock waves, etc., could result in injury or mortality of these animals and at what distances could these sounds be considered a disturbance to these animals (e.g., interfering with normal communications, prey detection, etc.).

The document should also address any by-products of the explosion such as possible pollutants and their potential effects, as well as a discussion of the long-term fate of the pollutant by-products. Information on whether they may become assimilated biologically, such as methylated byproducts, should also be included. Additionally, a plan to clean-up debris resulting from the explosion is necessary. Other international environmental agreements may need to be considered for the NEPA review, such as MARPOL, the Ocean Dumping Act, the Toxic Substance Control Act, etc. A permit may be required if the detonation by-products are listed as toxic.

In addition to clean-up of debris following explosions, mitigative measures should include, but not necessarily be limited to, use of any available and practicable means of detecting marine mammals and/or sea turtles in the area, and assurances that prior to detonation, it will be determined to the best of the Navy's ability (i.e., through use of aerial surveys,

side-scanning sonar, monitoring of sonobuoys, etc.) that no such animals are present within any zone of influence of the blast site. Other protective measures should include demonstration that there will be adequate communication between any protected species observers and those responsible for conducting the tests, in order to ensure that no blast is initiated when such animals are present, and that any succeeding blasts will be terminated if any such animal is noted subsequent to the initial blast (either alive or dead). Tests should occur during daylight hours only, unless it can be demonstrated that the Navy has adequate means of detecting marine mammals/sea turtles after dark.

Aerial surveys should also be conducted immediately following the ship shock tests, in order to assess any possible takes/effects of marine mammals/sea turtles and other wildlife, as well as at some period (perhaps two to four weeks) afterward to observe whether sightings of marine mammals and sea turtles are within a normal range for the time period. Local stranding networks should be notified in advance to be alert to a possible increase in strandings; this should be monitored via follow-up contacts subsequent to the tests. If stranding levels are notably high after the initial explosions, future tests should be cancelled or placed on hold until the circumstances can be reviewed by both NMFS and the Navy.

Although you state that the proposed ship shock tests would occur between April and October of 1997, your letter indicates that pre-test aerial surveys of the proposed sites will be conducted during the months of April through September, to determine tempero-spatial patterns of protected species in the two proposed test sites. If ship shock tests may occur in October, we strongly urge you to extend these surveys at least through that month. As seasonal patterns can vary in timing from year to year, extending the surveys at least another month beyond the latest potential test date is advisable. Additionally, it will be useful to have data on marine mammal/sea turtle distribution and abundance patterns for a two- to four-week time period following the test dates, to be used for comparison with post-detonation surveys as described above. However, in order to avoid interaction with right whales, it is advisable to restrict ship shock activities to the months of June through August, if this is feasible.

Please be reminded that incidental take of marine mammals can only be authorized under an incidental take permit issued under MMPA Section 101(a)(5). The application procedures are enclosed.

Finally, we recommend that you also consult with the U.S. Fish and Wildlife Service with respect to the possible effects of these activities on seabirds.

If you have any further questions concerning this matter, please contact Dr. Katherine Wang of our Protected Species Management Branch at (813) 570-5312.

Sincerely,

for Andrew J. Kemmerer
Regional Director

enclosures

cc: F/PR2: M. Payne, K. Hollingshead
NER: D. Beach

File: 1514-22-g.2.

5

References Cited

Kraus, S.D., R.D. Kenney, A.R. Knowlton, and J.N. Ciano. 1993. Endangered Right Whales of the Southwestern North Atlantic. Final Report. Minerals Management Service Contract No. 14-35-0001-30486. Edgerton Research Laboratory, New England Aquarium, Boston, MA. 69 pp.

Marine Mammals Investigation (eds.), 1992. Harbor Porpoise in Eastern North America: Status and Research Needs. Results of a Scientific Workshop held May 5-8, 1992 at the Northeast Fisheries Science Center. Woods Hole, MA USA. Northeast Fisheries Science Center Reference Doc. 92-06.

Mead, J.G. 1986. Twentieth-century records of right whales (*Eubalaena glacialis*) in the northwestern Atlantic Ocean. In Right Whales: Past and Present Status. R.L.J. Brownell, P.B. Best and J.H. Prescott, eds. Int. Whal. Commn, Cambridge, U.K. pp. 109-120.

Polacheck, T., F.W. Wenzel and G. Early, 1991. What do stranding data say about harbor porpoise (*Phocoena phocoena*)? Rept. Int. Whal. Commn, Working Paper. SC/42/SM 39.

Sources of Information on the Effects of Sound on Marine Organisms

Jehl, J.R., M.H. White Jr., and S.I. Bond. 1980. Effects of sound and shock waves on marine vertebrates: An annotated bibliography. USFWS, National Coastal Ecosystems Team & Office of Migratory Bird Management.

Klima, E.F., G.R. Gitschlag, and M.L. Renaud. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. Mar. Fish. Rev. 50(3):33-42.

LGL Ecological Research Assoc., Inc. Effects of Noise on Marine Mammals. Prepared for Minerals Management Services. 1991.

National Research Council. 1994. Low-frequency Sound and Marine Mammals: Current Knowledge and Research Needs. National Academy Press, Washington.

Young G.A. Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life. Naval Surface Warfare Center, Dahlgren Division. NSWC MP 91-220.

Other Useful Resources on the Effects of Noise on Marine Organisms

ATOC DEISs available through: Ms. Pat Aguilar, Campus Planning Office, 0006, 9500 Gilman Dr., Univ. of California, San Diego, CA 92093 (619) 534-3860.

Dr. Darlene Keton, Dept. of Otolaryngology, Harvard Medical School, MEE1 (617) 573-0483 (hearing in marine mammals and sea turtles)

Dr. Art Myrberg, University of Miami, Rosenstiel School of Marine and Atmospheric Science (305) 361-4177 (effects of noise on fish)

1

Dr. Art Popper, University of Rhode Island, Naragansett, RI (effects of noise on fish)

Scott Eckert, Scripps Inst. of Oceanography (involved with assessing effects of ATOC project on sea turtles)

References on Chemical Pollutants

Sittig, M. 1985. Handbook of Toxic and Hazardous Chemicals and Carcinogens. 2nd. Edition. Noyes Publications, Park Ridge, NJ.

Suter, G.W. and A.E. Rosen. Comparative toxicology for risk assessment of marine fishes and crustaceans. Envir. Sci. Technol. 22(5):548-556.

2

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
One Blackburn Drive
Gloucester, MA 01930

JUL 19 1995

Mr. L.M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, SC 29419-9010

Re: The preparation of an Environmental Impact Statement (EIS) for "shock testing" the SEAWOLF Submarine at a site to be located off the east coast of the United States.

Dear Mr. Pitts:

The Navy proposes a series of ship shock tests to be conducted in offshore waters by exploding underwater charges and measuring the effects on the ship. Each proposed shock test will involve the detonation of a 10,000-pound charge at an approximate depth of 100 feet below the water surface.

Norfolk site

Enclosed is a list of endangered and threatened marine species within the purview of the National Marine Fisheries Service (NMFS) Northeast Region that are likely to occur in the project vicinity. In addition to the listed species, the Atlantic bottlenose dolphin (Tursiops truncatus, coastal population only) is listed as "depleted" under the Marine Mammal Protection Act, and the harbor porpoise (Phocoena phocoena) is proposed for listing as "threatened" under the Endangered Species Act. For more information concerning endangered species issues, please contact the Protected Species Program at (508) 281-9254.

ENDANGERED

Right whale (Eubalaena glacialis) - Cape Cod area from December to June. Lower Bay of Fundy from July to November. Migrate along entire shelf to Florida from November to June. A few sightings have been made in the Norfolk Canyon area primarily in the spring and fall when migratory aggregations are observed.

Humpback whale (Megaptera novaeangliae) - Southern edge of Gulf of Maine and off southern New England from April to December. They are also found off Virginia and Maryland primarily in the fall and winter.

Fin whale (Balaenoptera physalus) - All continental shelf waters in all seasons. They are most prominent near the Norfolk Canyon area in the spring.

Sperm whale (Physeter macrocephalus) - Found along the continental shelf edge waters in all seasons. Sperm whales are concentrated along the 1000 meter contour and are relatively abundant in the Norfolk Canyon area during spring and summer months.

Kemp's ridley sea turtle (Lepidochelys kempii) - Inhabit inshore bay and estuarine habitats from Hatteras to Cape Cod Bay from July to November. In Virginia waters they can be present from April 15/May 15 to November.

Leatherback sea turtle (Dermochelys coriacea) - Inhabit large open bays from June to November. The southern migration (MA to VA) occurs in nearshore waters from August to November. This pelagic species has been sighted in the Norfolk Canyon area in summer months.

THREATENED

Loggerhead sea turtle (Caretta caretta) - Found along the continental shelf area throughout the Mid-Atlantic and in large bays from July to November as far north as Cape Cod Bay. In Virginia waters they can be present from April 15/May 15 to November. This species has also been sighted in the Canyon area.

In addition, other marine mammals (not regarded as endangered or threatened) have been observed in Norfolk Canyon and adjacent waters, such as the Minke whale (Balaenoptera acutorostrata), Long Finned Pilot whale (Globicephala melaena), Short Finned Pilot whale (Globicephala macrorhynchus), Grampus whale (Grampus griseus), Striped dolphin (Stenella coeruleoalba), and Spotted dolphin (Stenella attenuata; S. rontalis; S. plagiodon).

Minke whales occur in the shelf waters of the Canyon and adjacent waters primarily in the spring.

The long and short finned pilot whales occur along the 100 meter contour seasonally and are also found offshore as well. In the summer, they concentrate along the 2000 meter contour.

Sightings of Grampus whales also occur between the 100 meter and 2000 meter contour, primarily in the fall and summer.

Striped dolphin occur along the shelf edge, at the 100 meter contour and offshore over the continental slope and rise. Although they are common year round, they have been sighted in the greatest density in the spring.

The distribution of Atlantic bottlenose dolphins is generally centered about the 1000 meter contour. Nearshore, they periodically move into the mouth of Chesapeake Bay and other estuaries.

Two species of Spotted dolphins also occur along the Canyon and adjacent shelf areas in the spring.

In addition to marine mammals and turtles, the waters in the project vicinity contain a deep-sea demersal fish fauna dominated by the macrourids (rattails), morids (codlings), gadids (cods, hakes), zoarcids (eelpouts) and synaphobrandchids (cutthroat eels). Decapods and echinoderms are also well represented among megafaunal organisms.

Proposed shock test site block #1 encroaches into the Proposed Norfolk Canyon National Marine Sanctuary. The Norfolk Canyon is located approximately 60 nautical miles off of the mouth of the Chesapeake Bay and the coast of Virginia, and is the southernmost submarine canyon in a series of prominent deep water features on the eastern continental margin of the United States. The area, 262 square nautical miles, recommended for the proposed sanctuary provides habitat for a distinctive assortment of living marine resources. Two species of soft coral (Paragorgia arborea; Primnoa reseda) rarely encountered elsewhere, have been documented in the Canyon. Stands of these gorgonian "trees" are as much as 2 meters high. To protect the unique fauna of the proposed Marine Sanctuary from shock waves, we recommend a buffer area be implemented of at least 2.5 nautical miles from it's southern most boundary.

The DEIS should address the environmental concerns raised by our Southeast Regional Office. We concur with their comments that the effects of this project on marine mammals, sea turtles, and their prey species be addressed. These concerns include: effects of auditory sounds produced by underwater explosions on protected resources; effects of by-products of the explosion on the animals in the short- and long-term, as well as their long-term fate; and monitoring these animals before and after explosions to determine impact to protected resources. Mitigative protective measures should also be included in the DEIS.

If you would like to discuss this project further, please contact John C. Strample at (410) 226-5771.

Sincerely,

Dr. Andrew A. Rosenberg
Regional Director

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Region
One Blackburn Drive
Gloucester, MA 01930

NATIONAL MARINE FISHERIES SERVICE

Endangered Species List for Northeast Region

ENDANGERED -

Right whale (Eubalaena glacialis) - Cape Cod area from December to June. Lower Bay of Fundy from July to November Migrate along entire shelf to Florida from November to June.

Humpback whale (Megaptera novaeangliae) - Southern edge of Gulf of Maine (MA, NH, ME) and off southern New England (MA, RI, NY - Long Island) from April to December. They are also found off Virginia and Maryland in the winter.

Fin whale (Balaenoptera physalus) - All continental shelf waters in all seasons.

Sperm whale (Physeter macrocephalus) - Found along the continental shelf edge waters in all seasons.

Blue whale (Balaenoptera musculus) - Found in open seas, usually in colder sub-artic waters. Occasionally seen in NE>.

Sei whale (Balaenoptera borealis) - Found along the eastern and southern edge of Georges Bank.

Kemp's ridley sea turtle (Lepidochelys kempii) - Inhabit inshore bay and estuarine habitats from Hatteras to Cape Cod Bay from July to November.

Leatherback sea turtle (Dermochelys coriacea) - Inhabit large open bays from June to November. The southern migration (MA to VA) occurs in nearshore waters from August to November.

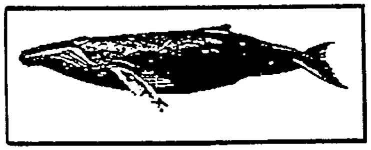
Green sea turtle (Chelonia mydas) - Occasionally seen in nearshore waters from MA to VA from July to November.

Shortnose sturgeon (Acipenser brevirostrum) - Found in the lower reaches of all major river systems.

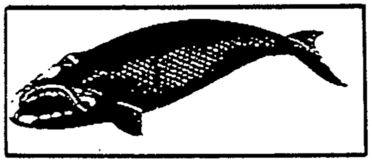
THREATENED -

Loggerhead sea turtle (Caretta caretta) - Found along the continental shelf and in large bays from July to November as far north as Cape Cod Bay.

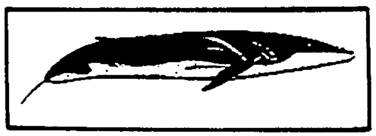
CETACEANS



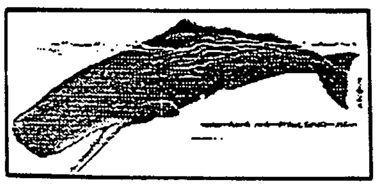
Humpback whale - Occur from the Gulf of Maine, over Georges Bank, to southern New England in spring, summer, and fall. Found in small groups on coastal banks. Mid-sized whale (25-45 feet) with a small irregular dorsal fin, long (more than 1/3 of body length) white flippers, and white on the underside of the tail flukes. Feeds on krill and small schooling fishes.



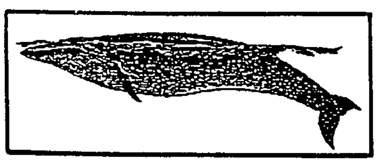
Right whale - Occur in the Gulf of Maine, Great South Channel, and southern edge of Georges Bank in summer and fall. Large (30-50 feet) stocky black whale with no dorsal fin. White markings may be seen on top of the head. Blow characteristic, V-shaped. Feeds primarily on zooplankton.



Fin whale - Occur throughout the Northeast shelf waters in all seasons. Large (50-70 feet) dark grey whale with a white lower jaw on the right side only. Light grey chevron markings may be seen behind the blowhole. Feeds on small fishes, pelagic crustaceans, and squids.



Sperm whale - Found along edge of the continental shelf in Atlantic during all seasons. Rarely at depths less than 100 fathoms. Large (to 69'), snout blunt, squarish. Dark brownish gray, distinct dorsal hump 2/3 of way back from snout tip. Flukes broad, triangular. Feeds primarily on squids.

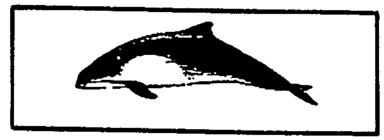


Sei whale - Found along the eastern and southern edge of Georges Bank during all seasons. Some animals move inshore in Bay of Fundy in summer. Large (to 62'), dark steel-gray body, snout slightly arched, paired blowholes, dorsal fin tall, strongly falcate. Feeds on surface plankton, krill, small schooling fishes, and squids.

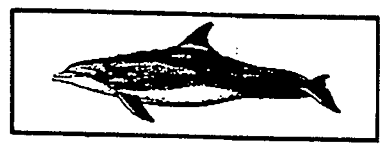
CETACEANS CONTD.

Blue whale - Mostly found in open seas although sometimes they occur in shallow, inshore waters. Largest cetacean species, to 98', they are light bluish-gray above. Belly is sometimes yellowish. Dorsal fin is extremely small and far back on tail stock. Feeds primarily on krill.

PROPOSED FOR LISTING



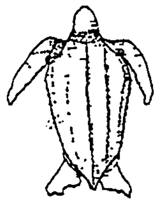
Harbor Porpoise - Occur in the Gulf of Maine year-round, and east and southeast of Cape Cod in spring and summer. Small (less than 6 feet) all black porpoise with white on the belly. The head is rounded and blunt, with no beak. Dorsal fin triangular. Feeds on fish and squid.



Bottlenose dolphin (coastal population only) - Mid-Atlantic coastal migratory stock ranges from Florida to New Jersey in spring, summer, and fall. Mid-sized (9-12'); grey dolphin with a white belly and short beak. Dorsal fin falcate. Feeds on variety of fish, squids, shrimps and crabs.

SEA TURTLES

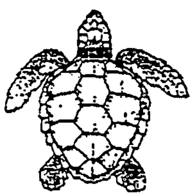
LBST



Leatherback -

Found in open water throughout the Northeast in the summer. Leathery shell with 5-7 ridges along the back. Largest sea turtle (4-6 feet) Dark green to black, may have white spots on flippers and underside.

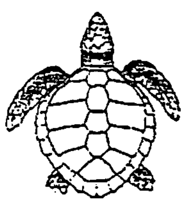
LGST



Loggerhead

Bony shell, reddish-brown in color. Mid-sized sea turtle (2-4 feet). Commonly seen from Cape Cod to Hatteras from spring through fall, especially in southern portion of range. Head large in relation to body.

RST

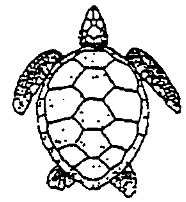


Kemp's ridley

Most often found in Bays and coastal waters from Cape Cod to Hatteras from summer through fall. Offshore occurrence undetermined. Bony shell, olive green to grey in color. Smallest sea turtle in Northeast (9-24 inches). Width equal to or greater than length.

SEA TURTLES (Cont.)

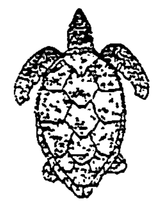
GST



Green turtle

Uncommon in the Northeast. Occur in Bays and coastal waters from Cape Cod to Hatteras in summer. Bony shell, variably colored; usually dark brown with lighter stripes and spots. Small to mid-sized sea turtle (1-3 feet). Head small in comparison to body size.

HST

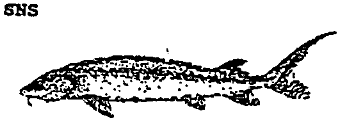


Hawksbill

Rarely seen in Northeast. Elongate bony shell with overlapping scales. Color variable, usually dark brown with yellow streaks and spots (tortoise-shell). Small to mid-sized sea turtle (1-3 feet). Head relatively small, neck long.

FISH

SNS



Shortnose sturgeon

Occur in the major river systems along the Atlantic seaboard. Found offshore only within a few miles of land. Shortnose have a wide mouth, short snout, and are brownish to black in color, with bony plates along the sides of the body Rarely reach 4 feet.

FROM OFF OF PROTECTED RES   08.25.1995 13:10

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

AUG 24 1995

Mr. L.M. Pitts
Head, Environmental Planning Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, SC 29419-9010

Dear Mr. Pitts:

Thank you for your letter requesting the National Marine Fisheries Service (NMFS) to be a cooperating agency (as that term is defined by the Council on Environmental Quality (40 CFR 1501.6)), in the preparation of a Draft Environmental Impact Statement (DEIS) for shock testing of the SSN-21, a SEAWOLF-class submarine.

We support the U.S. Navy's determination to do a DEIS on this activity and have been participating in both the scoping process under the National Environmental Policy Act and more recent planning sessions on scheduling and content of the DEIS. As a result, we agree with the schedule that the Navy has established to complete the shock trial by mid-1997. In cooperating with the U.S. Navy on this activity, NMFS will have a dual role, both through (and limited to) review and comment on the document's preparation and through the regulatory process involved with the issuance of an incidental small take authorization under section 101(a)(5)(A) of the Marine Mammal Protection Act. NMFS will also be in consultation with the U.S. Navy for this activity under section 7 of the Endangered Species Act. Therefore, although NMFS agrees to be a fully cooperating agency in the preparation of the DEIS, because of its regulatory role, we believe that it would be inappropriate for NMFS to be a signatory agency on the document. As a result, we reserve the ability to review that document when it is released to the general public, and to provide the U.S. Navy with appropriate comments. Provided our comments are addressed in the Final EIS, NMFS is prepared to adopt the U.S. Navy FEIS when making the final decision on the issuance of the small take authorization.

If you have questions or need additional information, please contact Mr. Kenneth Hollingshead, at 301/713-2055.

Sincerely,

William W. Fox, Jr. Ph.D.
Director
Office of Protected Resources

cc: F/PR, F/PR2-Hollingshead, F/PR2-Reading File, F/SER-Oravetz, F/SER-Coogan, F/NER-Beach, GCF
KHollingshead:F/PR2:713-2055:08/21/95:c:\ken50\\navy\seawcoop.ltr

United States Department of the Interior

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

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

April 16, 1996

Mr. L. M. Pitts, Head, Environmental Planning
Department of the Navy
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

Dear Mr. Pitts:

Thank you for the opportunity to reevaluate the Department of the Navy/Continental Shelf Associates, Inc. notice of intent to prepare an Environmental Impact Statement (EIS) for the SEAWOLF Submarine "shock testing" site located near Norfolk, Virginia along the continental shelf edge. Our original response was sent to your office on June 23, 1995. This letter responds to your recent letter dated April 15, 1996. Our comments are provided in accordance with Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act).

Based on the information provided in previous correspondence as well as your recent letter, the Service has determined that this project is not likely to adversely affect any Federally-listed endangered or threatened species under the purview of this agency. We are pleased to note that your agency plans to consult with the National Marine Fisheries Service concerning sea turtles, marine mammals and other species protected by Federal mandate.

Please note that in the future, in accordance with Section 7 (a)(2)(3) of the Act, if threatened and endangered species are present on the project site, the Federal agency authorizing, funding or carrying out the action is responsible for the final effect determination the project may have on Federally-listed species and forwarding that determination to the Service (or NMFS) for concurrence.

We believe that the requirements of Section 7 of the Act have been satisfied. We remind you that obligations under Section 7 consultation must be reconsidered if: (1) new information reveals impacts of this identified action that may affect listed species or critical habitat in a manner not previously considered; (2) this action is subsequently modified in a manner that was not considered in this review; (3) a new species is listed or critical habitat determined that may be affected by the identified action.

Thank you for your cooperation with our agency.

Sincerely,

Tom Augspurger
Acting Supervisor

FWS/R4:KGRAHAM:KLG:4/15/96:919/856-4520 ext. 28: SEAWOLF.CON

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
P.O. Box 480
6983 Mid-County Drive, Suite D
White Marsh, Virginia 23183

July 10, 1995

L. M. Pitts
Environmental Planning
Department of the Navy
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, S.C. 29419-9010

Re: "Shock Testing" the SEAWOLF Submarine

Greetings:

We have reviewed your request for information on endangered and threatened species and their habitats for the above referenced project. Based on the project description and location, it appears that no impacts to Federally listed species will occur. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

Sincerely,

Karen L. Mayne
Supervisor
Virginia Field Office

United States Department of the Interior

FISH AND WILDLIFE SERVICE
6620 Southpoint Drive, South
Suite 310
Jacksonville, Florida 32216-0912

AUG 0 9 1995

Mr. L.P. Pints
Head, Environmental Planning
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, S.A. 29419-9010

FWS Log No: 4-1-95-419D

Dear Mr. Pints:

This responds to your letter regarding the preparation of a draft Environmental Impact Statement for "shock testing" the SEAWOLF submarine approximately 40 miles east of Mayport Naval Station, Duval County, Florida.

There are no federally listed threatened or endangered species located at the proposed test site that are under the jurisdiction of the U.S. Fish and Wildlife Service. We suggest that you contact the National Marine Fisheries Service, 9450 Koger Boulevard, St. Petersburg, Florida 33702, for that agency's review, since they have jurisdiction over most marine mammals and endangered and threatened species in ocean waters.

We appreciate the opportunity to provide our comments.

Sincerely yours,

Michael M. Bentzien
Assistant Field Supervisor

United States Department of the Interior

FISH AND WILDLIFE SERVICE
4270 Norwich Street
Brunswick, Georgia 31520

September 18, 1995

Mr. Will Sloger
Southern Division, Naval Facilities Engineering Command
U.S. Navy
2155 Eagle Drive
North Charleston, South Carolina 29418

RE: Environmental Impact Statement for Shock Testing the Seawolf Submarine
FWS Log 4-4-95-272

Dear Mr. Sloger:

Thank you for your September 13, 1995, FAX requesting information on Federally listed species that could be impacted by shock testing the Seawolf submarine near Jacksonville, Florida. Shock testing will involve detonation of a series of 10,000-pound charges at approximately 100 feet below the water surface to determine if the craft is seaworthy and combat ready. Tests will be conducted 70 to 100 miles offshore in water up to 500 feet deep to ensure that bottom conditions do not affect results of the shock tests or impact crew safety.

It is not likely that the shock testing 70 to 100 miles offshore will adversely affect Federally listed species or critical habitat under the Service's purview. Requirements of Section 7 of the Endangered Species Act have been satisfied. However, obligations under the Act must be reconsidered if (1) the project is modified in a manner not considered in this assessment; (2) a new species is listed or critical habitat is determined that may be affected by the project; or (3) new information indicates that the project may affect listed species or critical habitat in a manner not considered.

We appreciate the opportunity to comment during the planning stages of this project. If you have any questions, please call Robin Goodloe of my staff at (912) 265-9336.

Sincerely,

for Kathy Chapman
Deborah Harris
Acting Field Supervisor

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
P.O. BOX 190010
2155 EAGLE DRIVE
NORTH CHARLESTON, S.C. 29419-9010

11000
Code 064WS
17 Jun 96

National Marine Fisheries Service
Director, Office of Protected Resources F/PR
Marine Mammals Division
1315 East-West Highway
Silver Spring, Maryland 20910

RE: REVIEW OF THE BIOLOGICAL ASSESSMENT FOR THE SEAWOLF SHOCK TEST

Dear Sirs:

The Navy requests initiation of formal consultation under Section 7 of the Endangered Species Act for the Shock Testing of the SEAWOLF Submarine which is proposed to take place during five weeks between April 1 and October 1 of 1997. The enclosed Biological Assessment fully describes the proposed project. The Biological Assessment is included as Appendix G of the Draft Environmental Impact Statement (DEIS) for Shock Testing the SEAWOLF Submarine and references many other parts of the DEIS. The primary action addressed in the document is the impact of five underwater explosive charges on various species, particularly with regard to marine mammals and threatened and endangered species.

We look forward to receiving your Biological Opinion on this project at the site to be determined through the National Environmental Policy Act process. Please direct all inquiries regarding this request to Mr. Will Sloger at 803-820-5797.

Sincerely,
L. M. Pitts
Head, Environmental Planning
By direction of
the Commanding Officer

Encl:
(1) Biological Assessment for the Proposed Action to Shock Test the SEAWOLF Submarine (Appendix G of SEAWOLF DEIS)

Copy: (w/o enclosure)
PMS350A1 (Schulze)
NAVSEA (SEA 00T-Evans; SEA 00L-J. Lewis; SEA 08U-Knoll)
CNO (N456-Depaul)
OAGC (Borro)
CDNSWC-UERD (Code 662-Barfield)

DEPARTMENT OF THE NAVY
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
P.O. BOX 190010
2155 EAGLE DRIVE
NORTH CHARLESTON, S.C. 29419-9010

11000
Code 064WS
17 Jun 96

National Marine Fisheries Service
Southeast Regional
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

RE: REVIEW OF THE BIOLOGICAL ASSESSMENT FOR THE SEAWOLF SHOCK TEST

Dear Sirs:

The Navy requests initiation of formal consultation under Section 7 of the Endangered Species Act for the Shock Testing of the SEAWOLF Submarine which is proposed to take place during five weeks between April 1 and October 1 of 1997. The enclosed Biological Assessment fully describes the proposed project. The Biological Assessment is included as Appendix G of the Draft Environmental Impact Statement (DEIS) for Shock Testing the SEAWOLF Submarine and references many other parts of the DEIS. The primary action addressed in the document is the impact of five underwater explosive charges on various species, particularly with regard to marine mammals and threatened and endangered species.

We look forward to receiving your Biological Opinion on this project at the site to be determined through the National Environmental Policy Act process. Please direct all inquiries regarding this request to Mr. Will Sloger at 803-820-5797.

Sincerely,
L. M. Pitts
Head, Environmental Planning
By direction of
the Commanding Officer

Encl:
(1) Biological Assessment for the Proposed Action to Shock Test the SEAWOLF Submarine (Appendix G of SEAWOLF DEIS)

Copy: (w/o enclosure)
PMS350A1 (Schulze)
NAVSEA (SEA 00T-Evans; SEA 00L-J. Lewis; SEA 08U-Knoll)
CNO (N456-Depaul)
OAGC (Borro)
CDNSWC-UERD (Code 662-Barfield)

G.2 BIOLOGICAL OPINION

This section contains the Biological Opinion issued by the National Marine Fisheries Service (NMFS) on December 12, 1996.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

DEC 12 1996

Mr. L.M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division, Naval
Facilities Engineering Command
P.O. Box 190010
North Charleston, North Carolina 29419-9010

Dear Mr. Pitts:

This responds to your request for an Endangered Species Act (ESA) Section 7 Consultation on the U.S. Navy's proposal to shock test the USS SEAWOLF by detonating a single 4,536-kg (10,000-lb) explosive charge near the submarine once per week over a 5-week period between May 1 and September 30, 1997, at a minimum of 78 km (42 nmi) offshore Mayport, Florida. In accordance with 50 CFR 402.12(b) of the ESA, a Biological Assessment was submitted to NMFS.

Enclosed is the biological opinion prepared by the National Marine Fisheries Service (NMFS) concerning the proposed activity. As stated in the biological opinion, NMFS has determined that the proposed activity is not likely to jeopardize the continued existence of those endangered or threatened species under the jurisdiction of NMFS. NMFS has provided a list of reasonable and prudent measures in the incidental take statement that would minimize the potential impacts on listed marine mammals and sea turtles.

I look forward to your continued cooperation in future consultations.

Sincerely,

Patricia A. Montanio
Acting Director
Office of Protected Resources

Enclosure

Endangered Species Act - Section 7 Consultation

BIOLOGICAL OPINION

AGENCY: U.S. Department of the Navy, Naval Facilities Engineering Command, Southern Division.

ACTIVITY: Proposed Shock Testing of the SEAWOLF Submarine off the Atlantic Coast of Florida During the Summer of 1997.

CONSULTATION CONDUCTED BY: National Marine Fisheries Service

DATE ISSUED: 12-12-96

I. Background

The USS SEAWOLF is the first of a new class of submarines being acquired by the Navy. In accordance with 10 U.S.C. 2366, each new class of ships constructed for the Navy cannot proceed beyond initial production until realistic survivability testing of the ship and its components are completed. Realistic survivability testing means testing for vulnerability in combat by firing munitions likely to be encountered in combat. This testing and assessment is commonly referred to as "Live Fire Test & Evaluation (LFT&E)." Because realistic testing by detonating torpedoes or mines against a ship's hull could result in the loss of a multi-billion dollar Navy asset, the Navy has established an LFT&E program consisting of computer modeling, component and surrogate testing, and shock testing the entire ship. Together, these components complete the survivability testing as required by 10 U.S.C. 2366.

The shock test component of LFT&E is a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions. Shock tests simulate near misses from underwater explosions similar to those encountered in combat. Shock testing verifies the accuracy of design specifications for shock testing ships and systems, uncovers weaknesses in shock sensitive components that may compromise the performance of vital systems, and provides a basis for correcting deficiencies and upgrading ship and component design specifications. While computer modeling and laboratory testing provide useful information, they cannot substitute for shock testing under realistic, offshore conditions. To minimize cost and risk to personnel, the first ship in each new class is shock tested and improvements are applied to later ships of the class.

On June 14, 1996, the Navy released a draft environmental impact statement (DEIS) on shock testing the SEAWOLF submarine. This document, which was transmitted to NMFS on that same day, contained a biological assessment that described the activity's impact on listed endangered and threatened marine species. In addition, at the same time, the Navy applied for an incidental small take authorization under section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA). This application is the subject of a rulemaking action that has been described in 61 FR 40377 (August 2, 1996). Should an authorization be issued for this activity under the MMPA, the Incidental Take Statement appended to this Biological Opinion may be subsequently modified.

II. Proposed Activities

The Navy proposes to shock test the USS SEAWOLF by detonating a single 4,536-kg (10,000-lb) explosive charge near the submarine once per week over a 5-week period between May 1 and September 30, 1997, at a minimum of 78 km (42 nmi) offshore Mayport, FL. A 4,536 kg (10,000 lb) charge is selected to ensure that the entire submarine is subjected to the desired level of shock intensity; the use of smaller charges would require many more detonations to excite the entire ship to the desired shock intensity level.

Detonations would occur 30 m (100 ft) below the ocean surface in a water depth of 152 m (500 ft). A water depth of 152 m (500 ft) was selected to allow mooring of the operations vessel with the test array, permit recovery of the submarine and crew in the unlikely event of a control failure, and yet minimize the effect of a bottom reflected pressure wave on the submarine.

An operations vessel would moor at the site and test personnel would deploy a one-mile long array. The array would consist of an explosive charge, marker buoys, instrumentation, connecting ropes, and a "gate." The USS SEAWOLF would be underway at a depth of 20 m (65 ft) at the time of the test and would navigate toward the marker buoys located on each side of the gate. As the submarine passes through the gate, the explosive would be detonated from the operations vessel. For each test, the submarine would move closer to the explosive so the submarine would experience a more severe shock. After the detonation, the test array would be recovered and floats and rigging debris would be removed.

Measures to Reduce Impacts

The Navy's proposed action includes mitigation in order to minimize risk to marine mammals and sea turtles. The Navy plans to undertake the following measures:

(1) Site Location. Through pre-detonation aerial surveys, the Navy would select a test area offshore Mayport, FL, potentially with the lowest number of marine mammals and sea turtles. A primary and two secondary test sites would be determined based on aerial surveys conducted 3 weeks prior to the shock test. Of these sites, one would be chosen as

the final test site based on marine mammal abundance determined during an aerial survey conducted 2-3 days prior to each detonation;

(2) Pre-detonation Monitoring.

(A) The Navy proposes to monitor the area visually (aerial and shipboard monitoring) beginning 2.5 hours before each test and acoustically, beginning 1 hour before each test, and postpone detonation if:

(a) any marine mammal, sea turtle, sargassum raft, or jellyfish abundance is detected within a safety zone of 3.8 km (2.05 nmi),

(b) within a buffer zone of an additional 1.8 km (0.95 nmi) any marine mammal or sea turtle detected within the zone is on a course that will bring it into the safety zone prior to detonation, or

(c) the sea state exceeds Beaufort 4 (i.e., wind velocity >16 kt), or the visibility is not 3 nmi (5.6 km) or greater and the ceiling is not 305 m (1,000 ft) or greater;

(B) To locate marine mammals and sea turtles during the aerial surveys, the Navy proposes to:

(a) use a Partanavia (or equivalent) aircraft which provides a belly window for a third, full-time aerial observer; and

(b) establish line-spacing for aerial monitoring to 0.25 nmi (instead of 1 nmi);

(C) If deep-diving marine mammals are detected within the buffer zone and subsequently cannot be detected, sighting and acoustic teams would search the area for twice the typical dive duration before assuming the animal had left the buffer zone; and

(D) If a northern right whale is sighted, detonation would be postponed until the animal was positively determined to be outside the buffer zone;

(3) Post-detonation Monitoring.

The Navy proposes to monitor the area after each test to find and treat any injured animals. If post-detonation monitoring shows that marine mammals or sea turtles were killed or injured as a result of the test, testing would be halted until procedures for subsequent detonations could be reviewed by NMFS and modified as necessary. A Marine Animal Recovery Team led by a marine mammal veterinarians would attempt to recover and treat any injured animals.

(4) Reporting.

Within 120 days of the completion of shock testing, the Navy would be required to submit a final report to NMFS. This report must include the following information: (1) Date and time of each of the detonations; (2) a detailed description of the pre-test and post-test activities related to mitigating and monitoring the effects of explosives detonation on marine mammals and their populations; (3) the results of the monitoring program, including numbers by species/stock of any marine mammals noted injured or killed as a result of the detonations and numbers that may have been harassed due to undetected presence within the safety zone; and (4) results of coordination with coastal marine mammal/sea turtle stranding networks.

III. Listed Species

The following endangered and threatened marine mammal and sea turtle species which are under the jurisdiction of NMFS are known to occur in the project area and may be affected by underwater explosives detonation:

Common Name	Scientific Name	Status
Marine Mammals		
Fin whale	*Balaenoptera physalus*	E
Humpback whale	*Megaptera novaeangliae*	E
Right whale	*Eubalaena glacialis*	E
Sei whale	*Balaenoptera borealis*	E
Sperm whale	*Physeter macrocephalis*	E
Blue whale	*Balaenoptera musculus*	E
Sea Turtles		
Loggerhead turtle	*Caretta caretta*	T
Green turtle	*Chelonia mydas*	E/T*
Leatherback turtle	*Dermochelys coriacea*	E
Hawksbill turtle	*Eretmochelys imbricata*	E
Kemp's ridley	*Lepidochelys kempii*	E

* Green turtles in U.S. waters are listed as threatened except for the Florida breeding population, which is listed as endangered.

Marine Mammals

Six species of endangered marine mammals may be found seasonally in the waters offshore northern Florida. Although only the sperm whale has some likelihood to be within the shock trial area during the shock trial, several other stocks are discussed below because of their possible appearance at the time of the shock trial. Two species, blue whale and sei whale are not discussed because they are unlikely to be within the vicinity of the shock trial. Additional information on these two species, and the other species discussed below, can be found in Blaylock *et al.* (1995).

Fin whale (*Balaenoptera physalus*)

The fin whale is considered one of the more abundant large whale species, with a worldwide population estimate of 120,000 (Braham 1991). The fin whale was a prime target for commercial whaling after the Norwegian development of the explosive harpoon in 1864. North Atlantic stocks were heavily fished and because these stocks were relatively small, they were quickly depleted.

Braham (1991) indicates that although fin whales are abundant compared to other stocks, they remain depleted relative to historic levels. Only a few thousand are believed to exist in the North Atlantic (Gambell 1985). Current estimates for fin whales found in the northwest Atlantic are not available, although CeTAP (1982) estimated 5,423 fin whales occurred in the waters between Cape Hatteras and the Bay of Fundy in the spring, more than half of which (2,788) occur in the Gulf of Maine.

Current stock assessments (Blaylock *et al.* 1995) continue to use CeTAP (1982) data as the best available. A population estimate based on an inverse variance weighted pooling of CeTAP (1982) spring and summer data is 4,680 fin whales (CV = 0.23) and includes a dive-time correction factor of 4.85. An average for these two seasons was chosen because the greatest proportion of the population off the northeast U.S. coast appears to be in the CeTAP study area in these seasons. However, this estimate is highly uncertain because the data are a decade old, and values were estimated just after cessation of extensive foreign fishing operations in the region.

Surveys conducted by NMFS in 1991 and 1992 covered a portion of the area included in the CeTAP study, produced an estimate of 2,700 fin whales (uncorrected for dive time). This figure has been used in the NMFS Marine Mammal Stock Assessment Reports (Blaylock *et al.* 1995) to estimate the minimum size of the North Atlantic fin whale population. The minimum population estimate is 1,704 fin whales, and is based on the lower limit of the two-tailed 60 percent confidence interval of the above estimate of

2,700. This is equivalent to the 20th percentile of the log-normal distribution as specified by NMFS (Anon. 1994).

During summer in the western North Atlantic, fin whales can be found along the North American coast to the Arctic and around Greenland. The wintering areas extend from the ice edge southward to the Caribbean and Gulf of Mexico. They are widely distributed in the Gulf of Maine, and may stay in the region through the winter. Fin whales in the Gulf of Maine concentrate in the area extending from the southern base of the Great South Channel, northwest along the 50 fathom contour into the southwestern Gulf of Maine over Stellwagen Bank, to Jeffreys Ledge. Sightings are most numerous in spring and summer with peaks in May and July and occur at Jeffreys Ledge, Stellwagen Bank and the Great South Channel.

Seipt *et al*. (1990) discuss characteristics of the population of fin whales in Massachusetts Bay as observed through the photo-identification of individuals between 1980 and 1987. During that period, 156 individuals were identified. Ninety-eight were observed more than once, including 70 that were observed in more than one year. The authors suggest this information indicates that the occurrence and annual return of individual fin whales is similar to that observed for humpbacks as discussed below. They conclude that fin and humpback whales in high latitudes are distributed according to the occurrence of their prey, and return repeatedly to consistently productive habitats such as Jeffreys Ledge, Stellwagen Bank, and Massachusetts Bay. As suggested by Kenney *et al*. (1986) and Payne *et al*. (1990), regarding right and humpback whales, such a strategy would be energetically efficient.

Fin whales are often spotted in mid-Atlantic waters, although nearshore occurrences off Virginia were undocumented until recently. Some fin whales were observed off the Delmarva Peninsula during aerial surveys conducted over a decade ago (Shoop *et al*. 1982). However, since 1989, sightings of feeding juvenile fin whales have increased along the coast of Virginia in the same area as the humpback whales mentioned below (Swingle pers. comm.). Fin whales are more difficult to study due to their speed; however, they are believed to be feeding with the humpbacks, on bay anchovies and menhaden.

Fin whales in the North Atlantic feed on herring, cod, mackerel, pollack, sardine, and capelin, as well as squid, euphausids, and copepods. In the 1970s and 80s, fin whales were observed to feed primarily on sand lance, in proximity to humpbacks (Overholtz and Nicolas 1979, Payne *et al*. 1990). Bigelow and Schroeder (1953) reported fin whales feeding on sand lance that were abundant in Cape Cod Bay in 1880. Affects of the abundance of finfish on the distribution of fin whales are similar to those discussed for humpback whales below. Changes in fin whale distribution have not been as distinct as those observed for humpbacks, suggesting greater success at exploiting alternative prey species.

The peak months for breeding are December and January in the Northern Hemisphere. A single calf averaging about 6 meters in length is produced after a gestation period of a little more than 11 months. Fully mature females may reproduce every 2 to 3 years. In the Northern Hemisphere, females become sexually mature at a length of 18.3 meters and males at 17.7 meters. Although fin whales are sometimes found singly or in pairs, they commonly form larger groups of 3 to 20 which may in turn coalesce into a broadly spread concentration of a hundred or more individuals, especially on the feeding grounds (Gambell 1985).

At least two fin whales died in association with the 1987-1988 multiple mortality of humpbacks, the cause of which has been linked to ingestion of mackerel that had concentrated neurotoxins from plankton (Geraci *et al*. 1989). Lambertson (1986) identifies the occurrence of the nematode *Crassicauda* in fin whales taken in whaling efforts off Iceland, and describes the associated pathology. Known and theorized anthropogenic effects on recovery of fin whales are similar to those discussed below for humpbacks.

Humpback whale (*Megaptera novaeangliae*)

The Humpback Whale Recovery Plan (NMFS 1991a) contains information regarding humpback life history, distribution, and taxonomic parameters. Worldwide, humpbacks are thought to number between 10,000 and 12,000 individuals (Braham 1991), down from in excess of 125,000 prior to exploitation. Humpback whales were commercially hunted from the seventeenth century into the twentieth century. At least 9,125 humpback whales were killed within the North Atlantic Ocean west of Iceland between 1850 and 1971 (Mitchell and Reeves 1983).

The Humpback Whale Recovery Team has recommended an interim recovery goal of twice the current population estimates within the next 20 years. The western North Atlantic population is currently estimated to include approximately 5,543 individuals (CV = 0.16, Katona *et al*. 1994). Katona and Beard (1990) estimate the population's annual growth rate at 9.4 percent (with broad confidence intervals). The current NMFS stock assessment reports (SARs) (Blaylock *et al*. 1995) estimate the minimum size of the North Atlantic humpback whale population to be 4,848. This is based on the lower limit of the two-tailed 60 percent confidence interval of the above estimate by Katona *et al*. (1994). This is equivalent to the 20th percentile of the log-normal distribution as specified by NMFS (Anon. 1994).

After calving and mating in warm waters of the Caribbean, whales return to five separate foraging areas, distributed between latitudes of 42° N to 78° N. These feeding areas are (with approximate number of humpback whales in parenthesis): Gulf of Maine (400); Gulf of St. Lawrence (200); Newfoundland and Labrador (2,500); western Greenland (350); and the Iceland-Denmark strait (up to 2,000) (Katona and Beard 1990). The western North Atlantic stock is considered to include all humpback whales from these five feeding areas. Courtship groups on the wintering ground contain whales from different feeding aggregations, so humpbacks from the western North Atlantic probably interbreed (Katona *et al.* 1994).

Until recently, humpback whales in the mid- and south Atlantic were considered transients. Few were seen during aerial surveys conducted over a decade ago (CeTAP 1982). However, since 1989, sightings of feeding juvenile humpbacks have increased along the coasts of Virginia and North Carolina, peaking during the months of January through March in 1991 and 1992 (Swingle *et al.* 1993). Studies conducted by the Virginia Marine Science Museum (VMSM) indicate that these whales are feeding on, among other things, bay anchovies and menhaden. Researchers theorize that juvenile humpback whales, which are unconstrained by breeding requirements that result in the migration of adults to relatively barren Caribbean waters, may be establishing a winter foraging area in the mid-Atlantic (Mayo, pers. comm.). The lack of sightings south of the VMSM study area is a function of shipboard sighting effort, which was restricted to waters surrounding Virginia Beach, Virginia.

Katona and Beard (1990) summarized information gathered from a catalogue of photographs of 643 individuals from the western North Atlantic population of humpback whales. These photographs indicated reproductively mature western North Atlantic humpbacks winter in tropical breeding grounds in the Antilles, primarily on Silver and Navidad Banks, north of the Dominican Republic. The primary winter range also includes the Virgin Islands and Puerto Rico (NMFS 1991a). In general, it is believed that calving and copulation take place on the winter range. Calves are born from December through March and are about 4 meters at birth. Sexually mature females give birth approximately every 2 to 3 years. Sexual maturity is reached between 4 and 6 years of age for females and between 7 and 15 years for males. Size at maturity is about 12 meters.

Clapham and Mayo (1987) studied the reproduction and recruitment of humpbacks in Massachusetts Bay between 1979 and 1985. During this period, cows and calves occurred in the Bay as early as April. Apparent nursing behavior has been observed, although this could not be verified. Calves were observed feeding, or attempting to feed, on sand lance by late July. Clapham and Mayo (1987) reported that 44 adult females were identified with 72 calves, including 20 females which returned with calves more than once during their 1979-1985 study period.

Cows with calves were seen from one to 62 times during a year, with a mean of 18.5 occurrences. This was significantly higher than cows without calves, which were seen from one to 45 times with a mean of 10.1. This difference in occurrence of cows with and without calves indicates Massachusetts Bay may provide important nursery habitat to humpbacks. This is supported by Goodale's (1981), observation of a significant difference in mean depth of water where calves were sighted as compared to water depths associated with sightings of mature animals without calves. Of the 49 calves born prior to 1985, 75.5 percent returned in one or more years after separation from the cow, indicating that an affinity for foraging areas may be determined maternally.

All humpback whales feed while on the summer range. Overholtz and Nicolas (1979) observed humpback whales apparently feeding on the American sand lance (*Ammodytes americanus*) in 1977 on Stellwagen Bank. Since that time, sand lance have been identified as the major prey species for humpbacks in Massachusetts and Cape Cod bays. Payne *et al.* (1986) discuss the correlation between the decline of herring stocks from the mid-1960s through the mid-70s. The resultant increase in stocks of sand lance and the shift of the distribution of humpback whales from the northern to the southwestern Gulf of Maine, including Stellwagen Bank. Payne *et al.* (1986) identified a relationship between the observed number of humpbacks per unit effort and the log-mean number of sand lance per tow after 1978, and sharp changes in depth such as those found in the Great South Channel and at Stellwagen Bank. They suggest humpbacks follow the Great South Channel north to the Gulf of Maine until they reach concentrations of sand lance off Cape Cod or on Stellwagen Bank. Concentration of sand lance in response to their zooplankton prey found near the surface in areas of high bottom relief provide an energetically efficient source for the whales when compared to feeding at depth.

The Humpback Whale Recovery Plan (NMFS 1991a) identifies entanglement, ship collisions, disturbance, habitat degradation, and competition with commercial fisheries as potential sources of mortality or delayed recovery.

Swingle *et al.* (1993) identify a shift in distribution of juvenile humpback whales in the nearshore waters of Virginia, primarily in winter months. Those whales using this mid-Atlantic area that have been identified were found to be residents of the Gulf of Maine feeding group, suggesting a shift in distribution that may be related to winter prey availability. In concert with the increase in mid-Atlantic whale sightings, strandings of humpback whales have increased between New Jersey and Florida since 1985. Strandings were most frequent during the months of September through April in North Carolina and Virginia waters, and were composed primarily of juvenile humpback whales of no more than 11 meters in length (Wiley *et al.* 1995). Six of 18 humpbacks (33 percent) for which the cause of mortality was determined were killed by vessel strikes. An additional humpback had scars and bone fractures indicative of a previous vessel strike that may have contributed to the whale's mortality. Sixty percent of those mortalities that were closely investigated showed signs of entanglement or vessel collision (Wiley *et al.* 1995).

Northern Right whale (*Eubalaena glacialis*)

A complete description of the natural history and taxonomy of the northern right whale can be found in the Right Whale Recovery Plan (NMFS 1991b).

The northern right whale population was decimated during the 1700s by commercial whaling fleets; it was the preferred target species because it floated and was easily captured and butchered. Shore whaling was conducted off Massachusetts, New York, New Jersey, North Carolina, and Florida beaches. By 1750, directed harvest of right whales had reduced the population to numbers no longer able to sustain a vigorous coastal fishery (Allen, 1916). NMFS, in recent marine mammal stock assessment reports (SARs) (Blaylock *et al.* 1995) estimates the minimum size of the northern Atlantic right whale population to be 295. This is based on a census of individual whales identified using photo-identification techniques (Knowlton *et al.* 1992). The Right Whale Recovery Team set a recovery goal of 7,000 North Atlantic right whales, which represents 60-80 percent of the estimated pre-exploitation level (NMFS 1991b).

Despite over 50 years of protection, there is no indication that the North Atlantic right whale population is recovering from eight centuries of harvest (NMFS 1991b). Schevill *et al.* (1986) compared historical whaling data and modern sighting information and concluded that there was no evidence that the right whale population in the seventeenth century was any larger than it is today. Reeves and Mitchell (1987) also compiled whaling records in an attempt to determine the pre-exploitation population levels of right whales. Their studies of the North Atlantic harvest of other mysticetes resulted in population estimates through assumptions that the sum of removals during the peak decade was comparable to a conservative minimum estimate of the pre-exploitation population size.

Cape Cod Bay and portions of Massachusetts Bay are among the five known right whale high-use areas (NMFS 1991b). Right whales occur in Massachusetts waters in most months (Watkins and Schevill 1982, Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990). Most sightings occur between February and May, with peak abundance in late March. Schevill *et al.* (1986) report 764 sightings of right whales between 1955 and 1981 in Cape Cod waters. More than 70 right whales were seen in one day in 1970. Hamilton and Mayo (1990) report 2,643 sightings of 113 individual right whales in Massachusetts waters, with a concentration in the eastern part of Cape Cod Bay. A number of right whales, including cow/calf pairs, resided in Cape Cod and Massachusetts bays during the summers of 1986 and 1987. Hamilton and Mayo (1990) as well as Payne *et al.* (1990) attributed this shift in distribution to a dearth of sand lance in the bays and an associated abundance of calanoid copepods — the preferred prey of North Atlantic right whales.

Precise interpretation of data regarding the normal length of residency of individual right whales in the bays is difficult to interpret, especially in light of recent satellite transmitter results indicating right whales tagged in the Bay of Fundy may travel long distances in the few days or weeks between sightings (Mate 1992). Schevill *et al.* (1986) report individual right whales residing in Cape Cod waters for no more than a few successive days. In 1976 they observed a cow and calf over a 7-week period, the longest residence time documented between 1955 and 1981. Prior to the summer of 1986, Hamilton and Mayo (1990) report observations of individual whales up to 12 times in a year, with the longest apparent residency being 89 days. Prior to 1986, 50 percent of the individual right whales observed by Hamilton and Mayo (1990) were seen in more than one year.

Right whales are present in foraging areas such as Cape Cod Bay, the Great South Channel, the mouth of the Bay of Fundy and Brown's Bank (NMFS 1991b) in the spring and summer months. Recent satellite tracking efforts have identified individual animals embarking on far-ranging foraging episodes not previously known (Knowlton, pers. comm.).

During the winter, a portion of the population moves from the summer foraging grounds to the calving/breeding grounds off Florida, Georgia, and South Carolina. Adult females calve every three to five years. Sexual maturity is reached as early as the fifth year and as late as age nine (Knowlton and Kraus 1989). The animals size at this stage is from 30-40 feet in length.

The whereabouts of 85 percent of the population during the breeding season, including a significant portion of the female segment, is unknown. Those whales not congregating on the Georgia/Florida breeding grounds are likely scattered in distribution. Sightings over this season have been reported from the Gulf of Mexico (Moore and Clark 1963, Schmidley *et al.* 1972). During the winter in 1992, right whales were reported in North Carolina waters, north of Cape Hatteras (Knowlton, pers. comm.).

Mead (1986) identifies Massachusetts waters as second only to Florida waters for documented right whale calf sightings. Winn *et al.* (1986) observed right whale calves in this region, and indicate calves throughout the western Atlantic were sighted in significantly shallower depths than adult right whales without calves. Hamilton and Mayo (1990) report the occurrence of mother/calf pairs in the bays in six of the ten years of their study, and indicate cow/calf pairs remain in the bays for only short periods. A total of 30 calves were observed between 1979 and 1987, associated with 21 different cows. Nine of the 21 mothers were observed with calves in two different years, and calving intervals appeared to average three years. This is consistent with Kraus *et al.*'s (1986) estimates of calving intervals, which ranged from two to five years with a mean of 3.1 years. Schevill *et al.* (1986) report 21 sightings of small calves in 12 of the 26 years of their study, including two calves likely born in the bays. Hamilton and Mayo (1990) indicate 28 percent of the calves identified prior to 1987 have been resighted in the bays as juveniles or adults. Both studies documented observations of mating behavior, and Hamilton and Mayo (1990) report observations of nursing.

Right whales feed primarily on copepods, but also consume euphausiids and other zooplankton. Estimates of right whale energetic requirements (Kenney *et al.* 1986) indicate only very dense patches of zooplankton provide sufficient calories to meet the needs of right whales. While precise energetic requirements have not been determined, this model has been supported by two quantitative scudies of zooplankton patches in the vicinity of feeding right whales (Murison and Gaskin 1989, Mayo and Marx, 1990). Both studies indicate right whales are capable of detecting dense prey patches and may not exploit patches if concentrations are reduced below certain threshold levels (around 1,000 individual copepods per cubic centimeter). Payne *et al.* (1990) show the strong correlation between abundance of copepods due to the absence of sand lance in the summers of 1986 and 1987 in Massachusetts waters, and the occurrence of right whales in the area in those summers. Competition between sand lance and right whales may be the basis for the seasonal patterns of right whale use of this area (Payne *et al.* 1990, Kenney *et al.* 1986). Kenney *et al.* (1986) suggest variations in the location of adequate prey patches from year to year would compel right whales to expend significant amounts of energy to locate acceptable zooplankton patches. Gaskin (1991) identified the availability of dense concentrations of calanoid copepods as the "bottom line" for right whales in the northwest Atlantic. Inadequate prey availability and/or competition for prey with other planktivorous animals has also been suggested by Mitchell (1975), Reeves *et al.* (1978) and NMFS (1991) as one possible factor in the lack of recovery of this species.

Anthropogenic causes of right whale mortality are discussed in detail in Kraus (1990) as well as in NMFS (1991b). Ship collisions and entanglements are the most common direct causes of mortality identified through right whale strandings. Knowlton et. al. (1994) presented data (through 1992) which suggests an annual population growth rate of 2.5 percent and an annual mortality rate of 2.1 percent. The mortality rate was calculated using the number of animals known to be dead (from both anthropogenic and natural causes) added to the number presumed to be dead based on the fact that they were not observed in over five years (sighting rate based on a photo-identification sighting database). A whale not observed in 5 years is considered dead in Year 6. A list of the most recent known right whale mortalities can be found in NMFS' Biological Opinion on the Reinitiation of Consultation on United States Coast Guard Vessel and Aircraft Activities along the Atlantic Coast. This information is incorporated here by reference.

In early 1996, an estimate of total mortality was derived using this method through the end of 1995. This resulted in an apparent mortality increase in 1994 to 19 whales and 18 whales in 1995. This preliminary estimate of number of animals presumed dead in 1994 and 1995, coupled with an increase in known deaths in early 1996, strongly suggested that the population may be declining. However, a further analysis of the sighting database and the method for estimating the presumed dead whales has shown that this calculation has been biased by the cessation of sighting effort in offshore areas since 1989 relative to the known movements of individual whales based on their previous sighting record (i.e., the reduction in offshore effort approximately 5-6 years ago resulted in an increase in the number of animals not observed in 5-6 years because many of the whales presumed to be dead in 1996 have an offshore sighting distribution. Therefore it is not known whether they are really dead, or have not been observed because of reduced effort in the past 6 years in offshore habitats). Correcting for the effort bias resulted in an estimated mortality of 6 whales presumed dead in both 1994 and 1995 rather than 19 and 18, respectively, as the preliminary analysis had indicated. Adding the corrected presumed dead numbers to known dead numbers yields an estimated total mortality of 7 whales in 1994 and 8 in 1995, within the range of estimated annual right whale mortality in years prior to 1994. The presumed dead number for 1996 is not yet available, but the known dead number alone totals 6. In addition, one right whale has been observed with serious injuries from entanglement thus far in 1996.

Therefore, the re-analysis of the sighting database concluded that the presumed dead component of the mortality rate calculation has likely not increased in recent years. Population parameters must be further analyzed to quantify the various biases and validate the vital rate estimates before known or presumed numbers of mortalities can be used to indicate trends with scientific certainty. Since effort bias has been determined in this database, and in consideration of the possible effects of this bias as it relates to the methods used by Kraus

(1990), Knowlton et al. (1994), and Kenney et al. (1995) to estimate mortality and calf production, a review and re-assessment of these biological parameters for the northern right whale population is now being conducted. Until that information is available, it is not possible to determine population trends.

Regardless of whether the growth rate has changed since 1992, this rate is still lower than that calculated for 4 populations of the southern right whale, *Eubalaena australis*, a similar species. This difference in growth rates may indicate greater impediments to the recovery of the northern right whale and justifies a highly conservative approach to managing the northern right whale population. These differences in population parameters between populations also suggest that the northern right whale may be more susceptible to human perturbations than other whale species (Blaylock *et. al.* 1995).

Since 1970, 41 northern right whale mortalities from anthropogenic (ship strike or entanglement), natural, or unknown sources have been reported. Mortalities include 14 ship strikes, 2 entanglements, and 25 mortalities of unknown or natural causes. Twelve mortalities in the latter category were adults or juveniles, or calves which had survived their first 6 months. Although the actual cause of death for these whales remains uncertain, it is likely that many of these animals died from anthropogenic causes.

Right whales which have been struck by vessels usually strand or are found floating in the vicinity of critical habitats in the north and south or near the shipping lanes in the Mid-Atlantic. In addition to the 14 ship strikes which resulted in mortality, the prevalence of injuries (not immediately lethal) from ship strikes was estimated from scarification analysis to be 7 percent (Kraus 1990). One animal was seen on a NMFS research cruise in 1995 with a deep gash in its head. This animal was not included in the above mortality estimate; however, experts believed that the whale would not survive the injury (Knowlton, pers.comm.).

Gear entanglements are the other major known anthropogenic source of right whale mortality and injury. An analysis of entanglement data since 1970 reveals approximately 31 records of entanglement of right whales in commercial fishing gear which did not result in immediate mortality. Although entanglements are not always immediately lethal, evidence suggests that entanglements may result in serious injuries which lead to mortality by causing substantial wounds or reducing the animal's ability to swim and/or feed, thereby reducing the likelihood of survival. NMFS recognizes that the total level of take is an unknown, but considers the known level a minimum.

Habitat degradation is cited as potentially the most important factor affecting the recovery of the species (NMFS, 1991). The Right Whale Recovery Team (NMFS 1991b) indicated disposal of terrestrially generated pollutants into Massachusetts and Cape Cod bays could slow the recovery of the species. Another factor possibly inhibiting recovery of the right whale population is inbreeding depression. Schaeff *et al.* (1993) have determined through genetic analyses that western North Atlantic right whales probably represent a single breeding population based on three matrilines.

Sperm whale (*Physeter macrocephalis*)

There are estimated to be two million sperm whales worldwide with a population of 130,000 or more thought to occur in the North Atlantic (IWC 1983). In the western North Atlantic they range from Greenland to the Gulf of Mexico and the Caribbean. The sperm whales that occur in the eastern US EEZ are believed to represent only a portion of the total stock (Blaylock *et al.* 1995). In most areas sperm whales are found in waters greater than 180 meters in depth. While they may be encountered almost anywhere on the high seas their distribution shows a preference for continental margins, sea mounts, and areas of upwelling, where food is abundant (Leatherwood and Reeves 1983). Waring *et al.* (1993) suggest sperm whale distribution is closely correlated with the Gulf Stream edge. Sperm whales migrate to higher latitudes during summer months, when they are concentrated east and northeast of Cape Hatteras. Bull sperm whales migrate much farther poleward than the cows, calves, and young males. Because most of the breeding herds are confined almost exclusively to warmer waters many of the larger mature males return in the winter to the lower latitudes to breed.

Sperm whales feed primarily on medium to large-sized mesopelagic squids *Architeuthis* and *Moroteuthis*. Sperm whales, especially mature males in higher latitude waters, also take significant quantities of large demersal and mesopelagic sharks, skates, and bony fishes (Clarke 1962, 1980). Sperm whale populations are organized into two types of groupings: breeding schools and bachelor schools. Older males are often solitary (Best 1979). Breeding schools consist of females of all ages and juvenile males. The mature females ovulate April through August in the Northern Hemisphere. During this season one or more large mature bulls temporarily join each breeding school. A single calf is born at a length of about 4 meters after a 15 month gestation period. A mature female will produce a calf every 3-6 years. Females attain sexual maturity at the mean age of 9 years and a length of about 9 meters. Males have a prolonged puberty and attain sexual maturity at about age 20 and a body length of 12 meters. Bachelor schools consist of maturing males who leave the breeding school and aggregate in loose groups of about 40 animals. As the males grow older they separate from the bachelor schools and remain solitary most of the year (Best 1979).

Sperm whales were hunted in America from the 17th century through the early 1900's. The International Whaling Commission estimates that nearly a quarter-million sperm whales were killed worldwide in whaling activities between 1800 and 1900 (IWC 1969). With the advent of modern whaling the larger rorqual whales were targeted. However as their numbers decreased, greater attention was paid to smaller rorquals and sperm whales. From 1910 to 1982 there were nearly 700,000 sperm whales killed worldwide from whaling activities (Clarke 1954, Committee for Whaling Statistics 1959-1983). In recent years the catch of sperm whales has been drastically reduced as a result of the imposition of catch quotas. NMFS believes there are insufficient data to determine population trends for this species (Blaylock *et al*. 1995).

Sea Turtles

Loggerhead turtle (*Caretta caretta*)

The threatened loggerhead is the most abundant species of sea turtle occurring in U.S. waters. Like Kemp's ridleys, they commonly occur throughout the inner continental shelf from Florida through Cape Cod, Massachusetts. The loggerhead's winter and early spring range is south of 37°00′ N in estuarine rivers, coastal bays, and shelf waters of the southeastern United States. Loggerheads move northward and enter northeast coastal embayments as water temperatures approach 20°C (Burke *et al*. 1989, Musick *et al*. 1984) to feed on benthic invertebrates, leaving the northern embayments in the fall when water temperatures drop. Juvenile and subadult loggerheads occur in southern Massachusetts waters from mid-summer through fall, probably feeding on crabs and other benthic invertebrates. They are commonly found in the Chesapeake from May through October, with peak numbers observed in June (Lutcavage 1981) in water depths of 4 to 20 meters (Musick *et al*. 1984). Mark-recapture studies have shown that loggerheads in the Bay exhibit strong foraging site fidelity within and between seasons (Musick *et al*. 1984, Byles 1988).

Like the Kemp's ridley sea turtle, the activity of the loggerhead is limited by temperature. Prolonged exposure to water temperatures below 8°C may result in dormancy, shock, or death. Loggerheads are regularly found cold-stunned in Cape Cod Bay (e.g., 17 in 1992, Teas, pers. comm). Keinath *et al*. (1987) observed sea turtle emigration from the Chesapeake Bay when water temperatures cooled to below 18°C, generally in November. Surveys conducted offshore and sea turtle strandings during November and December in some years associated with the summer flounder fishery off North Carolina suggest that sea turtles emigrating from northern waters in fall and winter months may concentrate in nearshore and southerly areas influenced by warmer Gulf stream waters (Epperly *et al.* 1995).

Aerial surveys of loggerhead turtles at sea north of Cape Hatteras indicate that they are most common in waters from 22 to 49m deep, although they range from the beach to waters of 4481m (Shoop and Kenney 1992). There is no information regarding the activity of these offshore turtles. They may be traveling to and from inshore foraging habitats, or feeding on resources available in the water column. The latter behavior is undocumented, although there are documented takes of loggerheads on longline hooks baited with squid (NMFS, unpublished data), indicating that they do feed in the water column when offshore.

The preferred prey of the loggerhead turtle includes mollusks, crustaceans and sponges (Mortimer 1982). Crabs and conchs were identified (Carr 1952) as the most frequently found items in stomachs, although loggerheads often eat fish, clams, oysters, sponges, and jellyfish. Ernst and Barbour (1972) included marine grasses and seaweeds, mussels, borers, squid, shrimp, amphipods, crabs, barnacles, and sea urchins among the foods of loggerhead turtles. The horseshoe crab (*Limulus polyphemus*) has been identified as a major food source of loggerheads in Mosquito Lagoon, Florida and the Chesapeake Bay (Mortimer 1982, Keinath *et al.* 1987); however, spider crabs (*Libinia* sp.) and rock crabs (*Cancer irroratus*) have been determined as the primary components of loggerhead diet in Long Island Sound (Burke *et al.* 1990a).

Pursuant to a November 1994 Biological Opinion on the continued operation of the shrimp fishery in the southeastern United States, NMFS selected an Expert Working Group (EWG) consisting of population biologists, sea turtle biologists and state and federal managers to consider the best available information to formulate population estimates for sea turtles affected by human activities in the Southeast Region. The EWG focused on determining population estimates for Kemp's ridley and loggerhead sea turtles, the species taken most frequently in shrimp trawls. Draft reports by the Group, entitled "Kemp's ridley (Lepidochelys kempii) Sea Turtle Status Report", dated June 28, 1996 and the "Status of the Loggerhead Turtle Population (Caretta caretta) in the Western North Atlantic" dated July 1, 1996, were submitted to NMFS in early July. New information or conclusions provided within these reports are summarized very briefly below, and the reports are incorporated by reference.

The EWG identified four nesting subpopulations of loggerheads in the western North Atlantic based on mitochondrial DNA evidence. These include: (1) the Northern Subpopulation producing approximately 6,200 nests/year from North Carolina to Northeast Florida; (2) the South Florida Subpopulation occurring from just north of Cape Hatteras on the east coast of Florida and extending up to Naples on the west coast and producing approximately 64,000 nests/year; (3) the Florida Panhandle Subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City and producing approximately 450 nests/year; and (4) the Yucatan Subpopulation occurring on the northern and eastern Yucatan Peninsula in Mexico and producing approximately 1,500 - 2,000 nests/year.

The EWG considered nesting data collected from index nesting beaches to index the population size of loggerheads and to consider trends in the size of the population. They estimated that for the 1989 - 1995 period, there were averages of 224,321 or 234,355 benthic loggerheads, respectively. The EWG listed the methods and assumptions in their report, and suggested that these numbers are likely underestimates. Aerial survey results suggest that loggerheads in U.S. waters are distributed in the following proportions: 54 percent in the Southeast U.S. Atlantic, 29 percent in the northeast U.S. Atlantic, 12 percent in the eastern Gulf of Mexico, and 5 percent in the western Gulf of Mexico.

Overall, the EWG determined that trends could be identified for two loggerhead subpopulations. The Northern Subpopulation appears to be stabilizing after a period of decline; the South Florida Subpopulation appears to have shown significant increases over the last 25 years suggesting the population is recovering, although the trend could not be detected over the most recent 7 years of nesting. An increase in the numbers of adult loggerheads has been reported in recent years in Florida waters without a concomitant increase in benthic immatures. These data may forecast limited recruitment to South Florida nesting beaches in the future. Since loggerheads take approximately 20-30 years to mature, the effects of decline in immature loggerheads might not be apparent on nesting beaches for decades. Therefore the EWG cautions against considering trends in nesting too optimistically.

Green turtle (*Chelonia mydas*)

Green turtles are distributed circumglobally, mainly in waters between the northern and southern 20°C isotherms (Hirth 1971). In the western Atlantic, several major nesting assemblages have been identified and studied (Peters 1954, Carr and Ogren 1960, Parsons 1962, Pritchard 1969, Carr *et al.* 1978). Most green turtle nesting in the continental United States occurs on the Atlantic Coast of Florida (Ehrhart 1979). Only one nest has been reported on the Florida Panhandle (Schroeder, pers. comm.). Most green turtle nesting activity occurs on Florida index beaches, which were established to standardize data collection methods and effort on known important nesting beaches. Green turtle nesting numbers show biennial peaks in abundance, with a generally positive trend during the six years of regular monitoring since establishment of the index beaches in 1989.

While nesting activity is obviously important in determining population distributions, the remaining portion of the green turtle's life is spent on nearshore foraging grounds. Some of the principal feeding pastures in the western Atlantic Ocean include the upper west coast of Florida, the northwestern coast of the Yucatan Peninsula, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean coast of Panama, and scattered areas along Colombia and Brazil (Hirth 1971). The preferred food sources in these areas are *Cymodocea, Thalassia, Zostera, Sagittaria, and Vallisneria* (Babcock 1937, Underwood 1951, Carr 1952, 1954).

Although no green turtle foraging areas or major nesting beaches have been identified along the offshore Atlantic Coast, evidence provided by Mendonca and Ehrhart (1982) indicates that immature green turtles may utilize estuarine systems during periods of their lives. These authors identified a population of young green turtles (carapace length 29.5-75.4 cm) believed to be resident in Mosquito Lagoon, Florida. The Indian River system, of which Mosquito Lagoon is a part, supported a green turtle fishery during the late 1800s (Ehrhart 1983), and these turtles may be remnants of this historical colony. Additional juvenile green turtles occur north to Long Island Sound, presumably foraging in coastal embayments. In North Carolina, green turtles occur in estuarine and oceanic waters (Epperly *et al.* 1995). Green turtle nesting has occurred in North Carolina, with generally less than five nests reported each year. No information is available regarding the occurrence of green turtles in the Chesapeake Bay, although their presence in embayments north and south of the Chesapeake suggest that they are present in very low numbers.

Leatherback turtle (*Dermochelys coriacea*)

The Recovery Plan for Leatherback Turtles (*Dermochelys coriacea*) contains a description of the natural history and taxonomy of this species (USFWS and NMFS 1992b). Leatherbacks are widely distributed throughout the oceans of the world, and are found throughout waters of the Atlantic, Pacific, Caribbean, and the Gulf of Mexico (Ernst and Barbour 1972). Leatherbacks are predominantly distributed pelagically, feeding primarily on jellyfish such as *Stomolophus, Chryaora*, and *Aurelia* (Rebel 1974).

Trends in the leatherback population are difficult to assess since major nesting beaches occur over broad areas within tropical waters outside the U.S. In the eastern Caribbean, nesting occurs primarily in the Dominican Republic, the Virgin Islands, and on islands near Puerto Rico. Sandy Point, on the western edge of St. Croix, Virgin Islands, has been designated by the U.S. Fish and Wildlife Service as critical habitat for nesting leatherback turtles. Nesting also occurs on the Atlantic Coast of Florida on a smaller scale. The primary leatherback nesting beaches in the western Atlantic occur in French Guiana, Surinam and Mexico. Although increased observer effort on some nesting beaches has resulted in increased reports of leatherback nesting, declines in nest abundance have been reported in the beaches of greatest nesting densities. At Mexiquillo, Michoacan, Mexico, between 1986 and 1987, 4,796 nests were laid on 4.5 km of beach. During the 1990-1991 season, only an estimated 1200 nests were reported. Another large western Atlantic nesting beach is located at Yalimapo-Les Hattes, French Guiana, where Fretey and Girondot estimated the total number of adult females at 14,700 to 15,300 in the late 1980s. Beach erosion has pushed nesting into Surinam, confounding efforts to monitor trends from this colony. Anecdotal information suggests nesting has declined at Caribbean beaches over the last several decades (Eckert 1993).

Leatherbacks are the largest of sea turtles, and are able to maintain body temperatures several degrees above ambient temperatures, likely by virtue of their size, insulating subdermal fat, and an arrangement of blood vessels in the skin and flippers that enables retention of heat generated during swimming (Paladino *et al.* 1990). Although their tolerance of low temperatures is greater than for other sea turtles, leatherbacks are generally absent from temperate Atlantic waters in winter and spring. Stranding patterns suggest that leatherbacks move north along the coast with increasing water temperatures.

Periodically, large numbers of leatherback strandings occur from northern Florida in January and February, through North Carolina in May. Aerial surveys conducted during stranding events confirmed the abundance of leatherback turtles. Two separate studies, one involving aerial surveys for right whales off Georgia and northern Florida (Kraus and Knowlton, pers comm) and the other involving public reporting of leatherback sightings off North Carolina (Braun and Epperly, unpublished), illustrate peaks of leatherback abundance in nearshore waters.

Shoop and Kenney (1992) observed leatherbacks during summer months scattered along the continental shelf from Cape Hatteras to Nova Scotia. Relative concentrations of leatherbacks were seen off the south shore of Long Island and off New Jersey during summer and fall months. Leatherbacks in these waters are thought to be following their preferred jellyfish prey, including *Cyanea* sp. (Lazell 1980, Shoop and Kenney 1992). Researchers in the Chesapeake have observed leatherbacks in the mouth of the Bay during summer months (Byles 1988). Extensive migrations well beyond North American boundaries have been documented. Leatherbacks tagged on nesting beaches in French Guiana and Surinam have stranded on New York beaches (Morreale, pers comm), and other leatherbacks tagged while nesting in the Caribbean have stranded on New England Beaches (Eckert 1993).

Hawksbill turtle (*Eretmochelys imbricata*)

The hawksbill turtle is relatively uncommon in the waters of the continental United States. Hawksbills prefer coral reefs, such as those found in the Caribbean and Central America. However, there are accounts of hawksbills in south Florida and a surprising number are encountered in Texas. Most of the Texas records are small turtles, probably in the 1-2 year class range. Many of the individuals captured or stranded are unhealthy or injured (Hildebrand 1982). The lack of sponge-covered reefs and the cold winters in the northern Gulf of Mexico probably prevent hawksbills from establishing a viable population in this area.

Hawksbills feed primarily on a wide variety of sponges but also consume bryozoans, coelenterates, and mollusks. The Culebra Archipelago of Puerto Rico contains especially important foraging habitat for hawksbills. Nesting areas in the western North Atlantic include Puerto Rico and the Virgin Islands.

In the Atlantic, small hawksbills have stranded as far north as Cape Cod, Massachusetts (STSSN database 1990). Many of these strandings were observed after hurricanes or offshore storms. Although there have been no reports of hawksbills in the Chesapeake Bay, one has been observed taken incidentally in a fishery just south of the Bay (Anon. 1992).

Researchers believe that hawksbills occurring in U.S. waters are from populations that are depleted but are no longer declining (NMFS 1995). Habitat loss, fisheries, and continued exploitation are all identified as factors preventing recovery.

Kemp's ridley sea turtle (*Lepidochelys kempii*)

The Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) (USFWS and NMFS, 1992a) contains a complete description of the natural history, taxonomy, and distribution of the Kemp's or Atlantic ridley turtle. Of the seven extant species of sea turtles of the world, the Kemp's ridley is in the greatest danger of extinction. Following is a brief summary of the information on the distribution and trends in abundance of this species.

Adult Kemp's ridleys are found primarily in the Gulf of Mexico. Adult females nest in daytime aggregations known as arribadas, primarily at Rancho Nuevo, Mexico. Most of the population of adult females nest in this single locality (Pritchard 1969). Ridley hatchlings leave the nesting beach and are not seen again until they reach over 20 cm, when they are found in the northern Gulf of Mexico and the embayments along the eastern Atlantic seaboard as far north as Cape Cod Bay. Nothing is known about the specific movements of hatchling Kemp's ridley turtles, although it is believed that they may be controlled by current patterns: either the loop current for northward transport or an eddy for southward transport with occasional transportation through the Florida Straits via the Gulf Stream system (Hildebrand, 1982). Pritchard and Marquez (1973) suggest that passive transportation via the Gulf Stream up the eastern coast of the United States may be the usual dispersal pattern of young Kemp's ridley turtles. It is widely believed that hatchlings inhabit and forage in *Sargassum* rafts that occur at fronts and eddies (Carr 1986, 1987). However, some authors have observed that *Sargassum* may be used for resting only, since ample food is available throughout the water column, where the likelihood of aggregated predators may be lower (Collard 1990).

Pritchard and Marquez (1973) speculated that ridleys feed and grow rapidly during passive transport, and by the time they reach offshore waters of New England are large enough for active swimming. However, Morreale *et al.* (1992) hypothesize that passive drifting would result in only sporadic occurrence of ridleys in the northeast United States and that the observed annual occurrence suggests some alternative mechanism. Regardless of the mechanism, small juvenile ridleys enter Atlantic coastal embayments in the summer, when water temperatures approach 20°C (Burke *et al.* 1989, Musick *et al.* 1984) and become benthic feeders. Ridleys leave the northern embayments in the fall, when water temperatures cool (Burke *et al.* 1991). Morreale *et al.* (1992) give evidence for directed movements of Kemp's ridleys south, out of northeastern coastal waters, as temperatures drop below 14°C, generally in late October (Morreale, pers. comm.). Keinath *et al.* (1987) observed sea turtle emigration from the Chesapeake Bay when waters dropped below 18°C in November. High Kemp's ridley mortality during November and December in some years associated with the summer flounder fishery off North Carolina suggest that sea turtles emigrating from northern waters in fall and winter months may concentrate in nearshore and southerly areas influenced by warmer Gulf stream waters (Epperly *et al.* 1995).

Kemp's ridley population estimates are imprecise due to the inaccessibility of the predominantly pelagic occurrence of these animals. Nests, hatchlings and nesting females provide the only accessible portions of sea turtle populations; therefore population trends are monitored through counts of adult females. When nesting aggregations at Rancho Nuevo were discovered in 1947, greater than 40,000 adult females were estimated to have nested in one day (Hildebrand 1963). Recent estimates by the sea turtle Expert Working Group suggest that there now may be 1500 adult females (EWG 1995).

Ridley nest numbers continued to decline until 1987, when less than 750 nests were counted. The subsequent increase in documented nest numbers was not dramatic until 1994, when over 1,500 nests were documented in Mexico. During 1995, over 1,900 nests were observed, and greater than 2000 nests were observed during the summer of 1996. These nest counts far surpass the numbers of nests observed in any year since monitoring was initiated in 1978. While these data need to be interpreted cautiously due to expanded monitoring efforts since 1990, greater than 110,000 hatchlings were released from Rancho Nuevo during 1994 and 1995, compared to 50,000 to 80,000 over the previous five to six years (Byles, pers. comm.).

Expanded beach survey areas were established in 1989, when much of Rancho Nuevo was destroyed by Hurricane Gilbert. Approximately 25 percent of the ridley nests observed each year since 1990 have occurred on the expanded survey beaches adjacent to Rancho Nuevo despite the fact that Rancho Nuevo's beaches have returned to their original conformation (Marquez, pers comm 1995). Ridley nests have always been observed on the beaches north of Rancho Nuevo during the opportunistic aerial surveys frequently conducted during the decade prior to expansion of the survey area. However, significant nesting was not noted. The large number of nests now collected from those beaches may be the result of a northern expansion of the ridley population's nesting beach, or may reflect a previously undocumented group of nests. After 1994, the positive nesting trend is apparent even exclusive of the nests along the expanded survey area.

The EWG identified an average Kemp's ridley population growth rate of 13 percent annually since 1991. Continued growth at that rate would have resulted in 2,190 Kemp's ridley nests during 1996. As illustrated in Figure 1, only approximately 2,060 ridley nests were actually documented during the 1996 nesting season, and only 1300 of these nests were counted at Rancho Nuevo. The 13 percent increase in nest production does not appear as steady as forecasted. The discrepancy may be due in part to annual fluctuations in irregular internesting periods that are normal for sea turtle populations. Alternatively, the removal of large numbers of Kemp's ridleys from the population during elevated mortality events associated with the Southeast U.S. shrimp fishery in 1994 and 1995 may be reflected in the decreased rate of increase in nests observed during 1996. Lastly, it is unclear what the contribution of unusual nesting behavior observed during 1996, such as two weeks of night-time nesting attributed to unusually dry and hot conditions this summer, might have had on nest production.

IV. Assessment of Impacts

Potential impacts to marine mammals and sea turtles from explosives detonation include exposure to chemical by-products, lethal and non-lethal incidental injury, as well as physical and acoustic harassment. Injury or death could occur as a direct result of the explosive blast (concussion) and resultant cavitation. (The area of cavitation is where the water pressure becomes extremely low with the passage of the negative shock wave that moves down from the surface. The water separates, producing a region of cavitation bubbles for a brief time. This volumen of water then collapses and generates a weak positive pressure wave). Injury could include damage to internal organs and/or the auditory system. Harassment of marine mammals and sea turtles could occur as a result of physiological response to both the explosion-generated shockwave as well as to the acoustic signature of the detonation. An assessment of these impacts on endangered/threatened marine mammals and sea turtles in the project area are discussed in detail below.

Exposure to Chemical By-Products

Changes to the marine habitat resulting from detonation of the explosives include contact with chemical by-products of the explosions and permanent changes to the local environments caused by the detonation. With the exception of carbon and aluminum oxide, the by-products from the explosions are all gases. Virtually 100 percent of the solid material and at least 10 percent of the gases are contained within the surface or submerged pool created by the explosion (Young 1995). The initial concentration levels of the by-products are below the levels considered harmful for fish (Young, 1984) and would not be expected to pose a threat to marine mammals or sea turtles after the relatively short stabilization times of less than one hour (NMFS 1993). For these reasons, the likelihood that injury to marine mammals or sea turtles would occur as a result of exposure to the chemical by-products from the explosions is extremely small. More detailed information of the fate of by-products can be found in Naval Air Station (1990) and NMFS (1993).

Exposure to Explosive Shock Wave

Impacts to fish and other marine life from the explosive shock wave cannot be accurately estimated. However, as the area of cavitation at the detonation site is an area of near total physical trauma, the Navy does not expect that any animals, would survive the effects of the extensive cavitation area for the 10,000-lb charges. The maximum lateral extent of cavitation has been estimated by the Navy to be 1,620 ft (494 m) for a 10,000-lb. charge detonated at a depth of 100 ft (30 m). The cavitation region would extend from the surface to a maximum depth of about 80 ft (24 m). Peak shockwave pressure at the above horizontal distance from the charge would be expected to be about 159 lbs/in^2 (psi; 1084 kPa)(Appendix D).

A. Assessment of Impacts to Marine Mammals

The incidental take of listed marine mammals associated with the proposed activities fall into three categories:

(1) Lethal, due to cavitation effects or extensive lung hemorrhage;

If animal inside the cavitation area survives the effects of cavitation, it could incur other injuries caused by the shockwave, such as injuries to the lungs or ear structures. Extensive lung hemorrhage, for example, is considered debilitating and potentially fatal; suffocation caused by lung hemorrhage is likely to be the major cause of marine mammal death from underwater shock waves, based on experiments with terrestrial mammals (Hill 1978). This range, which will vary inversely with the marine mammal's weight, is predicted to extend to 5,000 ft (1,524 m) from the point of detonation. While only 1 percent of the animals within this range would be predicted to die, for purposes of calculating take, NMFS and the Navy have presumed that 100 percent will die from these injuries.

(2) Injuries, due to lung hemorrhage or damage to ear structures;

These are injuries from which animals would be expected to recover on their own. Based upon extensive calculations provided in Appendix D of the DEIS, the maximum range for slight lung hemorrhage is estimated at 6,069 ft (1,850 m). The maximum range for 10 percent probability of eardrum rupture in terrestrial mammals varies from 7,900 ft (2,408 m) at the surface to 12,440 ft (3,792 m) at the sea floor. The 10 percent ear rupture range at the sea floor (500 ft) was used as the maximum range for non-lethal injury. For purposes of estimating incidental take however, NMFS and the Navy have assumed that 100 percent of those marine mammals found between 5,000 ft (1,524 m) and 12,440 ft (3,792 m) from the detonation point would be injured, even though the probability of eardrum rupture (of terrestrial mammals) at the outer edge of this range would be only 10 percent (and less in near-surface waters).

Some percentage of the animals within the theoretical "eardrum rupture or slight lung hemorrhage" zone could eventually die from their injuries, the Navy believes that has been taken into account by the mortality criterion because the mortality criterion for onset of extensive lung hemorrhage deliberately overestimates mortality by assuming 100 percent of the animals within a radius of 5,000 ft (1,524 m) would be killed. At this radius, the probability of ear structure injury is considered to be 50 percent or less in the upper water column and 50-95 percent in deeper water (i.e., all animals within this radius are assumed to be killed even though some animals might not even incur an injury to its hearing mechanism).

While the Navy's approach probably does overestimate actual mortalities, loss of hearing could result in the debilitation of cetaceans due to compromised foraging abilities. The potential loss of equilibrium due to ear structure damage, which could be devastating in an animal that must always know which way is up to get air, has not been evaluated. Additionally, even slight lung hemorrhage could cause more severe problems for cetaceans than for terrestrial involuntary mammals. Cetaceans must exchange its entire lung capacity at each breath, potentially stressing and expanding any damaged areas on the lung surface.

Permanent threshold shift (PTS) is an injury resulting in a permanent loss of hearing. Such an injury would occur within the frequency range of the animal's necessary hearing. As mentioned above, because marine mammals depend upon hearing for communication, food location etc., it is generally believed that, when such injuries occur within the frequency range of the animal's hearing, a PTS injury may ultimately result in the death of the animal. According to calculations done by the Navy (DEIS, p.4-24) based upon Richardson *et al*. (1995, p.376), a PTS injury might be expected to occur within distances of about 1.7 nmi (3.1 km) (slant range) from the detonation point for a 10,000-lb (4,536-kg) charge. Since this distance (in the upper water column) is greater than the distance for potential ear rupture discussed above, when PTS injuries are taken into account, the number of injuries that may eventually result in marine mammal mortality may be greater than presumed in the above discussion.

(3) <u>Harassment, due to acoustic discomfort</u>;

Marine mammals that are not within an area wherein they may incur either an ear rupture or more serious injury may still be subject to acoustic discomfort due to the momentary disturbance of the passing <0.50 sec. signal. Based upon an analysis provided by the U.S. Navy (Navy 1995, Appendix E), the maximum range for acoustic discomfort at Mayport is estimated to be 6 nmi (11.11 km). Animals within this zone are expected to experience some discomfort from the passing signal and may, depending upon location, incur a temporary threshold shift (TTS) in hearing ability. Marine mammals outside this zone would not be expected to incur TTS. Because of the brevity of the signal from the explosion, no marine mammals are expected to incur a disruption in behavioral patterns such as migration, breathing, nursing, or feeding and should not be affected by masking of communication. In addition, the one week between detonations, combined with the migratory nature of marine mammals ensures that marine mammals should not incur cumulative impacts from the 5 detonations.

B. Assessment of the impacts of the project on listed sea turtles

The Navy, in their DEIS, their Biological Assessment, and in their application for a marine mammal take permit, considered modeled and experimental information to assess the likely impacts of the shipshock trials on marine mammals. Their results, discussed in detail in the above documents, indicate that bulk cavitation caused by the ship shock detonation will kill all animals within 494 m (1,620 ft) of the explosion, particularly from the surface to a depth of approximately 24 m (80 ft). The application cites Ketten (1995) as identifying a 70 to 800 m (230 to 2,625 ft) range within which lethal damage to marine mammal ear structures is likely to occur due to a blast of 10,000 lbs. Further mortalities due to extensive lung hemorrhages were considered likely for marine mammals within 1,525 m (5,000 ft) of the detonation. Although the Navy did not believe that mortality would likely result for all marine mammals within this range, for the purpose of establishing a conservative lethal take range, or "safety range", the Navy estimates that all animals within this 1525 m range are killed. Additional damage caused by lung hemorrhaging was considered possible to a distance of 1,850 m (6,069 ft), and a 10 percent likelihood of ear structure damage was considered to predict an injury range out to approximately 3,792 m (12,440 ft or 2.05 miles). Although the DEIS acknowledged that some of the animals within this injury range might be killed and some uninjured, for the purpose of estimating injuries caused by the detonation, the Navy will consider all marine mammals between 1,525 and 3,792 m from the blast likely to be injured by the blast. The safety range is considered to encompass a circular area of 45.17 square kilometers, of which 7.30 square kilometers are within the mortality range.

Specific information regarding the likely impact of the shipshock trials on sea turtles is not available. Studies regarding the impacts of relatively minuscule explosives on humans noted that minor injuries such as small bruises or perforations of the intestinal tract occasionally occur well beyond ranges in which human lung damage could occur (Christian and Gaspin 1974). Christian and Gaspin (1974) note that these minor injuries could become serious if left unattended. Sea turtles with untreated internal injuries would have increased vulnerability to predators and disease. Nervous system damage, cited as a possible result of blasting in Appendix C of the Navy's marine mammal incidental take application, could kill sea turtles through disorientation and subsequent drowning in the water column. The Navy's review of previous studies suggested that rigid masses such as bone (or carapace and plastron) could protect tissues beneath them; however, there are no observations available to determine whether the turtles' shells would indeed afford such protection.

Studies conducted by Klima *et al*. (1988) evaluated blasts of only 92 kg (approximately 42 pounds) on sea turtles (4 ridleys, 4 loggerheads) placed in surface cages at varying distances from the explosion. Christian and Gaspin's (1974) estimates of safety zones for swimmers found that, beyond a cavitation area, waves reflected off a surface have reduced pressure pulses, therefore an animal at shallow depths would be exposed to a reduced impulse. This finding, which considered only very small explosive weights, implies that the turtles in the Klima *et al*. (1988) study would be under reduced effects of the shock wave. Despite this possible lowered level of impact, five of eight turtles were rendered unconscious at distances of 229 to 915 m from the detonation site. Unconscious sea turtles that are not removed and rehabilitated likely have low survival rates.

Clearly, if sea turtles occur near the shipshock detonation site, lethal takes are likely. Because of the lack of specific information on the impacts of shock waves anticipated by the proposed project on sea turtles, the zones of impact identified for marine mammals are considered for sea turtles as well. Although the Navy intends to delay detonations if sea turtles are observed within the 3,792 m zone in which lethal takes or injuries could occur, difficulties inherent in surveying for sea turtles due to their small size and limited time at the surface limits the efficacy of this mitigation method.

The area identified by the Navy for the proposed shipshock tests runs along the continental shelf edge off of Mayport, Florida. This area comes no closer to the coast of Georgia and Florida than 37 miles. Tests will be conducted from May through September, and will include detonations once per week. The DEIS identifies the average position of the Gulf Stream's western wall as along the shoreward edge or just shoreward of the proposed project area. Eddies and other Gulf Stream structures may extend shoreward of the project area, and lateral meanders could shift the Gulf Stream seaward or shoreward of the project area.

Loggerhead, leatherback, and green sea turtles nest in significant numbers along the beaches downstream of and adjacent to the proposed project area in Florida and southern Georgia. South of Cape Canaveral, leatherback nests have been observed by late February in some years, and loggerhead nests have been documented in April (Meylan *et al*. 1995, Table 3). North of Cape Canaveral, a four to six-week lag has been observed. Early nests were reported despite the lack of significant nesting beach survey effort prior to May of each year. Leatherback eggs incubate for 55 to 75 days, likely averaging approximately 64 days in southern Florida (NMFS and FWS 1992). Loggerhead eggs incubate for 53 - 55 days in Florida, and 63 days in Georgia.

Sargassum occurs throughout the Gulf Stream. However, as described in the DEIS, rafts of *Sargassum* that provide the basis for floating biological communities (including hatchling sea turtles) are most common along convergence zones, such as those which frequently occur along the western wall of the Gulf Stream. Hawksbill nests have rarely been documented in Florida, perhaps due to incorrect identification as loggerhead nests and only two Kemp's ridley nests have been documented on the east coast of Florida (Florida DEP, unpub. data). NMFS believes that the likelihood of hawksbill or Kemp's ridley hatchlings occurring within the project area is low. However, the project area is downstream and offshore of major sea turtle nesting beaches, and is scheduled to occur during the nesting season. Roughly 50,000 to 100,000 sea turtle hatchlings, including primarily loggerhead turtles, could enter Florida east coast waters during a midsummer night. Loggerhead and leatherback hatchlings may occur within the rafts of *Sargassum* throughout the proposed project period. Green turtle nesting occurs later in the year and extends further into the fall than leatherback and loggerhead nesting, however green turtle hatchlings may occur in the *Sargassum* for most of the later summer months. Researchers conducting studies on hatchling orientation report collecting dozens of hatchlings from *Sargassum* rafts throughout the summer (Witherington, FLDEP, pers comm). They estimate that, depending on currents, it may take two days for hatchlings to reach the western wall of the Gulf Stream. They believe that they aggregate along the front, and those that enter the Gulf Stream are quickly taken north.

Therefore, NMFS believes that loggerhead, leatherback, and to a lesser extent, green sea turtle hatchlings are likely to be killed or injured by the proposed shipshock tests if they occur near or shoreward of the western wall of the Gulf Stream. Injured hatchlings are likely to be subsequently killed by predators. Although the natural mortality rates of hatchlings are high, repeated losses of hatchlings may occur due to the 5 planned detonations that will occur during the shipshock trials. NMFS believes that conduct of the trials two or more miles away from the western edge of the Gulf Stream and avoidance of drifts of *Sargassum* within the Stream are effective measures to minimize the number of hatchling sea turtles likely to be killed during the shipshock trials. While some hatchlings may occur within the Gulf Stream and independent of *Sargassum* rafts, aggregations are unlikely and therefore significant levels of take would not be anticipated.

Aerial surveys were conducted once per month from April through September, 1995, as described in the DEIS prepared for the shipshock tests. Survey methods used were identical to those employed by NMFS. Density adjustments that were developed for the 1995 surveys incorporated subjective sightability estimates that introduce an undefinable margin of error. No error margins are offered within the information submitted to NMFS. However, the sightability estimates introduced into the density estimate calculations may have resulted in an overestimation of the calculated density relative to actual density, based on observations in 1995 (Henwood, pers. comm.). The results of the Navy's observations can be found on Table B-5 of the DEIS, Appendix B. An adjusted mean density of loggerheads off of Mayport of 24.12 per 100 square km was calculated. Densities were particularly high in April, therefore the conduct of shipshock tests off of Mayport in April was considered by the Navy to be inadvisable (this is also a precautionary measure to avoid the potential for interaction with right whales which may still linger in the area over that month). They recalculated the adjusted mean density estimates excluding the April observations and estimated that 15.15 loggerheads per 100 square km occurred off Mayport during the surveys conducted in 1995. Leatherbacks were also sighted, at adjusted densities of 0.94 and 0.04 per 100 square km, including and excluding April sightings respectively. Additional sea turtles were observed and not identified, bringing the total adjusted density for all species combined to about 26 sea turtles per 100 square km including the April observations, and about 17 excluding those observations. Within the safety zone of the project, which encompasses an area of 45.17 square kilometers, 8 to 12 pelagic immature and adult sea turtles would be vulnerable to take by injury or mortality for each ship shock detonation if sea turtle densities during 1997 are similar to those observed during the 1995 surveys. Hatchlings that occur within the safety zone may also be injured or killed by the detonations.

The Navy's calculations for sea turtle density estimates are lower, but not dissimilar to those reported elsewhere from waters adjacent to or including the project area. Hoffman and Fritts (1982) discussed the results of a portion of the Southeast Turtle Surveys (SETs) conducted along the western wall of the Gulf Stream. They reported on a portion of the survey conducted south of the project area, between 27.37° N and 28.31° N and more or less between 80.20° and 80° W, during August of 1980. Most (252 of 255) of the turtles sighted were seen just west of the Gulf Stream's western boundary. Three sea turtles were observed close to *Sargassum* rafts. Loggerheads were the most common species observed. The authors considered the abundance of loggerheads to perhaps be a post-breeding aggregation, although some nesting was still occurring onshore. All 18 of the leatherbacks observed occurred west of the Gulf Stream boundary. Seven of the leatherbacks were aggregated in an area in which large quantities of jelly fish were also observed. Six green turtles were observed near leatherbacks and within the generally densest area of sea turtle observations. Turtle abundance was not correlated precisely with bottom topography, occurring nearshore in waters of waters of 50 to 70 m, rather than at the shelf break. The authors opined that the turtles may have been avoiding the northern drift of the Gulf Stream.

Shoop and Thompson (1982 a and b), Thompson and Shoop (1983) and Thompson (1984) reported further on the results of the first year of the SETS surveys. The surveys were conducted along the approximate western edge of the Gulf Stream and shoreward to the coast from Cape Hatteras, North Carolina to Key West, Florida. The shipshock project area correlates most closely with portions of the SETS surveys within blocks 6, 7 and 8. Forty percent of all turtles observed during the 1982 surveys occurred in their survey Block 8. Over 80 percent of all turtles seen were observed in spring and summer. Turtles were concentrated in Block 8 during the spring survey (April 19 - May 8, 1982), with a secondary concentration further north in block 7. The same relative abundance of sea turtles was observed in Block 8 in the spring (April/May) surveys as in the summer (June/July) suggesting that the decline in relative abundance observed during 1995 might not occur each year or in all areas. Notable aggregations of loggerheads were observed during the spring and summer surveys, in waters extending from just south of Canaveral, north to near Brunswick Georgia. The authors considered the western edge of the Gulf Stream to be a possible natural offshore border for summer distribution. They noted an apparent shift in the concentration of sea turtles southward, primarily south of the project area. During the winter, turtle distributions were uniformly sparse, with slight relative concentrations north of the project area offshore in blocks 2-6. Thompson (1984) reported that while sea state 3 was the most common condition during aerial surveys, both loggerheads and leatherbacks were seen more frequently in sea state 1. Preliminary analysis of these observations suggested that as sea state increased, the frequency and proportion of sightings decreased in sea states 3 and 4.

Estimated Level of Incidental Take

For the purpose of identifying a maximum conservative incidental take level that describes the possible extent of take, the sea turtle densities estimated from the Southeast Sea Turtle Surveys (SETs) survey block of highest abundance (includes much the project area) are considered here. Thompson (1984) provided an adjusted density estimate of 2.7 sea turtles (+/- .7) per square nautical mile. Therefore, in the circular safety zone with an area of 13.16 square nautical miles, 35.5 (+/- 9) sea turtles could occur, particularly shoreward of the western boundary of the Gulf Stream, if the number of turtles occurring in the area during 1997 are similar to the density observed in 1982.

Aerial surveys conducted off Mayport to collect data for an assessment of impacts of the shipshock trials resulted in the estimation of an adjusted mean density of 24.12 loggerheads, and .94 leatherbacks per 100 square km. Unidentified turtles were also sighted, bringing the total adjusted mean density estimate to 26 sea turtles per 100 square km from April through September. The surveys suggested that turtle densities were particularly high in April, which was therefore considered to be an inappropriate time for the shipshock trials. The adjusted mean density estimates were recalculated to exclude the April observations, and were then estimated as 15.15 loggerheads,.04 leatherbacks, and a total of about 17 sea turtles of all species per 100 square km off of Mayport between May through September. This apparent change in relative seasonal abundance was not noted by the earlier SETs surveys, suggesting that it does not occur every year, or not in the waters adjacent to the proposed site of the trials. The observations reported by the Navy from 1995 surveys suggest that, 8 to 12 turtles could occur within the safety zone of the project, which encompasses an area of 45.17 square kilometers and would be vulnerable to take by injury or mortality for each ship shock detonation.

Thompson and Shoop (1983) discuss two survey blocks sampled during the summer months further offshore to sample the Gulf Stream itself. Only 17 turtles, including one that was unidentified and one leatherback, were observed in the Gulf Stream blocks. Sixteen of these sea turtles were observed in the southern Gulf Stream survey block, adjacent to the project area. The relative abundance of sea turtles in the Gulf Stream during the summer months (the only period surveyed) appear to be significantly lower than the abundance of turtles along the western edge and shoreward of the Stream. Transects that extended shoreward of the western wall of the Gulf Stream during these same surveys confirmed the relative increase in abundance of sea turtles once the western boundary was crossed.

Given the available information, it appears that 12 to 35 pelagic immature and adult sea turtles could be reasonably expected to occur within the safety zone of shipshock detonations during the summer months off of Mayport, Florida. The Navy can significantly reduce the likelihood of takes of hatchlings and larger sea turtles by injury or mortality by avoiding the western boundary of the Gulf Stream and waters shoreward of the Stream. Additionally, avoidance of large rafts of *Sargassum* or removal of hatchlings from *Sargassum* patches, and avoidance of jelly fish aggregations would further reduce sea turtle takes. Implementation of these measures would reduce the number of sea turtles likely to be taken to the lower range of the estimate discussed above, and would minimize the number of hatchling sea turtles affected. The proportion of each species of larger sea turtle that may be taken may vary, but are likely to be similar to those observed in the most recent surveys. Given these caveats, NMFS estimates that, if the Navy conducts the shipshock trials in the Gulf Stream and avoids *Sargassum* and jelly fish aggregations, a minimal number of hatchling sea turtles and 12 larger turtles, including about 84 percent loggerheads, 10 percent leatherbacks, and 6 percent unidentified sea turtles that may include greens, Kemp's ridleys and hawksbills may be taken by injury or mortality during each detonation.

For marine mammals, the Navy (1995) has attempted to estimate the number of animals potentially subject to each type of incidental take for each of the marine mammal species based upon aerial survey observations made in the waters offshore northern Florida during May - October, 1995. Their intent is to provide the best estimates of incidental take possible with the data at hand.

Six species of marine mammals that may potentially occur off Mayport, FL between May and September are listed under the ESA. However, none of these species, except the sperm whale, were detected during the above-mentioned surveys. Because blue, fin, humpback, and northern right whale generally inhabit northern feeding grounds during spring, summer, and early fall, this is not unexpected.

Sperm whales could be present, but in low densities, and these animals are likely to be detected by passive acoustic monitoring. The Navy has estimated that 0.01 or less sperm whales per detonation for both mortality and injury; totals for five detonations are 0.01 mortalities and 0.05 non-lethal injuries of sperm whales. Therefore, it is unlikely that any sperm whales would be killed or injured by the detonations. Also, because sperm whales produce distinctive clicked vocalizations (Jefferson *et al.*, 1993), they are very likely to be detected (if present) using passive acoustic monitoring.

The other endangered marine mammals (blue, fin, humpback, sei and northern right whales) are balaenopterid species which generally inhabit northern feeding grounds during the period proposed for shock testing and which were never observed off Mayport during the 1995 aerial census effects. Therefore, it has been presumed that none of these species would be killed or injured by the proposed action. As a result, NMFS concludes that, at Mayport, it is very unlikely that any endangered marine mammal would be killed or injured.

V. Conclusions

NMFS believes that the conduct of shipshock trials off of Mayport, Florida, during the summer of 1997, as described in the Proposed Action section above, may affect, but is not likely to jeopardize, sea turtle species within our purview. Eight to 35 sea turtles, primarily loggerheads, may occur within the safety area identified by the Navy and therefore may be vulnerable to take by injury or mortality during each detonation. Avoidance of jellyfish, *Sargassum* and the western edge of the Gulf Stream would provide important mitigation measures that would reduce the likelihood of take significantly and are provided as reasonable and prudent measures.

In addition, NMFS has concluded that conducting the shipshock trial with the mitigation measures proposed in waters off Mayport, Florida, between the months of May through September, are unlikely to jeopardize the continued existence of listed marine mammal populations due to the highly unlikely event of their occurrence in the study area during the time of the detonations (based on available sighting data).

VI. Critical Habitat

The only critical habitat in marine waters near the project area is for the northern right whale.

Right Whales

The nearshore waters of northeast Florida and southern Georgia were formally designated as critical habitat for right whales on June 3, 1994 (59 FR, 28793). These waters were first identified as a likely calving and nursery area for right whales in 1984. Since that time, Kraus *et al.* (1993) have documented the occurrence of 74 percent of all the known mature females from the North Atlantic population in this area. While sightings off Georgia and Florida include primarily adult females and calves, juveniles have also been observed.

There are five well-known habitats used annually by right whales, including 1) coastal Florida and Georgia, 2) the Great South Channel, east of Cape Cod, 3) Cape Cod and Massachusetts bays, 4) the Bay of Fundy and, 5) Browns and Baccaro Banks, south of Nova Scotia. The first three areas occur in U.S. waters and have been designated by NMFS as critical habitat (59 FR, 28793).

Detonations will be confined to waters greater than 25 miles from the seaward boundary of the designated right whale critical habitat off of Florida and Georgia; therefore, no adverse effects on critical habitat are anticipated.

VII. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal actions, that are reasonably certain to occur within the action area of the federal action subject to consultation. State regulated fishing activities, including trawl and gillnet fisheries, in inshore Atlantic and Gulf of Mexico waters probably take endangered species. These takes are not regulated or reported. NMFS will continue to work with states to develop ESA Section 6 agreements and Section 10 permits to enhance programs to quantify and mitigate the effects of these fisheries. It is expected that states will continue to license/permit large vessel and thrill-craft operations which do not fall under the purview of a Federal agency and will issue regulations that will affect fishery activities.

Increased recreational vessel activity in inshore waters of the Gulf and Atlantic will likely increase the number of turtles taken by injury or mortality in vessel collisions. Recreational hook and line fisheries have been known to lethally take sea turtles, including Kemp's ridleys. In a study conducted by the NMFS Galveston Laboratory between 1993 through 1995, 170 ridleys were reported associated with recreational hook and line gear; including 18 dead stranded turtles, 51 rehabilitated turtles, 5 that died during rehabilitation, and 96 that were released by fishermen (Cannon and Flanagan, 1996).

Although pathological effects of oil spills have been documented in laboratory studies of marine mammals and sea turtles (Vargo *et al.*, 1986), the impacts of other anthropogenic toxins have not been investigated.

Stomach content analyses conducted on sea turtle carcasses indicate that ingestion of plastic is not uncommon. In Texas, for example, 34 percent of the Kemp's ridleys necropsied had plastic items among the stomach contents found (Shaver, 1991). Although infrequent, the ingested debris does appear to occasionally contribute to the mortality of sea turtles.

Impacts on sea turtles on nesting beaches due to vehicular driving, beachfront lighting, and poaching have been documented: Vehicles driven on the beach leave deep tire ruts that can entrap emergent hatchlings; photopollution results in hatchlings traveling inland away from the ocean; and although poaching has been virtually eliminated in the United States, occasional incidents occur such as in South Carolina where approximately 10,000 eggs were taken recently.

Hatchling loggerheads are widely dispersed during their pelagic existence, reappearing as juveniles in nearshore waters from Maine through Texas, as well as along the northeastern Atlantic, and in European waters. All of the small juvenile loggerheads sampled from longline vessels operating off the Azores were genetically identified as originating from southeastern U.S. nesting beaches (Bolten, U. of FL., Gainesville, pers comm. 1996). Fifty-seven percent of the loggerheads encountered in the western Mediterranean feeding grounds are believed to have been derived from the Atlantic U.S. nesting beaches (Bowen et al., 1993). Aguilar et al. (1992) have estimated that greater than 20,000 juvenile loggerheads are taken annually by the Spanish longline fleet in the Mediterranean. This estimate does not consider the impacts of longline vessels from other nations fishing in the Mediterranean. Survival rates of turtles collected from the Spanish fleet suggest that between 20 and 30 percent of these turtles die after capture by longline. Sea turtle bycatch appears to be high near the Azores, and is likely high throughout the Madeiras and other islands off western Europe (Bolten, U. of FL., Gainesville, pers comm. 1996). Where possible, the U.S. should work with foreign governments to mitigate the effects of fisheries with high incidental take, as well as to mitigate or prevent potentially devastating projects on land, such as the potential extension of the Gulf Intracoastal Waterway from the U.S. border to Tampico, Mexico. Further protection of loggerheads in U.S. waters is necessary to reduce mortality where possible while efforts to reduce mortality outside of U.S. waters are pursued.

VIII. REINITIATION OF CONSULTATION

Reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in the ITS (attachment A) is exceeded, (2) new information reveals effects of the action that may affect listed species or critical habitat (when designated) 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 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. Examples of new information requiring reinitiation of consultation include (1) data indicating that the zones of injury or mortality are larger than predicted, or (2) if a listed marine mammal species is found within the 2.05 nmi (3.8 km) safety zone during the first post-detonation monitoring survey. Additionally, consultation shall be reinitiated when the proxy incidental take levels established by the EWG have been re-calculated for 1997. Finally, NMFS will reinitiate consultation if, and when, NMFS issues a small take authorization under section 101(a)(5)(A) of the MMPA, in order to revise the incidental take statement.

IX. Conservation Recommendations

NMFS recommends that the U.S. Navy implement all mitigation measures mentioned above, in the DEIS, and in the Biological Assessment. In addition, the Navy should:

1. Conduct or support studies to determine the structure and capabilities of the auditory systems in marine mammals and sea turtles; and

2. Conduct, during the first explosive charge detonation, a acoustic transmission loss study of the charge's pressure wave. Measurements should be made at distances of 2, 6, 8 and 10 nmi from the detonation.

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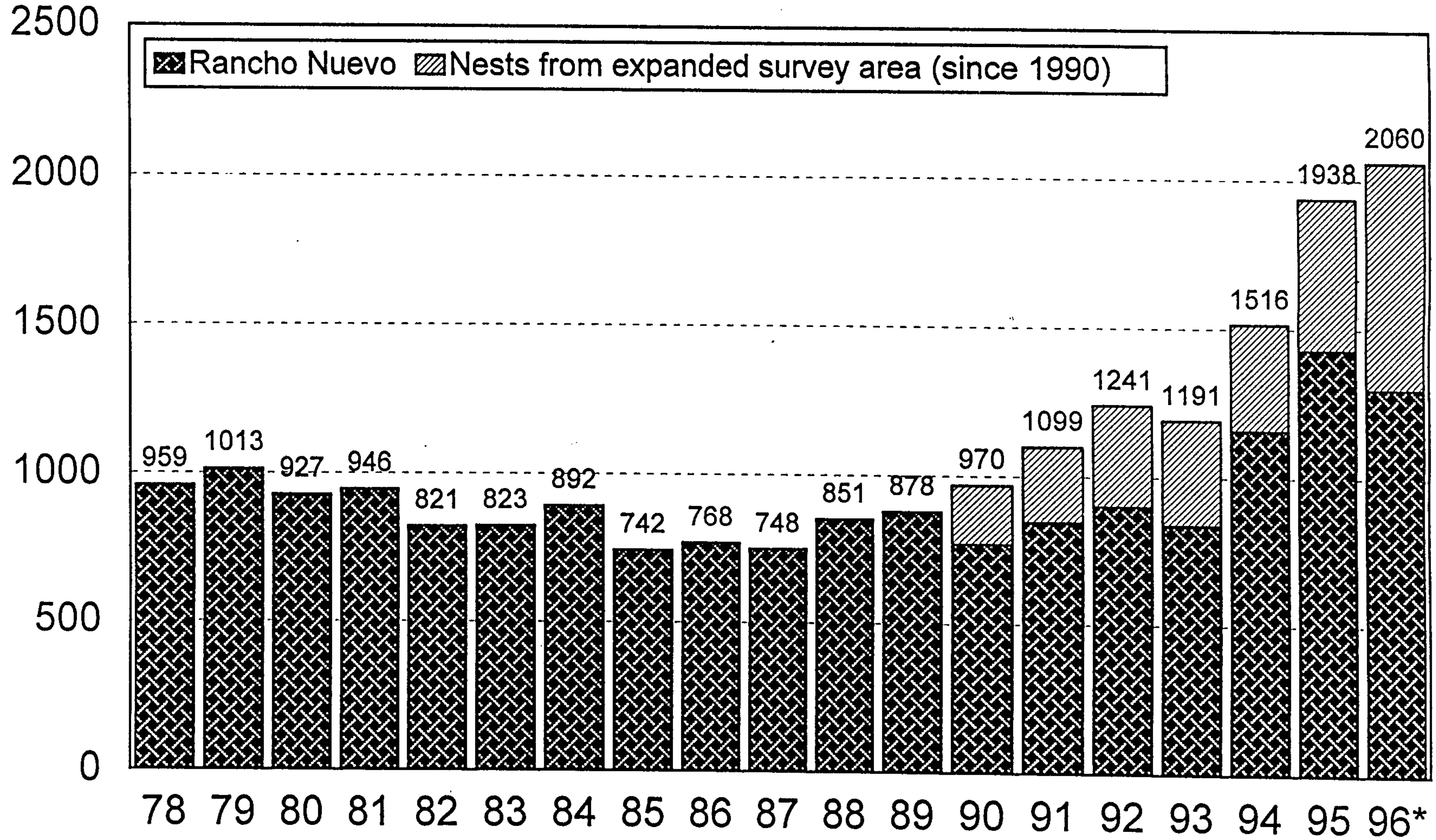
Figure 1

Kemp's ridley nests at Rancho Nuevo, Mexico, 1978-1996

Data from R. Marquez et al., 1995 manuscript submitted to Marine Turtle Newsletter and Marquez pers comm



*1996 numbers are preliminary

Attachment A

STATEMENT REGARDING INCIDENTAL TAKING PURSUANT TO SECTION 7(b) OF THE ENDANGERED SPECIES ACT OF 1973, AS AMENDED

Section 7(b)(4) of the Endangered Species Act (ESA) requires that when a proposed agency action is found to be consistent with Section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. It also states that reasonable and prudent measures, and terms and conditions to implement the measures, be provided that are necessary to minimize such impacts. Only incidental taking resulting from the agency action, including incidental takings caused by activities approved by the agency, that are identified in this statement and that comply with the specified reasonable and prudent alternatives, and terms and conditions, are exempt from the takings prohibition of section 9(a), pursuant to section 7(o) of the ESA. In addition, if the taking involves a threatened or endangered marine mammal, then the taking must be authorized pursuant to 16 U.S.C. 1371(a)(5). NMFS intends to issue a small take permit prior to action by the Navy, at which time the consultation will be reinitiated and this ITS will be amended to authorize such taking. However, the likely takings are discussed below.

NMFS anticipates that the proposed project, as described above, will result in the incidental take, by injury or mortality, of up to 12 sea turtles for each detonation, with a total of 60 sea turtle takes. These takes may include fifty (50) loggerheads, six (6) leatherbacks, and four(4)unidentified or endangered turtles, which may include one Kemp's ridley, hawksbill or Florida green sea turtle. This take level assumes that the terms and conditions, listed below, will be followed. Additional hatchling mortality may occur, but will likely be minimal if mitigation measures identified in the terms and conditions are met. Failure to meet these conditions, particular avoidance of the western edge of the Gulf Stream, avoidance of jellyfish aggregations and avoidance of *Sargassum*, may result in the take of over 170 large turtles and hundreds of hatchlings.

Based on recent estimates of the abundance and distribution of endangered whales in the project area, estimates on the detectability of these mammals by aerial, shipboard and acoustic monitoring, and information on the maximum ranges for each type of incidental take (lethal, injury and harassment), NMFS anticipates that no listed marine mammals will be injured or killed by the detonation of 5 10,000 lb. explosive charges in the offshore waters of northern Florida. NMFS also estimates that a maximum of 7 species may be harassed by acoustic discomfort. As no mortalities of endangered whales are established, consultation must be reinitiated if any endangered whale is observed injured or killed in the vacinity of operations.

Reasonable and Prudent Measures

The following reasonable and prudent measures and terms and conditions are specified as required by 16 U.S.C. 1536(b)(iv) and 50 CFR § 402.14(i), to minimize the impact of the take on listed species as a result of the proposed action.

1. Aerial surveys to determine the presence or absence of listed species or environmental indicators that species may be present must be conducted in sea states no greater than #3 on the following scale:

0 = Flat calm, no waves or ripples
1 = Small wavelets, few if any whitecaps;
2 = Whitecaps on 0 - 33% of surface; 1 - 2′ waves
3 = Whitecaps on 33 - 50% of surface; 2 - 3′ waves
4 = > 50% Whitecaps; > 3′ waves

2. The charge should not be detonated if visibility is less than 3 nmi.

3. *Sargassum* rafts and aggregations of jellyfish must be avoided. Detonations must occur no closer than 2.05 nm of sightings of these indicators of conditions favorable to sea turtle presence. If *Sargassum* rafts persist within the safety zone and cannot be avoided, the Navy should attempt to collect hatchlings from observed rafts.

4. The Navy must use satellite telemetry images of sea surface temperature and aerial survey indicators (*Sargassum* rafts, water color changes, etc., see Hoffman and Fritts 1982) to identify the western wall of the Gulf Stream. Detonations must be confined to waters west within the Gulf Stream, no closer than 2.05 miles of the western boundary, which appears to be the seaward boundary for aggregated hatchlings, pelagic immature and adult sea turtles.

5. If a northern right whale is sighted within the safety or buffer zone, detonation would be postponed until the animal was positively determined to be outside the buffer zone, and at least one additional aerial survey of the buffer and safety zones shows that no other right whales are present.

6. If listed marine mammals, excluding northern right whales, are detected within the buffer zone and subsequently cannot be detected either visually or acoustically, sighting and

acoustic teams would search the area for 2 1/2 hours (approximately 3 times the typical large whale dive duration) before assuming the animal had left the buffer zone.

7. If, during post-detonation monitoring, any (including uninjured animals) sea turtles or marine mammals azre observed in the safety area immediately after the detonation, then the Navy must review its pre-detonation monitoring procedures with NMFS prior to the next detonation.

In order to minimize impacts to endangered marine mammals, the Navy should implement all mitigation, monitoring and reporting requirements outlined in the final rule to authorize the taking of a small number of marine mammals incidental to the underwater detonation of conventional explosives in the waters off Mayport FL (50 CFR 216.161 through 216.166), in compliance with section 101(a)(5) of the MMPA. Additional requirements may also be specified in a Letter of Authorization issued under these regulations.

APPENDIX H

COMMENTS AND RESPONSES

This appendix presents and addresses public comments on the Draft Environmental Impact Statement (DEIS). Comment sets are assigned letters from A to Z. Within each set, comments are assigned a unique identifying number (for example, A1, A2, etc. in the first set). Each set of comments is followed by the corresponding Navy responses. The public hearing comments (sets A, B, and C) are excerpted from full transcripts of each hearing.

CONTENTS

Table H-1. Summary of changes to the SEAWOLF EIS in response to public comments. Comment numbers refer to specific sets of comments in Appendix H.

DEIS Section	Source and Comment Number	Change(s)
Executive Summary	Cavanagh/Young (Q1)	Comment: Should cite incidental take request Response: Cited it
	West (V1)	Comment: Better define mitigation Response: Defined where term first occurs
Section 1 Introduction	Cavanagh/Young (Q1)	Comment: Should cite incidental take request Response: Cited it
Section 2 Alternatives	Marine Mammal Commission (H3)	Comment: Change Table 2-5 and text to state that effects on marine mammal species and population stocks would be negligible Response: Changed as suggested
	Florida Dept. Environmental Protection (I6)	Comment: Address the alternative of winter testing at Norfolk Response: Added text clarifying operational requirements; winter testing is not analyzed in detail (does not meet operational requirements)
	Georgia Dept. Natural Resources (J1)	Comment: Search SEAMAP data base, exclude potential hard bottom points Response: Search was done; potential hard bottom points near Norfolk area were excluded; none found near Mayport area
	West (V1)	Comment: Better define mitigation Response: Defined where term first occurs
Section 3 Existing Environment	Marine Mammal Commission (H4)	Comment: Show variability in means and confidence intervals for mammal density Response: Added information to Appendix B
	Marine Mammal Commission (H6)	Comment: Search stranding database, discuss stranding data in relation to species list Response: Added information
	Florida Dept. Environmental Protection (I4)	Comment: Add information on right whales Response: Added information
	Georgia Dept. Natural Resources (J2)	Comment: Deepwater grouper spawning aggregations may be affected. Recommend conducting pre-detonation bottom surveys Response: Deepwater grouper spawning aggregations are unlikely to be affected; added discussion of this issue
	Humane Society (P18)	Comment: Coastal and offshore bottlenose dolphins are not a single stock Response: Added discussion of this issue
	Humane Society (P19)	Comment: Several species of marine mammals are "strategic stocks" Response: Changed to indicate which species are strategic stocks

Table H-1. (Continued).

DEIS Section	Source and Comment Number	Change(s)
Section 4 Environmental Consequences	Marine Mammal Commission (H1, H9) Cavanagh/Young (Q5, Q9)	Comment: Explain rationale for concluding that short-term effects on behavior have negligible effects on survival and productivity and do not constitute harassment. Clarify relationship between acoustic criterion and harassment Response: Information added
	Marine Mammal Commission (H2, H7)	Comment: Qualify statements regarding success of JOHN PAUL JONES shock trial (assumes all deaths and injuries detected) Response: Changed as suggested
	Marine Mammal Commission (H4)	Comment: Using mean densities of marine mammals could underestimate risks Response: Added information here and to Appendix B; adjusted mean densities exceed upper 95% confidence limit of observed data
	Marine Mammal Commission (H8)	Comment: Explain why clumped distribution means site would likely have zero animals Response: Information added
	Georgia Dept. Natural Resources (J2)	Comment: Deepwater grouper spawning aggregations may be affected Response: Information added
	Cetacean Society (N5), Humane Society (P12)	Comment: Provide reference (re 1 µPa) and frequency range for dB levels Response: Information added
	National Marine Fisheries Service (NMFS-2a,b), Humane Society (P12), Cavanagh/Young (Q7, Q17)	Comment: Discuss characteristics of the sound source. Compare acoustic harassment criterion with previous criteria (e.g., 160 dB) Response: Information added
Section 5 Mitigation and Monitoring	Florida Dept. Environmental Protection (I8), Georgia Dept. Natural Resources (J4) Barco/Swingle (Y4) Related: Stoll (C4), Sheen (C9), Humane Society (P11)	Comment: Mitigation plan does not adequately protect juvenile and hatchling turtles; removing turtles from sargassum is not feasible; recommend selecting area devoid of sargassum and postponing detonation if large sargassum rafts present in Safety Range Response: Agreed to avoid sargassum-rich areas during test site selection to the extent possible and postpone detonation if large sargassum rafts present within Safety Range
	Marine Mammal Commission (H10)	Comment: Minimum acceptable visibility of 1 nmi is insufficient for mitigation Response: Corrected error (should be 3 nmi)
	Marine Mammal Commission (H11)	Comment: State observer qualifications and explain how they will determine how far marine mammals are from detonation point Response: Information added

Table H-1. (Continued).

DEIS Section	Source and Comment Number	Change(s)
Section 5 (continued)	Marine Mammal Commission (H12, H14), Cetacean Society (N7)	Comment: Support contention that killed or injured animals could be found within 48 hr post-detonation. Also, state that all dead animals would be recovered and necropsied Response: Information added
	Marine Mammal Commission (H13)	Comment: List qualifications of veterinarian Response: Information added
	National Marine Fisheries Service (NMFS-3)	Comment: Mitigation would not be effective at Beaufort 4; recommend Beaufort 3 or less Response: Refined weather criteria as specified in Biological Opinion. Also, reduced line spacing of aerial transects from 1 nmi to 0.25 nmi to improve coverage and changed aircraft to accommodate a third observer to increase mammal, turtle detection
	National Marine Fisheries Service (NMFS-4a)	Comment: Concerned about ability of observers to determine that mammal or turtle in Buffer Zone could not enter Safety Range prior to detonation; recommend postponement if mammal or turtle detected in Buffer Zone Response: Developed species-specific protocols for animals detected in Buffer Zone, including postponement for listed species as required by Biological Opinion
	National Marine Fisheries Service (NMFS-5)	Comment: Various recommendations regarding necropsy protocols and coordination with NMFS stranding network Response: Agreed; expanded description of plans to coordinate with stranding networks
	Cetacean Society (N7), Humane Society (P8,P9)	Comment: Conducting necropsies on stranded animals up to one month post-detonation is inadequate (delayed mortality could occur) Response: Necropsies would be conducted by stranding network personnel; Navy would fund analysis of necropsy samples by Armed Forces Institute of Pathology for one year after tests
	Georgia Dept. Natural Resources (J6)	Comment: Postpone detonation if jellyfish shoals (turtle indicator) present in Safety Range Response: Agreed
	Cetacean Society (N6) Cavanagh/Young (Q30, Q31)	Comment: Provide more info on MMATS and its effectiveness Response: Information added
	Barco/Swingle (Y2)	Comment: Define the postponement period Response: Information added
	Barco/Swingle (Y3)	Comment: Define the go/no-go decision process Response: Information added
Section 6 Cumulative Impacts	--	No changes

Table H-1. (Continued).

DEIS Section	Source and Comment Number	Change(s)
Section 7 Unavoidable Adverse Environmental Impacts	No comments	No changes
Sections 8, 9, 10	No comments	No changes
Section 11 Relationship with Federal, State, and Local Plans, Policies and Controls	Marine Mammal Commission (H15)	Comment: Add description of requirements of section 101(a)(5)(A) of MMPA Response: Information added
Section 12 List of Preparers	Cavanagh and Young (Q2, Q34, Q35)	Comment: Add contributors to List of Preparers Response: Information added
Section 13 Literature Cited	Marine Mammal Commission (H16)	Comment: Add subsection for personal communications and unpublished literature Response: Added subsection
Appendix A Distribution List	No comments	No changes (but list has been updated)
Appendix B Marine Mammals, Turtles, and Birds	Marine Mammal Commission (H5, H18)	Comment: Add supporting material (literature review) for detection probabilities Response: Information added
	Marine Mammal Commission (H17)	Comment: Add further details on survey dates, numbers of animals seen, etc. Response: Information added
Appendix C ESA Consultation	No comments	No changes (but moved consultation letters to Appendix G.1)
Appendix D Potential Impacts of Explosions on Marine Mammals and Turtles	Marine Mammal Commission (H19)	Comment: State that extrapolation from humans to marine mammals is estimate only (for injury calculations) Response: Information added
	National Marine Fisheries Service (NMFS-4)	Comment: Discuss implications of Kooyman (1973) data for lung volume/body mass ratio Response: Recalculated using higher ratio as indicated by the Kooyman data
	National Marine Fisheries Service (NMFS-4b)	Comment: Update first part of Appendix D with literature provided by NMFS Response: Information added
	Humane Society (P10)	Comment: Not enough data on sea turtles Response: Information added
	Humane Society (P14)	Reword text on onset of extensive lung injury vs. 1% mortality (commenter misunderstood)
	Cavanagh/Young (Q20)	Comment: What is peak pressure at ranges and bearings of interest for injury calculations? Response: Added information

Table H-1. (Continued).

DEIS Section	Source and Comment Number	Change(s)
Appendix E Criterion for Marine Mammal Acoustic Discomfort	Marine Mammal Commission (H23)	Comment: No source for info on Figure 4 Response: N/A (appendix rewritten, comment no longer applies)
	Cavanagh/Young (Q8)	Comment: Have validation studies been done? Response: Added validation references for REFMS model
	Cavanagh/Young (Q12)	Comment: What is reference for statement on page E-10 (baleen whale sounds)? Response: N/A (appendix rewritten, comment no longer applies)
	National Marine Fisheries Service (NMFS-2a,b), Humane Society (P12), Cavanagh/Young (Q7, Q17)	Comment: Not enough info presented on sound source characteristics Response: Added information (waveform, pressure-time history)
Appendix F Nuclear Safety	No comments	No changes
Appendix G Biological Assessment	No comments	Replaced with new Appendix G, Endangered Species Act Consultation. Old Appendix C becomes G.1 and NMFS Biological Opinion becomes G.2
Appendix H Comments & Responses	N/A	New appendix

Table H-2. Summary of proposed changes to SEAWOLF EIS that were rejected (based on responses to DEIS comments).

Section	Source and Comment Number	Proposed Change that was Rejected
Section 2 Alternatives	Florida Dept. Environmental Protection (I5)	Comment: Do not test in September at Mayport because right whales may be present Response: Possibility of right whales at Mayport in September is remote, and if present, they would almost certainly be detected by mitigation
	Florida Dept. Environmental Protection (I6)	Comment: Evaluate the alternative of winter testing at Norfolk Response: Not a reasonable alternative (does not meet operational requirements)
	Georgia Dept. Natural Resources (J3)	Comment: Do not test in April or May at Norfolk to avoid right whales Response: Right whales unlikely to be present (none were seen at Norfolk during April or May surveys); believed to migrate near the coast; if present, would almost certainly be detected by mitigation
	Georgia Dept. Natural Resources (J5)	Comment: Delay Mayport test until June 1 to avoid leatherback turtles migrating along the Georgia coast in April and May Response: Already stated no testing in April at Mayport; further delay not warranted because no leatherbacks were seen during April or May 1995 surveys and only 1 was seen during May 1997 survey
	Humane Society (P4, P11)	Comment: Test only between June-August to avoid right whales and turtles Response: Possibility of right whales at Mayport in May or September is remote, and if present, they almost certainly would be detected by mitigation; already stated no testing in April at Mayport, further delays for turtles not warranted based on 1995 or 1997 survey data
	Humane Society (P7)	Comment: Cease testing if any marine mammal, turtle, or protected bird is killed Response: Already stated that testing would be halted until procedures for subsequent detonations could be reviewed and changed if necessary; not reasonable to cease testing altogether
	Various (B5, B10, B11, B21, R4, S1, T1, W1)	Comment: Select the "no action" alternative Response: Does not meet purpose and need
	Virginia Beach Friends Meeting (U2)	Comment: Postpone testing and study marine mammal issues further Response: Additional data are always desirable; however, existing information is adequate to evaluate alternatives

Table H-2. (Continued).

Section	Source and Comment Number	Proposed Change that was Rejected
Section 4 Environmental Consequences	Cavanagh/Young (Q3, Q5, Q6, Q9, Q11, Q14, Q15, Q28, Q29)	Comment: For harassment criterion, should use precedent (160 dB or similar threshold) instead of "acoustic discomfort" Response: The 160 dB criterion is based on avoidance of repeated seismic pulses by migrating gray whales and is not appropriate for SEAWOLF shock testing, which involves a single pulse each week. Also, "acoustic discomfort" has been replaced in the FEIS by "acoustic harassment" based on temporary threshold shift (TTS). Information supporting the change is presented in Appendix E and Section 4
Section 5 Mitigation and Monitoring	Georgia Dept. Natural Resources (J2)	Comment: Conduct fish-finder survey to detect grouper spawning aggregations Response: Groupers occur primarily on hard bottom, but Mayport and Norfolk areas are soft bottom; no firm evidence that grouper spawning aggregations could be present; unlikely to be affected because they occur close to the bottom
	Cetacean Society (N2) Barco & Swingle (Y1)	Comment: Expand the Safety Range: Cetacean Society: 5 km (2.7 nmi) Barco & Swingle: 5 nmi with 2 nmi buffer Response: Safety Range is based on conservative analysis and is adequate
	Cetacean Society (N3), Humane Society (P22)	Comment: Use a "soft start" protocol Response: Not proven to work and would interfere with passive acoustic monitoring
	Cavanagh/Young (Q32)	Comment: Reduce MMATS and use several aircraft to monitor the entire acoustic harassment zone Response: Safety-of-flight requires use of single aircraft (learned from DDG 53 shock trial). MMATS is needed because it detects submerged marine mammals not visible from aircraft
Section 6 Cumulative Impacts	Humane Society (P13)	Comment: Add discussion of LFA sonar Response: LFA sonar not being used at Mayport and any future use is speculative; impacts (including cumulative) would be evaluated if it were used in future
	Humane Society (P13)	Comment: Add discussion of routine Mayport operations (gunnery exercises, etc.) Response: Impact discussion takes into account cumulative impacts by overestimating potential lethal and injurious takes

A

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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SHOCK TESTING THE SEAWOLF SUBMARINE:

Draft Environmental Impact Statement and proposed Rule for Incidental Take of Marine Mammals

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PUBLIC HEARING

* * * * *

Monday,

August 19, 1996

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The Public Hearing was held in Conference Room 1W611, at the National Oceanic and Atmospheric Administration, 1305 East-West Highway, Silver Spring, Maryland, at 10:00 a.m., Commander John Heffron, presiding.

PRESENT:

JOHN HEFFRON, CMDR	Department of the Navy
STEVE SCHULZE	Department of the Navy
WILL SLOGER	Department of the Navy
KEN HOLLINGSHEAD	National Marine Fisheries Service

Also Present:

Richard Hammer	Hearing Organizer
Naomi Rose	Humane Society

Thank you very much for coming today.

That concludes the hearing.

(Whereupon, at 10:29 a.m. a brief recess until 10:33 a.m.)

COMMANDER HEFFRON: If I could have you attention for a minute please. I need to repeat the statement I just made a second ago for the Court Reporter.

This hearing will actual continue throughout the day until 4:00 p.m. There will be a Court Reporter here to receive verbal statements and we will also have people here to receive written statements throughout the day until 4:00 p.m. So, the hearing will actually continue until that time.

Thank you.

(Whereupon, at 10:33 a.m. a brief recess until 10:35 a.m.)

MS. ROSE: I'm Naomi Rose with the Humane Society of the U.S. And I just want to leave a couple questions with the Navy here. We will be submitting comments at the September 17th deadline so these comments and questions will be repeated.

But, as far as I can tell, the decision to not test in April if you choose Mayport, and also the entire conclusion of the densities of sea turtles and marine mammals in both the areas that are under consideration were based on surveys that were done in 1995.

My question would be, since that's just one season's worth of data, it's quite possible, of course, the sea turtles and marine mammals at other times -- at other years would have been distributed differently. I guess I'm just -- the question is, isn't there a problem there with bias in just one year's worth of survey data?

A1

And, the second question is, I couldn't tell from the proposed rule -- this is for NMFS really. I couldn't tell from the proposed rule for the incidental take authorization what would happen if more than the proposed take of the limit, proposed take limit, was taken, or, if in fact, an endangered or threatened species under the ESA was taken and killed. It says that that's prohibited under the proposed rule but it doesn't say what would happen if

A2

it was violated. So, I would like to see that clarified in the final rule and that's just another question I have.

But again, we will be submitting comments on both the proposed rule and the DEIS, so those question swill be repeated in our written comments.

(Whereupon, at 10:57 a.m., the public hearing in the above-entitled matter was adjourned, to be completed at 4:00 p.m. this same day.)

Public Hearing, Silver Spring, Maryland

August 19, 1996

Navy Response to:
Naomi Rose, Humane Society of the United States

A1. The Navy conducted additional aerial surveys at the Mayport area from May through September 1997. The results have been incorporated in the impact calculations in the FEIS.

Additional surveys will be conducted prior to shock testing, as explained in the mitigation plan (see Section 5.0 of the FEIS). Site selection surveys would be used to select a specific test site with the lowest possible density of marine mammals and turtles. These would include coverage of the entire Mayport area (the preferred alternative). Pre-detonation monitoring would be used to ensure that detonation does not occur until there are no marine mammals or turtles detected within the safety range.

A2. This question pertains to the proposed rule rather than the EIS. According to the NMFS, if the number of individuals specified in the incidental take authorization is exceeded, or if an endangered or threatened species is killed, then the authorization could be temporarily suspended pending a review of the circumstances.

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINSTRATION

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NAVY SEAWOLF SUBMARINE SHOCK TESTING

+ + + + +

PUBLIC HEARING

+ + + + +

TUESDAY

AUGUST 20, 1996

+ + + + +

The Public Hearing was held in Lafayette Winona Middle School, 1702 Alsace Avenue, Norfolk, Virginia, at 7:00 p.m.

PRESENT:

JOHN HEFFRON, CMDR	Department of the Navy
STEVE SCHULZE	Department of the Navy
WILL SLOGER	Department of the Navy
KEN HOLLINGSHEAD	National Maring Fisheries Service

Come up here or you can speak from there.

MS. SNYDER: Can I speak from here?

MR. SCHULZE: Speak loud.

MS. SNYDER: Bear with me, because I had questions. What I was concerned about at the hearing, especially --

MR. SCHULZE: The court reporter can't hear you, so in order for me to --

COMMANDER HEFFRON: In order for us to be able to answer your questions and address your comments, we need to have a record of it. If you could speak loud enough for the --

MS. SNYDER: I'm sorry.

I'm concerned there's only one vet mentioned to take care of injured or dead animals. That would average out to about 14 injured mammals and turtles per each test, and there is no comment in the EIS specifying how many assistants. This handout today just referred to, well, the amendment, Section D, under the direction of a certified marine mammal veterinarian. (B1)

I was concerned about how the count was

taken in the DEIS in that the marine fisheries suggested it would figure out to the mammal count 500 altitude, turtle count, yet in 1995 aerial survey was done at 750 feet rather than what's also mentioned was compromise of 650 feet or I would think the Navy would do it at 500 feet to ensure and have a more conservative guesstimate of mammals and turtles. (B2)

Also in this handout today, if you -- page number 40379, the right-hand column, about half way down: "Except that the taking by series injury or mortality or species listed in paragraph (b) of this section that are also listed as threatened or endangered under section 17.11 of this title, is prohibited."

And according to DEIS statement -- according to table 4.8 in the DEIS statement, the loggerhead is threatened at 5.57 mortalities are expected. So I just don't get it. (B3) And I was just, you know, mostly concerned that the DEIS didn't address the disposition as clearly as -- of marine life and turtles as they did the disposition of the bomb itself. That's all. (B4)

COMMANDER HEFFRON: Okay. Just to maybe clarify a little bit: The intention of this hearing is to receive comments and to receive questions. We don't propose to answer all the questions here today. We do propose to take them and incorporate your answers into a final EIS.

So for this particular forum, the thing to do to get good answers to those questions, I think, is to be sure you get on the list for distribution of the final EIS when it's issued.

COMMANDER HEFFRON: Lloyd Lee Wilson.

MR. WILSON: I'm Lloyd Wilson, resident of Virginia Beach, Virginia.

Seems to me that this very carefully crafted testing plan and environmental impact study rests on a mistaken premise, and that premise is that there is some credible addition to national security that can be added by the SEAWOLF submarine.

I would suggest to you that there is, in fact, is no addition to national security to be achieved by the SEAWOLF. (B5) Therefore, I suggest to you that the no action alternative of environmental impact statement should, in fact, be done fully because no action is consistent with non-production of the SEAWOLF.

I would also suggest that there is a socioeconomic impact to testing in that funds used to create, produce and put into active use the SEAWOLF submarine, in fact, would otherwise be used to improve the health and welfare of the citizens of the United States. (B6)

Since no action is an alternative then the proposed small take and harassment takes are not the least impact to be made on the environment. And you have not chosen the correct action in your environmental study. (B7)

I would recommend that you approve the no action alternative to the environmental impact; no testing and no induction of the SEAWOLF submarine.

COMMANDER HEFFRON: Next is Peter Ward.

MR. WARD: I came here today under the misbelief that you were not required to do this by law, so since you are required to do this by law, I will amend my comments for not you gentlemen, but for the powers

that be, if you will.

I believe that all of the ships, the Trident submarines, destroyers, cruise -- all the ships created, created over time, have been tested thoroughly. I know you have not put Trident submarine and the men in that in danger. I believe it's time to rely on the data that's been used in the past. I mean, a submarine is built. I understand you're going to build more, but I believe you can draw upon the conclusions and the studies that you have from Trident submarines and all the other ships and including combat, which you mentioned earlier. (B8)

I also believe, frankly, that there's no such thing as an incidental take. Nothing incidental about it. No matter where you do it, marine mammals are going to die and suffer. (B9)

So, therefore, I think, basically, as the previous gentleman, it should be a no action situation. Rely on the data that you have from the past. Rely on engineering. It's 1996; I know you guys can do it without killing marine mammals. (B10)

COMMANDER HEFFRON: Pam Snyder.

MS. SNYDER: I'll begin by saying nothing terrifies me more than public speaking other than this whole concept.

This concern not only for marine mammals, but for our federal laws, it seems they are confident here that needs resolution. A law requires that you do this; one law requires marine mammals be protected. Something is very amiss and I -- I agree with Mr. Wilson that no action is the only action, it's a resolution that can be made here. (B11)

I have several other comments. I plowed through the DEIS. It doesn't mention whether the exclusionary will also exclude monitoring and forcing federal law of Marine Mammal Protection Act by the Coast Guard and the National Marine Fishery Service. I want to know about that. I don't want the Navy monitoring the Navy. A government is checks and balances. (B12)

You mentioned the right whales. I ask you, check and balance; the Navy's operations relative to lab test kills? I didn't even know test kills until very recently. Due to the recent report by the

IWF concerning the Navy's 500 pound bombs, testing, detonated for war games off Georgia and Florida, these bombs coincided with multiple right whale deaths which fall under not only Marine Mammal Protection Act but the Endangered Species Act. (B13)

This report also said that the Navy was then and there most uncooperative. The few right whales there were retrieved died of shock trauma. We're talking about 500-pound bombs here, shock and trauma. We're not talking about five 10,000 pound bombs. I also found the DEIS extremely lacking and I hope they will cover this area concerning acoustic damage. I'm not an oceanographer, although many could be called in, including Navy scientists. There are many mentioned in this very draft I have.

To pretty much quote the DEIS, there's no hearing safety data available for marine mammals, so human sheep data, and other animals, were used. I don't know if the people in America, the Navy, finds this just acceptable or convenient. Marine mammals, sheeps and humans are not a comparison -- at all comparable. Tooths whales and dolphins, primary for (B14) their very survival is hearing. The jaw bones to which they receive sound is so thin and hollow they are translucent. How can I find out this information that is a big fat thick if DEIS can't? Or didn't.

Bear with me a minute, I'm trying to put emotions aside and logic forward.

To quote Dr. William Kellogg, hearing a dolphin is so sensitive that every time Dr. William Kellogg would drop a teaspoon of water into a large ocean or pool, dolphin heard an echo and located the spot.

When it rained outdoors, the sound of the rain hitting the water tank was so painful the dolphins kept leaping out of the water to escape the sound. In the oceans, to be able to dive deep enough to avoid the pain -- there's about a three-mile radius that's going to be monitored. They can't dive deeper than 500 feet -- 495 feet in proposed water for the testing. I think a serious review needs to be made here. (B15)

Go ahead. Thank you. Thank you.

COMMANDER HEFFRON: Lisa Lange.

MS. LANGE: This is just a brief statement basically relating --

Lisa Lange; People for the Ethical Treatment of Animals, and we will be submitting written comments and we really hope you'll listen to what we have to say.

Additionally, experiences in the Persian Gulf War should have told you what you need to know if you were paying attention. Wasted taxpayer money is incredible on this experiment and this isn't wartime except for the wartime you're proposing on our oceans. (B16) Words like incidental -- incidental, negligible are words used to confuse the public. Trying to ease our concerns by saying only the smallest schools of fish will be affected does not make us breathe a sigh of relief because our concerns are with all sea animals. Frankly, it's insulting. The only acceptable kill is zero. (B17)

COMMANDER HEFFRON: Clark Lee Merriam.

MR. MERRIAM: I hope you can hear me from here.

My major concerns are the decisions about animals that are found dead after one blast. Decisions affecting how the test needs to be changed afterward come from biologists and preferably people not directly involved in the testing and the development of the submarine. I agree with the previous speakers that I'd like to see more independent decision-making involved. (B18)

COMMANDER HEFFRON: Susan Barco.

Terri A. Whanger.

MS. WHANGER: I have a brief statement. First I would like to admit that I don't know all of the specifics. I just found out about this tonight on the news, and the first comment I would like to make is if you're really interested on hearing what the public has to say, it would be really nice if your public affairs office at the Naval Base, the submarine public affairs office at the Naval Base, knows about it and can at least tell you the area where the middle school is, because I had no idea where this was located. I don't have children. So I didn't know where this hearing was located and I had to drive around and ask people until I found it. That was just (B19)

a basic comment.

The other thing is, briefly reading through this, it talks about permissible methods of taking mitigation. And it says that the U.S. Navy may incidentally, but not intentionally, take marine mammals by harassment, injury or mortality in the course of detonating these five -- are they torpedoes? Just shocks. Okay.

That seems kind of like garbled words to me because you say earlier that you know that there probably will be some marine deaths; there have been in the past or there is the potential of marine deaths.

So, incidental and intentional does not make much sense to me. If you know that it's going to happen, it's already intentional. It's no longer -- it seems no longer incidental to me, if you think this is going to happen. (B20)

COMMANDER HEFFRON: Is there anyone else who wishes to speak at this time?

Trace Reiman.

MS. REIMAN: Tracy Reiman for the People

for the Ethical Treatment of Animals. Just a brief statement. I remember a couple of years ago we were fighting the Navy on a similar action. The ship shock tests off the coast of California in the middle of a marine sanctuary. All I've learned tonight is that the Navy has gotten a little bit smarter. They've decided to try and find an area where they can at least attempt to tell people that not as many marine mammals or sea animals will be injured or killed. And that's what they will be, injured or killed. Not harassed. Not incidentally taken. They will be injured and they will be killed and it will be a great number of them.

(B21)

I realize that you want people to believe that that possibility exists in the world, that no marine mammals will be injured or killed, and no fish -- well, a small number of fish may be injured or killed. The fact of the matter is, whether it's one or it's 500, I recommend strongly that you take the no action alternative; it is the only way.

We've done ship shock tests I can't even tell you how many times throughout history. We have

(B22)

battles. We can look at tests that have already been performed.

Thank you.

COMMANDER HEFFRON: Is there anyone else who wishes to speak?

MR. POSEY: My name is Mike Posey, and I don't represent anybody. I'm not here for a group. I just wanted to say that perhaps there are other ways to do this besides blasting in the water. One way which I'm sure you heard before is using and creating miniatures with electronic sensitive devices and using a huge tank and checking on impact that way.

(B23)

I also wonder, of course, just as every citizen, about the need to check the submarines further. I suspect that the barracks at least were attacked because there is no way that people who are enemies of ours would ever attempt to -- they wouldn't have the resources to attack our fleet, which is no comparison anywhere until the world -- other fleets.

(B24)

The other thing was it's a question of trying to test for the future? Possible. I just -- well, that's the point, basically. I don't believe it's necessary. I think technology exists now to ride the same information without endangering mammals and fish. I suspect that we will learn, as we go along, of course, that we are part of a life system and a world of information. We know -- we probably do for survival. More so whether our submarines might be a danger.

COMMANDER HEFFRON: Is there anyone else who would like to speak?

If not, I'd like to thank you all for attending this public hearing. Your comments and questions are important to us. If you have any written comments to turn in, please turn those in to one of us before you leave. This really concludes our presentation. We'll have a court reporter here to receive any other verbal comments from anyone who shows up later, until 10 o'clock, and we'll also have someone here to collect statements until 10 o'clock, if anyone has a statement that they want to turn in at that time. If not, thank you.

(Whereupon, the hearing was concluded at 10 p.m.)

Public Hearing, Norfolk, Virginia

August 20, 1996

Navy Response to:
Tracy Snyder

B1. The mitigation plan was developed to prevent injuries to marine mammals, so a significant number of injured animals is not anticipated. If Mayport (the preferred alternative area) is chosen, the total number of mammals injured would be less than 5 marine mammals and 30 turtles, or an average of about 7 animals per detonation. Due to the assumptions which deliberately overestimate potential impacts, these are considered upper limits. Also, as explained in Section 4.0, "injury" means a non-lethal injury from which an animal would be expected to recover on its own. The Marine Animal Recovery Team (MART) would not attempt to capture marine mammals that appear to be slightly injured; such a capture might cause further trauma and injury to the animal and injury to MART members. Few, if any, animals are expected to require treatment.

The veterinarian would have ample assistance from (1) the turtle handling expert, who has an extensive background in turtle, mammal, and seabird physiology, (2) one of the marine mammal observers, who has several years of experience in assisting with necropsies and pathology analysis, and (3) a marine animal collection specialist.

B2. Several factors must be balanced in choosing a survey altitude. Most importantly, while lower altitudes may improve turtle sightings, they may also reduce detection of marine mammals that dive in response to low-flying aircraft.

All aerial surveys were conducted under the appropriate permits and authorizations or with specific permission from NMFS. The altitude was specified in these permits. According to the NMFS, standard altitudes for aerial surveys are 229 to 305 m (750 to 1,000 ft) for marine mammals and 152 m (500 ft) for sea turtles. The 1995 aerial surveys were flown at an altitude of 229 m (750 ft). The first four surveys were conducted under a provisional permit which specified an altitude of 229 m (750 ft). Although a permit to conduct the surveys at a compromise altitude of 198 m (650 ft) was received before the fifth survey (August 1995), the fifth and sixth surveys were flown at the original altitude so that the data would be consistent and comparable with the first four surveys. Similarly, 1997 surveys at Mayport were flown at the original altitude for consistency and comparability.

To develop conservative estimates of mammal and turtle abundance, counts from aerial surveys were multiplied by correction factors that accounted for undetected individuals, as explained in Appendix B. Observed turtle densities were multiplied by a factor of about 30, for example. This helps to correct for any underestimates that may have resulted from flying at the higher altitude.

During shock testing, aerial surveys and aerial monitoring would be flown at an altitude of 198 m (650 ft) to increase detection of turtles and marine mammals.

B3. This comment applies to the Proposed Rule rather than the EIS. However, to address the commenter's concern, an explanation is presented here.

The Marine Mammal Protection Act, under which the Proposed Rule was prepared, does not apply to sea turtles. All sea turtles which could occur at Mayport or Norfolk are protected under the Endangered Species Act (ESA), which does not specify zero mortality. Rather, the ESA specifies that the proposed action must not jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat. That issue has been evaluated by the NMFS in their Biological Opinion prepared in accordance with Section 7 of the ESA (see Appendix G).

B4. Section 3.2 of the EIS discusses marine life and Section 4.2.2 discusses impacts on marine life, including marine mammals and sea turtles. The information is presented in sufficient detail to evaluate potential impacts and to allow comparison of alternatives, which is the central purpose of the EIS.

Navy Response to:
Lloyd Lee Wilson

B5. Whether or not the SEAWOLF is needed for national security is not an issue for this EIS, the subject of which is shock testing the submarine. The need for shock testing the SEAWOLF is explained in Section 1.0. As explained in Section 2.1, the "no action" alternative is not a reasonable alternative because it would prevent the Navy from making the survivability assessment required by 10 USC 2366.

B6. The EIS evaluates potential impacts of the proposed action and reasonable alternatives that could meet the project purpose and need. A "no action" alternative is also evaluated as required by regulations implementing the National Environmental Policy Act. The EIS is not required to evaluate alternatives unrelated to the purposes of the action proposed by the Navy, such as the socioeconomic impacts of using Navy funding for other purposes.

B7. Neither the National Environmental Policy Act nor Executive Order 12114, under which the EIS was prepared, require that the alternative with the least impact on the environment be chosen. Shock testing at Mayport is the preferred alternative because it meets the purpose and need, satisfies operational requirements, and minimizes potential impacts, including potential take and harassment of marine mammals and turtles.

Navy Response to:
Peter Ward

B8. Data from previous shock tests and wartime experience have been incorporated into computer models which are used to help predict the survivability of SEAWOLF class submarines. However, this modeling is only one of three components of the SEAWOLF Live Fire Test & Evaluation program which together provide the data necessary to assess the SEAWOLF's survivability. The components are computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. As explained in Section 1.0, this project is needed because computer modeling and component testing on machines or in surrogates do not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366.

Shock testing the manned submarine at sea is the only way to evaluate the response of the entire ship, including the interaction of its systems and components. Although computer models and component testing are helpful, combat experience has demonstrated that they cannot predict the broad range of complex failure mechanisms which could occur inside sophisticated electronic components or complex mechanical systems.

B9. "Incidental take" is a regulatory term that refers to unintentional death, injury, or harassment of marine mammals. The Navy does not intend to harm marine mammals or turtles and has developed an extensive mitigation/monitoring program to avoid doing so during shock testing. However, recognizing that these animals could be affected, the Navy submitted an "incidental take" request to the National Marine Fisheries Service as required by the Marine Mammal Protection Act.

B10. The "no action" alternative does not meet the project purpose and need, as explained in Section 2.1. Also, see response B8.

Navy Response to:
Pam Snyder

B11. The two laws do not conflict because the Navy can shock test the SEAWOLF while complying with the Marine Mammal Protection Act (MMPA). Section 101(a)(5) of the MMPA allows, upon request, the incidental (but not intentional) taking of marine mammals if certain findings are made and regulations are issued. Permission may be granted by the NMFS if the taking will (1) have a negligible impact on the species or stock(s); and (2) not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. Regulations must be prescribed setting forth the permissible methods of taking and the requirements pertaining to the monitoring and reporting of such taking. The Navy has complied with the MMPA by submitting an incidental take request to the NMFS. Based on this application, the NMFS published a Proposed Rule on August 2, 1996 (61 FR 40377). The Proposed Rule specifies take limits as well as mitigation, monitoring, and reporting requirements for SEAWOLF shock testing. A Final Rule must be issued by the NMFS before shock testing can proceed.

The "no action" alternative does not meet the project purpose and need, as explained in Section 2.1. Also see response B8.

B12. NMFS scientists and other non-Navy people would be part of the mitigation team. Also, in order for shock testing to proceed, the NMFS would have to issue an incidental take authorization (Final Rule) specifying mitigation, monitoring, and reporting requirements which the Navy must meet. Finally, the NMFS was responsible for preparing the Biological Opinion which evaluated whether shock testing would be likely to jeopardize the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat (see Appendix G).

B13. The speaker is referring to right whale mortalities which occurred off Georgia and Florida during January and February 1996. None of these mortalities have been shown to be caused by Navy activities [S.H. Ridgway (ed.), Final Report of the Right Whale Necropsy Assessment Team, Technical Document 2934, October 1996]. In any case, these events are not relevant to the SEAWOLF shock testing because:

- Shock testing at Mayport would not occur during the winter calving season (November through March). The testing would occur during May through September, when right whales generally inhabit northern feeding grounds. The possibility of a right whale being present in the Mayport area during May through September is remote (see response I5).

- The Mayport shock testing area is well outside the right whale critical habitat. The distance between the Mayport area and the right whale critical habitat ranges from 76 to 115 km (41 to 62 nmi). Although there have been a few sightings outside the critical habitat, available information indicates that right whales prefer cool, coastal waters well inshore of the Gulf Stream (Kraus et al., 1993).

- Shock testing would be conducted with extensive mitigation efforts, including aerial and surface observers and passive acoustic monitoring to detect marine mammals, including right whales. Even if a right whale were present, it would almost certainly be detected during pre-detonation monitoring (see response I5).

B14. A recent comprehensive review of Marine Mammals and Noise (Richardson et al., 1995) indicated there were no hearing safety data for marine mammals. In the absence of such information, the DEIS used the best available data, which are from humans and other terrestrial mammals. Assumptions used to apply these results to marine mammals are described fully in Appendices D and E.

Since the DEIS was issued, new hearing safety data have become available from experiments with bottlenose dolphins. These data, the first for any marine mammal, are explained in Appendix E and have been incorporated into the impact calculations in the FEIS.

B15. A serious review of potential impacts to marine mammals has already been made in the EIS (Section 4.2.2.3, Appendix D, and Appendix E). It is correct to state that, if a marine mammal is present within the safety range at the time of detonation, it cannot dive to avoid impacts. Hence, pre-detonation monitoring to ensure that no marine mammals or turtles are present is critical (see Section 5.0). The Navy's goal is to shock test the SEAWOLF without harming any marine mammals or turtles.

The EIS assumes that if any marine mammal is present within the mortality or injury range, it could be affected regardless of its depth in the water column. This assumption deliberately overestimates impacts because the most severe effects would be confined to the cavitation region extending from the surface to a depth of about 24 m (80 ft) (see Figure 4-1). Because the shock wave would pass in a fraction of a second, however, diving to avoid the effects is not possible. However, beyond a range of about 1.85 km (1 nmi), injury is unlikely regardless of the animal's depth. The safety range of 3.7 km (2 nmi) and the buffer zone of 1.85 km (1 nmi) provide additional protection and make it very unlikely that any marine mammal or turtle would be killed or injured.

Navy Response to:
Lisa Lange

B16. See response B8.

B17. Regarding the term "incidental take" see response B9. Neither the National Environmental Policy Act nor Executive Order 12114, under which the EIS was prepared, require that the alternative with the least impact on the environment be chosen, or that the "kill" be zero. Shock testing at Mayport is the preferred alternative because it meets the purpose and need, satisfies operational requirements, and minimizes potential impacts on marine mammals, turtles, and other sea life.

Navy Response to:
Clark Lee Merriam

B18. The proposed rule issued by the NMFS requires that the Navy report any dead or injured marine mammals from a detonation and consult with the NMFS about changing procedures before any further detonations occur. Also see response B12.

Navy Response to:
Terri A. Whanger

B19. Comment noted.

B20. See response B9.

Navy Response to:
Tracy Reiman

B21. Regarding "incidental take," see response B9. The "no action" alternative does not meet the project purpose and need, as explained in Section 2.1.

B22. See response B8.

Navy Response to:
Mike Posey

B23. The Navy has obtained as much information as possible from modeling and component and surrogate testing (see Section 1.0). This information does not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. There are no reasonable alternatives to shock testing the whole submarine. There is no tank or pond large enough to test the whole submarine.

B24. The need for shock testing is explained in Section 1.0. The Navy cannot assume that there would never be a threat to SEAWOLF class submarines.

C

PUBLIC HEARING

SHOCK TESTING THE SEAWOLF SUBMARINE: DRAFT ENVIRONMENTAL IMPACT STATEMENT AND PROPOSED RULE FOR INCIDENTAL TAKE OF MARINE MAMMALS

Mayport Middle School
Atlantic Beach, Florida

Wednesday,
August 21, 1996

NEAL R. GROSS
Court Reporters and Transcribers
1323 Rhode Island Avenue, NW
Washington, D.C. 20005
(202) 234-4433

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Draft EIS should be submitted to Mr. Will Sloger at the address on the slide. This information is also available on one of the handouts you were offered at the beginning of the hearing.

Again, please be sure your statement includes your name, affiliation, and address.

(Slide 19)

Written comments on the Proposed Rule can also be submitted up to September 17, 1996. Written comments should be submitted to the address shown on the slide. This information is also available in one of the handouts you were offered at the beginning of this hearing.

Ron Michaels. In order for the court reporter to get the information, we need you to speak into the microphone.

MR. MICHAELS: My name's Ron Michaels. I represent the Georgia Department of Natural Resources, Coastal Resources Division.

On July 30, 1996, our agency submitted our written comments in the form of a letter to Mr. Will Sloger and I'd like to read for the record the

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main body of this letter.

"Dear Mr. Sloger: Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement that evaluates environmental affects of shock testing the SEAWOLF off the east coast. Comments regarding marine mammals and turtles are being deferred to our agency's Wildlife Resources Division, Non Game Endangered Wildlife Program.

"On April 30, 1995, we responded to your request to identify significant issues that should be addressed in the DEIS. Based on our recent review of the Draft document, most of our marine fisheries concerns have been alleviated. There are however two areas of concern which remain. The first deals with the conclusion that no hard bottom areas exist along the 152 meter depth contour. In spite of limited survey data for this depth zone, we feel that hard bottom and other habitats which may occur in the test sites need to be better identified. One potential source of information is the regional data base developed by the Atlanta

C1

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Component to the Southeast Area Monitoring and Assessment Program. See Map South Atlantic.

"Our second concern is the inability of site surveys to locate subsurface aggregations of fish, especially groupers. Found over sand areas as well as rocky bottom, these highly overfished and stressed stocks cannot withstand further disruption if they are to recover under current management regimes. Being demersal but often occurring well up into the water column they will not be detected through visual observations on the surface but will likely be killed or injured by the detonations. It would be appropriate to get bottom surveys for the presence of hard bottom a few days prior to testing. Remote sensing equipment could be used to detect significant bottom aggregations or indications of hard bottom that should be further investigated."

Thank you.

COMMANDER HEFFRON: E. Kalakauskis.

MR. KALAKAUSKIS: My name's Ed Kalakauskis. I'm currently a member of the

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Jacksonville Offshore Sport Fishing Club, currently a community artificial reef builder in the community.

In 1986, we experienced one of our first detonations for artificial reefs off our coastline, which was on a 225-foot freighter, and at this time we utilized the DOD team out at Mayport to explode this vessel to sink it for an artificial reef. And as the first diver on-site in the water and the observation I had on that bottom of what the actual demolition did to that, I'm dead against any kind of explosions in this area because it was devastating to the fish population in that area at that time.

COMMANDER HEFFRON: Robert Stoll.

MR. STOLL: My name is Bob Stoll. I live in Ponte Vedra Beach. I'm a Florida Department of Environmental Protection Principal Sea Turtle permit holder for a portion of the beach in Ponte Vedra.

If this were a perfect world we wouldn't be here debating the merits of detonating five 10,000

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C3

pound charges of explosives to test the hull of a nuclear power attack submarine. And we wouldn't have to be concerned about what we're doing to our fellow creatures on this planet.

Unfortunately, this is not a perfect world. There are folks out there this very minute who are trying to figure out how to harm us. I have studied the Draft Environmental Impact Statement with particular attention to the possible affects on sea turtles. Under the circumstances, I'm convinced that the proposed measures to minimize harm to sea turtles are about as good as could be expected.

I have one area of concern, and that stems from a statement in the Executive Summary. The statement reads as follows: "Mitigation would be much less effective for sea turtles than for marine mammals because sea turtles are relatively small, do not swim in groups, are rarely on the surface, and do not make sounds."

Now, that statement may be true for adult sea turtles, but it clearly does not apply to the

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recent hatchlings. They do, in fact, congregate in the sargassum rafts that may well be present in the test area and they are on the surface, or very close to it, but they certainly cannot be detected by planes flying over during these preliminary surveys or after blast surveys.

I think that as far as mitigation for sea turtle goes, a great deal of emphasis must be placed on cleaning the hatchlings from the sargassum rafts in the test area during the months of July, August, and September if the tests are going to be conducted during those months. (C4)

Except for this reservation, I strongly support the shock testing off the coast of Mayport.

Thank you.

COMMANDER HEFFRON: Reverend Rene Robert.

REVEREND ROBERT: Hi. I'm with the Diocese of St. Augustine, Pax Christie. And my first question was: During this time of peace and where we're at right now it would appear to me that why do we need more nuclear weapons like the SEAWOLF submarine? We're asking other countries to (C5)

reduce nuclear weapons.

Secondly, I didn't see anything in the news. There may have been something in the Jacksonville newspaper or on the TV that, you know, this hearing was being held, but I think we need more publicity in this area to heighten awareness to other people that what's going to happen off our shores here. (C6)

Thirdly, are there any other options? I know we said -- you had talked about Norfolk, but any other way of testing the submarine without having to do the detonation and destroying life. (C7)

And then the other question is: Is there -- it appears to me after reading and listening to all this information, is there any other choice or has a choice already been made? Thank you. (C8)

COMMANDER HEFFRON: I'd just like to comment that as far as questions that come up, as the ones that just came up, they will be considered in the Final EIS. We won't be giving any answers to questions here during this presentation.

Is there anyone else who would like to make a comment?

Marie L.M. Sheen.

MS. SHEEN: Thank you. I haven't had much time to work on this because I was out of town, but I belong to the Amelia Island Turtle Watch Association and we are very concerned about this testing. We're also concerned about your data.

Amelia Island is small. It's about seven miles from one end to the other, and yet so far this year we've had 104 nests. A hundred and four nests and there is between 150 and 180 eggs in the nests. They haven't all hatched yet so far to date -- well, when the paper came out there was 3,280 hatchlings. Maybe 1,830 don't make it for some reason or other. There's still 2,000 hatchlings. So when you look at a turtle, it's not "a" turtle. It's 180 or 150 hatchlings per incubation. The turtles come ashore and lay their eggs. The one female has two or three nests. You're talking about a significant population. And this is in the time when the population of the loggerhead turtle and the ridleys turtle, the greenback turtles are

declining. And I don't want my grandchildren to say to their kids, "Well, there used to be these turtles, and they don't exist anymore."

"From the Florida beaches,"... National Geographic, February of '94: "From the Florida beaches the hatchlings swim about 25 miles in 30 hours to take shelter and feed in the sargassum." So they're going to be out there when you test. Even if you're 80 miles offshore they're still out there because they go out until they get to the Gulf Stream. (C9)

I still don't understand -- you can tell by the funny way I talk I'm from New England -- and I don't remember all this fog off of Groton, Connecticut. I really don't. I think, you know, there's a viable alternative up there. Eighty percent of all the loggerheads lay their nest from the mid Florida, north. (C10)

Something else that was just brought up during the environmental statement was about the right whales. I understand that one of the few carving areas for the right whale is right off of

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the northern end of Fernandino Beach where the St. Marys River comes into the Atlantic. I think that ought to be addressed. (C11)

I also would like to know where this NOAA and fisheries falls in as far as EPA approval. (C12)

I also would like to know, you mentioned Groton, no, you have Norfolk, Mayport. Certainly when you began you probably had 10 or 15 other sights. And I think we'd like to know what those sights were and why they were discarded. Thank you. (C13)

COMMANDER HEFFRON: Is there anyone else who would like to speak?

Veronica Pantling.

MRS. PANTLING: I'm Veronica Pantling, I represent me. It behooves the country to have state-of-the-art technology that is tried and tested. If SEAWOLF -- I'm getting nervous. If SEAWOLF is as state-of-the-art as they say, then she should be tried and tested before being put into service. (C14)

The wives and families need that security.

I'm a submariner's wife. That's why I'm getting choked up. And my husband's out to sea. And the loss of marine life is well worth looking out for those men's lives. Thank you. (C15)

COMMANDER HEFFRON: Is there anyone else who would like to speak?

(No response.)

COMMANDER HEFFRON: Okay. If not, I'd like to thank you all for attending this public hearing. Your comments are important to us and we would like to receive them.

We will have people here, the court reporter will be here to receive any other written comments or -- I'm sorry -- any other verbal comments if anyone comes in late. Also, we will receive written statements up until 10:00.

Please turn in your forms to us if you haven't done so. And thank you for coming.

(Whereupon, these proceedings were concluded at 7:42 o'clock p.m.)

* * * * *

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Public Hearing, Mayport, Florida

August 21, 1996

Navy Response to:
Ron Michaels, Georgia Department of Natural Resources

C1. Your comment is addressed in the response to the agency's formal comment letter. See response J1.

C2. Your comment is addressed in the response to the agency's formal comment letter. See response J2.

Navy Response to:
Ed Kalakauskis

C3. Without specific information on the location, water depth, and size of explosive used in this incident, the Navy cannot comment on whether any observed bottom effects were beyond those expected. Section 4.2.2.5 of the FEIS discusses potential effects on bottom dwelling organisms, including fish.

Navy Response to:
Robert Stoll

C4. Comment noted. The FEIS includes changes to the mitigation program (Section 5.0) designed to improve protection of sea turtles. These include tighter line spacing for aerial monitoring, addition of a third aerial observer, avoidance of sargassum-rich areas during test site selection (to the extent possible), and postponement of detonation if large sargassum rafts or jellyfish shoals are observed within the safety range. Also, it is important to note that animals at the surface (such as juvenile turtles in sargassum rafts) are unlikely to be affected unless they are very close to the detonation point (see Appendix D, Section D.6).

Navy Response to:
Rev. René Robert

C5. This is a policy question which is beyond the scope of the EIS. The need for shock testing is discussed in Section 1.0.

C6. Comment noted.

C7. As explained in Section 1.0, this project is needed because computer modeling and component testing on machines or in surrogates do not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. The entire manned submarine must be shock tested at sea.

C8. The purpose of the EIS is to present and evaluate the alternatives so that informed decisions can be made. The EIS identifies a preferred alternative (shock testing at the Mayport area) but also presents and evaluates other alternatives including "no action." No decision has been made at this stage. After the public review of the FEIS, the Navy will issue its Record of Decision (ROD) for publication in the *Federal Register*. The FEIS and ROD will be mailed to all commenters.

Navy Response to:
Marie L.M. Sheen

C9. See response C4.

C10. See Section 2.2.2.1 for discussion and analysis of the Navy's operational requirements and why Groton would be unacceptable. Fog occurs more frequently at Groton than at Mayport or Norfolk during summer months (see Table 2-2). In addition, there are no nearby Navy installations with the ships and aircraft required to support shock testing at Groton.

C11. The right whale critical habitat, which is the winter calving area, is shown on Figure B-1 of the FEIS. The shock testing area is 76 to 115 km (41 to 62 nmi) offshore from the critical habitat. More importantly, the possibility of a right whale being present in the Mayport area during May through September is remote, and even if one were present, it would almost certainly be detected during pre-detonation monitoring (see response I5).

C12. Under Section 309 of the Clean Air Act and Section 102(2)(C) of the National Environmental Policy Act, the EPA reviews and rates EISs but does not "approve" them. The EPA reviewed the SEAWOLF DEIS and rated it as EC-1, indicating that EPA has "a degree of environmental concern regarding the proposal, but the document contained sufficient information for reasoned decision-making." See comment D-1.

The NMFS is an agency within NOAA which has three roles in the project. First, the NMFS is responsible for preparing a Biological Opinion in accordance with Section 7 of the Endangered Species Act (see Appendix G). Second, the NMFS is responsible for issuing incidental take authorizations under the Marine Mammal Protection Act. The Navy has submitted a separate application to the NMFS for an incidental take authorization for this project. Third, the NMFS is a cooperating agency with the Navy in preparing the EIS.

The U.S. Fish and Wildlife Service (USFWS) also has responsibilities under Section 7 of the Endangered Species Act. Informal consultation letters are presented in Appendix G. No formal consultation with the USFWS is required because the USFWS has determined that there are no endangered or threatened species or critical habitats under its jurisdiction that could be adversely affected by the proposed action (i.e., the Navy and USFWS have already completed their responsibilities under the Endangered Species Act for species under USFWS jurisdiction).

C13. Section 2.2.2 discusses the Navy's operational requirements and the alternative areas that were considered.

Navy Response to:
Veronica Pantling

C14. Comment noted.

C15. Comment noted.

D

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

JUL 12 1996

Department of the Navy
Southern Division
Naval Facilities Engineering Command
Environmental Planning Branch
2155 Eagle Dr. P.O. Box ~~10068~~ 190010
Charleston, SC ~~29411~~ 29419-9010

Attention: Mr. L.M. Pitts

Subject: Draft Environmental Impact Statement (EIS) for Seawolf Ship Shock Test

Dear Sir:

Pursuant to Section 309 of the Clean Air Act and Section 102(2)(C) of the National Environmental Policy Act, EPA, Region 4 has reviewed the subject document which discusses the consequences of subjecting a recently constructed Seawolf submarine to explosive detonations of incrementally increasing intensity during the summer of 1997. Shock tests simulate near misses from underwater explosions similar to those encountered in combat. Genuine explosions are required to assess the survivability of the submarine since computer simulations are not currently adequate to provide sufficient information about actual equipment effects. A number of alternative sites were examined at which to conduct the test. The Mayport offshore contour appears to be the best compromise location based on the absence of marine sanctuaries, artificial reefs, hard bottoms, etc..

The analysis of the ramifications of this action together with the background information provided in the EIS appear adequate to determine the impacts of this proposal. We were pleased to note that the mitigation measures to protect marine mammals and turtles proved satisfactory in comparable situations in the Pacific. Similar techniques will be used in the Mayport test and appear competent to avoid any significant problems for targeted species. Post-monitoring results should be made available for review and analysis by involved state and federal agencies. This assessment is especially important in ascertaining both short- and long-term impacts to marine biota, especially since the Navy intends to conduct similar trails in the future for its New Attack Submarines. After deliberation, a rating of EC-1 was assigned, i.e., irrespective of the mitigation, we have a degree of environmental concern regarding the proposal, but the document contained sufficient information for reasoned decision-making pending the results of the test monitoring. (D1)

Thank you for the opportunity to comment. If we can be of further assistance in this matter, Dr. Gerald Miller (404-347-3776) will serve as initial point of contact.

Sincerely yours,

Heinz J. Mueller, Chief
Environmental Policy Section
Federal Activities Branch

U.S. Environmental Protection Agency, Region 4

Environmental Policy Section, Federal Activities Branch
Heinz J. Muller, Chief
Written Comment, July 12, 1996

Navy Response:

D1. Comment noted.

United States Department of the Interior

E

OFFICE OF THE SECRETARY
OFFICE OF ENVIRONMENTAL POLICY AND COMPLIANCE
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

August 12, 1996

ER-96/411

Mr. L. M. Pitts, Head,
Environmental Planning
Naval Facilities Engineering Command
U. S. Department of the Navy
2155 Eagle Drive
North Charleston, SC 29419-9010

ATTN: Mr. Will Sloger (Code 064WS)

Dear Mr. Pitts:

The Department of the Interior has reviewed the draft EIS for Shock Testing the Seawolf Submarine, as requested. We have no comments to offer on this document. (E1)

Thank you for the opportunity to review the draft EIS.

Sincerely,

James H. Lee
Regional Environmental Officer

CC: OEPC, WASO
FWS-ES, Atlanta

Department of the Interior

Office of the Secretary, Office of Environmental Policy and Compliance
Written Comment, August 12, 1996

Navy Response:

E1. Comment noted.

F

(no comments assigned to this letter)

G

(no comments assigned to this letter)

H

MARINE MAMMAL COMMISSION
1825 CONNECTICUT AVENUE, N.W. #512
WASHINGTON, DC 20009

12 August 1996

Mr. William Sloger
Code 06 4WS
Department of the Navy
Southern Division Naval Facilities
Engineering Command
2155 Eagle Drive
North Charleston, SC 29406

Dear Mr. Sloger:

The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the Department of the Navy's June 1996 "Draft Environmental Impact Statement (DEIS) [for] Shock Testing the SEAWOLF Submarine." We offer the following comments on the assessment of the possible impacts of the proposed action on marine mammals, and on the measures planned to minimize and document the impacts.

The tests would be done either offshore Mayport, Florida, or offshore Norfolk, Virginia. They would involve a series of five 4,536 kg (10,000 lb) explosive charge detonations sometime between 1 April and 30 September 1997. Visual and acoustic surveys would be carried out before each test to ensure, insofar as possible, that no marine mammals are present in the area where they could be affected adversely by the tests. The area around the test site would be searched methodically for 48 hours following each test to determine, insofar as possible, whether any marine mammals were killed or injured. The area offshore Mayport, Florida, is the preferred location for the tests, principally because the number of marine mammals likely to be present there is estimated to be about eight times less than in the area offshore Norfolk, Virginia.

The DEIS provides a thorough and generally well-reasoned assessment of the possible impacts of the proposed shock-tests on marine mammals. It concludes that, given the measures that would be taken to minimize the number of marine mammals potentially at risk, the tests would have insignificant effects on marine mammals. It also concludes, as noted earlier, that the risk to marine mammals can be further reduced by doing the tests offshore Mayport, Florida, rather than Norfolk, Virginia, provided they are begun no earlier than 1 May 1997.

Given the planned mitigation measures, the Commission concurs that the shock tests are unlikely to have significant adverse effects on any marine mammal species or population stock. The Commission also concurs that the number of animals that might be affected could be reduced further by doing the tests offshore Mayport, Florida, rather

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than Norfolk, Virginia, provided the start of the tests is delayed until 1 May. However, some of the assumptions and methods used to estimate how and how many marine mammals might be affected by the tests are not described in the DEIS in sufficient detail to fully judge their validity.

Below we note the uncertainties and how the impact statement might be strengthened.

Specific Comments

Page ES-10, par. 1: Here and elsewhere, the DEIS indicates that (1) marine mammals may be killed or injured if they are present near the detonation point and are not detected during pre-test monitoring; (2) animals at greater distances may experience temporary acoustic discomfort; and (3) behavioral responses and possible indirect impacts are discussed but are not considered significant. Possible behavioral responses are noted on pages 4-25 and 4-26 of the DEIS. The second paragraph on page 4-26 states that -- (H1)

> "It is reasonable to conclude that sounds produced by each detonation...could startle marine mammals or result in avoidance or other subtle behavioral changes at distances beyond the acoustic discomfort range.... However each detonation would be a single momentary disturbance. Because the five detonations would occur at about one-week intervals, it is very unlikely that any individual animal would hear more than one detonation. Therefore, no lasting impact on movements, migration patterns, breathing, nursing, breeding, feeding, or other normal behaviors would be expected."

The Commission concurs that the tests are unlikely to have lasting impacts on any biologically important behavior. Further, the Commission believes it unlikely that any short-term behavioral changes would negatively affect survival or productivity. However, the DEIS provides limited support for these conclusions. Further, the DEIS does not clearly explain the basis for concluding that, because there likely will be no lasting impact on any biologically important behavior, there will be no taking by harassment (disruption of behavioral patterns) as defined in section 3(18)(A)(ii) of the Marine Mammal Protection Act.

The Commission believes the Final Environmental Impact Statement (FEIS) could be strengthened by explaining more clearly the rationale for these conclusions. The Commission also believes it would be desirable to explicitly state and explain the rationale for the implied conclusion that any short-term effects on behavior are likely to have negligible effects on survival and productivity.

Page ES-11, par. 2: Here and elsewhere the DEIS indicates that the 1994 shock-tests of the USS JOHN PAUL JONES "resulted in no deaths or injuries of marine mammals." The statement implies that the post-detonation monitoring was capable of detecting all mortalities and injuries possibly caused by the shock-tests. The implication is not supported by information provided in the DEIS. The FEIS should provide an assessment of the likelihood that animals killed or injured as a consequence of the SEAWOLF shock-tests will be detected by the planned post-detonation monitoring. Among other things, the assessment should indicate the likelihood that dead animals will float to or will remain at the surface where they can be detected during the planned 48 hours post-detonation monitoring program. H2

Pages 2-19 and 2-20, Table 2-5: On page 2-19, the table references section 4.1.2 of the DEIS which concludes that there will be "no significant direct or indirect impacts on marine biota, including...marine mammals...." On page 2-20, the table references section 4.2.2.3 of the DEIS which concludes that, at distances beyond the calculated safety range "animals may experience brief acoustic discomfort, with no lasting effects expected." For the reasons noted earlier, the referenced sections of both the table and the text should be revised to also indicate that no non-negligible effects on marine mammal species or population stocks are expected. H3

Page 2-22, Table 2-6: The estimates of the numbers of marine mammals that possibly could be killed or injured incidental to the proposed shock-trials are based on (1) the average densities of the various marine mammal species observed during the six sets of aerial surveys conducted in 1995; and (2) assessments of the probability of detecting various species and size groups of marine mammals during the 1995 aerial surveys and during the planned pre-detonation mitigation surveys. The DEIS does not indicate the level of variability or the degree of confidence in the density estimates. If the variance is great, using the averages of the observed densities to estimate the numbers of animals that potentially could be killed or injured very well could underestimate the risks. The reason for this is explained in the enclosed paper by Barbara L. Taylor entitled *"Best" abundance estimates and best management: why they are not the same.* The FEIS should indicate the confidence intervals around the density estimates and, if the intervals are great, provide an assessment of the maximum number of the different marine mammal species that might be killed or injured. H4

In this same context, the data and assumptions used to estimate the probability of sighting different species and size groups of marine mammals are not described fully, either here or in Appendix B. In some cases, the choices of input values appear to be arbitrary and to be based on intuition, rather than on empirical data or clearly stated and well-supported assumptions. H5

For example, it is not possible, from the information provided in Appendix B, to judge the validity of the determination that all species have a probability of either 0.1 or 0.2 for being at the surface where they can be seen.

If the actual probability of detecting any species is less than estimated, both the estimate of the expected effectiveness of the planned mitigation program and the estimates of the numbers of animals that could be killed or injured could be biased. The FEIS therefore should provide a more thorough description and explanation of the rationale for the data, assumptions, and analyses used to determine the probability of detecting different species and different size-groups of marine mammals.

Pages 3-9 to 3-11 (Table 3-1): Among other things, this table includes indices of the historical presence of the various marine mammal species in the Mayport and Norfolk areas. It is not clear from the table or the related text whether marine mammal stranding data were used to help assess the historical presence in the two areas. Among other things, the stranding data may provide an indication of the seasonal presence and relative densities of some species in the Mayport and Norfolk areas. Comparison of the stranding and other historic data with the results of the 1995 aerial surveys might help to explain why so many of the species listed in Table 3-1 were not observed during the surveys. H6

In this regard, the enclosed paper by Wiley et al., published in 1995 in the *Fishery Bulletin*, provides data on 38 humpback whales that washed up dead on beaches in New Jersey, Delaware, Maryland, Virginia, North Carolina, Georgia, and Florida from 1985 through 1992. The majority of the strandings were in Virginia and North Carolina, supporting the conclusion that densities are greater in the Norfolk area than in the Mayport area. The data also suggest that humpback whales are more likely to be in the Norfolk area than in the Mayport area during the 1 April - 30 September period when the shock-tests would be conducted. They also suggest that humpback whales may occur more commonly in nearshore than in offshore waters or, alternatively, that fewer humpback whales were seen during the 1995 aerial surveys than might have been expected.

If the authors of the DEIS have not already done so, the Marine Mammal Commission recommends that they contact the following people to identify and obtain potentially useful stranding data --

James G. Mead, Ph.D.
Curator of Mammals
National Museum of Natural History
Rm. 39Q, MRC 108
10th and Constitution Avenue, NW
Washington, DC 20560
202/357-1920
202/357-1896 FAX

Daniel K. Odell, Ph.D.
Sea World
7007 Sea World Drive
Orlando, FL 32821
407/363-2662 (direct)
407/345-5397 FAX

Mr. Dean Wilkinson
Marine Resources Management Specialist
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Rm. 13340
Silver Spring, MD 20910
301/713-2322
301/713-0376 FAX

<u>Page 4-13, par. 1</u>: The beginning of this paragraph states that -- (H7)

"The actual numbers of marine mammals that may be killed, injured, or experience acoustic discomfort as a result of the SEAWOLF shock testing cannot be known in advance. Previous experience during the shock trial of the USS JOHN PAUL JONES, which involved detonation of two 4,536 kg (10,000 lb) charges, showed there were no marine mammal deaths or injuries despite marine mammal densities that were significantly higher than those observed at either Mayport or Norfolk...."

As noted earlier, it is not clear whether the monitoring done following the shock trial of the USS JOHN PAUL JONES could have detected all marine mammal mortalities or injuries possibly caused by the trial. Further, if the planned mitigation program is effective, there should be few, if any, marine mammal mortalities or injuries caused by the planned SEAWOLF shock-tests. Thus, these two sentences might be more accurate if they were revised to read something like --

"The actual number of marine mammals that may be killed, injured, or experience acoustic discomfort as a result of the SEAWOLF shock testing cannot be predicted with certainty. The results of the previous shock tests of the USS JOHN PAUL JONES, which involved

detonation of two 4,536 kg (10,000 lb.) charges, indicate that the measures taken to avoid marine mammal mortalities and injuries were effective despite marine mammal densities significantly higher than those observed in the areas offshore Mayport and Norfolk."

<u>Page 4-15, first complete paragraph</u>: Among other things, this paragraph indicates that -- (H8)

"...it was assumed that the mean density for a whole area (Mayport or Norfolk) can be used to predict the expected number of animals that would occur within a small test site. This assumption overestimates impacts, because the abundance of marine mammals is patchy within both areas...."

There is no explanation of why it is believed that the patchy distribution of marine mammal sightings would lead to overestimation of the numbers of marine mammals that might be killed, injured, or harassed. If marine mammal distribution is highly variable and mean densities are used as the basis for estimating the numbers of animals at risk, the likelihoods of underestimating and overestimating the numbers of animals at risk would be similar. If the distribution is patchy (as is indicated) and only a small portion of the ranges of the various species have been surveyed (as appears to be the case here), there would be a greater likelihood of underestimating than overestimating the number of animals that could be affected. Thus, the FEIS should provide a more thorough and critical examination of the data and methods used to estimate the numbers of the various marine mammal species that possibly could be killed, injured, or harassed.

<u>Page 4-24, par. 2</u>: This paragraph references and quotes the Marine Mammal Protection Act's definitions of Level A and Level B harassment. It states that "[t]he number of marine mammals potentially experiencing acoustic discomfort is an overestimate of Level B harassment." The veracity of this statement is not clear. (H9)

As noted in the DEIS, the Marine Mammal Protection Act defines Level B harassment as any act that "has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavior patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." The DEIS does not provide a convincing rationale for concluding that the planned shock-tests will not "cause disruption of behavioral patterns" beyond the distances at which acoustic discomfort may occur. As noted earlier, the Commission believes that the FEIS could be strengthened by (1) including a more thorough assessment of the possible short-term effects of the shock-tests on the vital behaviors of marine mammals, and (2) explaining more clearly the rationale for the implied but unstated conclusion that any short-term effects on behavior are likely to have negligible effects on survival and productivity.

<u>Page 5-3, par. 4</u>: The last sentence in this paragraph states that "[a] minimum ceiling of 305 m (1,000 ft) and 1.85 km (1 nmi) visibility must be available to support mitigation and safety-of-flight concerns." Elsewhere, the DEIS indicates that shock-tests would be postponed if marine mammals were detected, visually or acoustically within 2.05 nmi of the detonation point. Shipboard observers would be unable to view all of the designated "safety area" and buffer zone around it if visibility is no more than 1 nmi. Thus, the minimum visibility criterion presumably should be increased to ensure that all of the safety area and buffer zone can be searched by tne shipboard observers before charges are detonated. (H10)

<u>Page 5-6 (Shipboard Monitoring Teams)</u>: The effectiveness of the Marine Mammal Mitigation Program will depend, among other things, on the experience of the observers and their ability to determine when marine mammals are within the designated 2.05 nmi safety range and the adjacent 0.95 nmi buffer zone. To provide a better basis for judging the likely effectiveness of the program, the FEIS should (1) identify the minimum qualifications of the observers; and (2) explain how they will determine how far observed marine mammals are from the detonation point. (H11)

<u>Page 5-6, par. 4</u>: This paragraph indicates that the Marine Animal Recovery Teams (MART) would remain on station for a period of 48 hours after each detonation to look for marine mammals that may have been killed or injured. It states that "[d]epending upon their size, any injured or dead animals would be retrieved in an attempt to determine the cause of injury or death." A determination presumably has been made that any marine mammals that are killed or injured could be found within 48 hours. The basis for this determination is not, but should be, explained. (H12)

In this same context, it is not clear what is meant by the statement that "[d]epending upon their size, any injured or dead animals would be retrieved in an attempt to determine the cause of injury or death." The Commission believes that all dead animals found near the test site should be recovered and necropsied to determine the cause of death. If animals are too large to be brought aboard the recovery vessel, arrangements should be made to have them towed to the nearest place where detailed necropsies can be done. Likewise, every effort should be made to ensure that seriously injured animals are recovered and rehabilitated or, if the MART veterinarian judges injured animals are suffering and likely to die, that they are euthanized using appropriate means.

<u>Pages 5-9 and 5-13</u>: The sentence beginning at the bottom of page 5-9 and ending at the top of page 5-13 indicates that "[a] veterinarian would coordinate the tagging and retrieval of any dead or injured animals discovered during aerial or shipboard pre-denotation monitoring." Presumably, the veterinarian would also be responsible for retrieving and conducting or supervising the gross necropsy of dead animals and the clinical examination of injured animals found during post-detonation monitoring. Likewise he or she presumably would be responsible for identifying and for collecting and providing parts from dead animals to appropriate experts for more detailed analyses. To successfully fulfill these responsibilities, the veterinarian(s) must be experienced in cetacean anatomy, physiology, necropsies and medicine. Therefore, the FEIS should either name or indicate the basic qualifications for the veterinarian(s) who will be responsible for these tasks. (H13)

<u>Page 5-21 (Communications with Marine Mammal Stranding Network(s))</u>: For the reasons noted earlier, it would be useful, if it has not already been done, to obtain from the Stranding Network(s) data on marine mammals that have stranded along the coast inshore of the possible Norfolk and Mayport test locations. Among other things, the data may provide additional insight into the marine mammal species most likely to be present in and near the two locations between the 1st of April and 30th of September. Also, the Commission believes, as noted earlier, that arrangements should be made beforehand to recover and necropsy all marine mammals possibly killed incidental to the shock-tests. (H14)

<u>Page 11-2 (Marine Mammal Protection Act)</u>: This section indicates that "...the Navy will be submitting a small take application to the NMFS." It does not describe the purposes or provisions of the Act governing "small-take" exemptions. Readers not familiar with the background and requirements of section 101(a)(5)(A) of the Act likely would find such a description helpful. (H15)

<u>Pages 13-1 through 13-15 (Literature Cited)</u>: A number of the citations in this section reference personal communications and unpublished documents, the sources of which are not identified -- <u>e.g.</u>, "Young, G.A. 1995b. Letter report prepared for Continental Shelf Associates, Inc." Readers have no way to assess information obtained through such communications. Therefore, they are unable to judge the merits of determinations based upon the information. (H16)

To minimize this problem, personal communications and other unpublished information sources should be listed and the contents summarized in a separate reference section.

<u>Page B-12, par. 4</u>: The first sentence in this paragraph indicates that six aerial surveys of the Mayport and Norfolk (H17)

areas were done between April and September 1995. It would be helpful to know precisely when each of the twelve surveys were done. It also would be helpful to know the species, numbers, and group sizes of marine mammals seen during each survey.

Page B-19, par. 2: This paragraph indicates that -- "[p]robabilities of [marine mammals] being on the surface (S_t) were estimated by reviewing literature on the dive times of cetaceans and by consulting with marine mammal experts"... and that "[a]ll of the values for individual species were either 0.1 or 0.2...." It is not evident how the values were calculated. It appears that they were chosen arbitrarily. This paragraph also indicates that the probability of detecting various species of marine mammals during aerial surveys was estimated by (1) scoring each species according to one of six length categories and one of five "herding" categories, and then (2) summing the scores to generate an Aerial Detection Probability (ADP) between 0.1 and 0.9. There is no description or discussion of the data or criteria used to place species into one of the five "herding" categories. Also, it appears that some of the length and herding scores were pooled, rather than summed, to provide the Aerial Detection Probability. As noted earlier, the FEIS should provide a more thorough description of, and justification for, the procedure used to estimate the aerial detection probability. H18

Also, it would be useful, as noted earlier, to provide an assessment of the probability of finding animals that have been killed or injured as a result of the shock-tests.

Pages D-10 to D-46 (Injury from Underwater Explosions): This section should indicate more clearly that the distances at which the different species and sizes of marine mammals may be killed or injured are estimates only and that extrapolation from data on humans and terrestrial mammals may not provide reliable estimates of the possible effects on marine mammals whose physiology has been shaped largely by their aquatic existence. H19

Page D-21: The first full sentence on this page states that "[t]he nominal calculated range for onset of slight lung hemorrhage for a 220-lb (100 kg) mammal from a 10,000 lb (4,536-kg) charge (the charge to be used in the shock test) yields a maximum slant range of 6,069 ft. (1,850 m) for the onset of slight lung hemorrhage." Although not stated, the statement implies a determination that no marine mammals weighing less than 100 kg are likely to be present where they could be affected by the tests. The basis for this implied determination should be indicated. H20

Pages D-54 through D-57 (Physical Discomfort/Tactile Perception): This section does not, but should, identify clearly the assumptions that were made to infer, from data generated by experiments with human volunteers, the maximum distances at which H21

different species and sizes of marine mammals are likely to experience physical discomfort and tactile perception of shock waves from a 10,000 lb charge. Likewise, it does not, but should, discuss the rationale for the assumptions and identify the possible "worst-case" scenario.

Page E-4, par. 6: This paragraph indicates that -- H22

"Some measurements were made on hooded divers exposed to underwater explosions. Unfortunately, these data could not be used because we have no information on the amount of attenuation provided by the hoods."

The referenced 1950 paper by Wright *et al*. appears to be the only source of information on the effects of actual underwater explosions, rather than pure tones, on human hearing. The attenuation of sound as it passes through different densities and thicknesses of neoprene presumably can be measured. Likewise, the range of densities and thicknesses of neoprene likely to have been available and used by the divers in the referenced experiment presumably could be determined. Therefore, it might be possible to make some reasonable assumptions about the amount of attenuation provided by the hoods and to use these experimental data to help assess the distances at which marine mammals may experience acoustic discomfort.

Page E-8 (Figure 4): This figure identifies the hearing thresholds, at different frequencies, for beluga whales, killer whales, and harbor porpoises. Neither the text nor the figure identify the source or sources of the data. Likewise, there is no indication of the number and ages of animals tested. Also, there appears to be no recognition that, because of the small sample size, the data shown in the figure may not provide a true indication of the hearing thresholds of the three species. H23

* * * * *

I hope that these comments and recommendations are helpful. If you or your staff have questions about any of them, please let us know.

Sincerely,

John R. Twiss, Jr
Executive Director

Enclosures

cc with enclosures: The Honorable Rolland A. Schmitten

NOAA Technical Memorandum NMFS

OCTOBER 1993

"BEST" ABUNDANCE ESTIMATES AND BEST MANAGEMENT: WHY THEY ARE NOT THE SAME

Barbara L. Taylor

NOAA-TM-NMFS-SWFSC-188

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

"BEST" ABUNDANCE ESTIMATES AND BEST MANAGEMENT: WHY THEY ARE NOT THE SAME

Barbara L. Taylor
National Research Council Associate
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, CA 92038-0271

Abstract

Two management strategies are compared, one which uses the mean (or "best") estimate of abundance (N_{MEAN}) and one which uses a minimum estimate of abundance (N_{MIN}). The strategies are compared (using simulations) in the context of proposed management regimes for marine mammals. The calculation of the number of animals which can be removed from the population (by incidental fishery mortality) uses an estimate of abundance. With use of N_{MEAN}, the less precise the abundance estimate, the less conservative the management of the population. With the precision common to many marine mammal population estimates, the use of N_{MEAN} clearly does not meet management objectives. Use of N_{MIN} manages more conservatively when precision is low. The N_{MIN} strategy is superior given management objectives. I conclude that choice of the minimum abundance level to be used would be aided by availability of quantitative management objectives.

Introduction

In "New principles for the conservation of wild and living resources", Holt and Talbot (1978) give the second principle as, "Management decisions should include a safety factor to allow for the facts that knowledge is limited and institutions are imperfect." Inclusion of uncertainty in management has been difficult due in part to the failure of scientists to adequately explain uncertainty to policy makers and managers.

The National Marine Fisheries Service (NMFS) proposal to govern interactions between marine mammals and commercial fisheries (NMFS 1992) exemplifies this problem. To incorporate uncertainty into management, the proposal uses a minimum abundance estimate as the basis for management decisions. The reason why a minimum rather than a mean (or "best") estimate is used has not been made clear to all parties concerned with marine mammal management. On the surface, using the best estimates of abundance for management purposes seems sound. This paper explains why using the mean estimate of abundance (N_{MEAN}, often referred to as the "best" estimate) counter-intuitively can result in poor management practices.

Why should management be concerned with uncertainty in abundance estimates? Consider the following cases: animals are incidentally killed in fishery interactions from two populations. Population A is well known, but considerable uncertainty exists about population B. How should management proceed in the short term when decisions must be based on best current information? Relatively good estimates may be made for the number of animals which could be killed by the fishery without depleting A. Difficulties arise, however, with population B. Let us assume that the best abundance estimates for both populations are about the same. Confidence in the estimates, however, differs greatly. Is the best management strategy to permit incidental kill based on the best estimate (N_{MEAN}) or to somehow incorporate the level of uncertainty concerning the populations into our management decision? Using N_{MIN} incorporates uncertainty. It embodies Holt and Talbot's (1978) statement: "The magnitude of the safety factor should be proportional to the magnitude of risk." To compare management strategies using N_{MEAN} and N_{MIN}, we must first understand what these terms mean.

Background

Abundance estimation. In order to understand the effect of mortality caused by fisheries on a population, we need to know the size of the population. No population of marine mammals can be counted in its entirety (a true census). Instead, the population is sampled and mathematical techniques are used to estimate the absolute abundance. The precision of abundance estimates depends not only on the effort made to make the estimate, but on properties inherent to the populations themselves. To understand the concepts of precision and bias, consider the analogy of archery (Figure 1, White et al. 1982). For the small remaining population of Hawaiian monk seals, nearly every individual is identified. Thus the estimate should be both precise and unbiased (Figure 1a). Seals and sea lions are photographed and counted during maximum abundance on land (breeding or moulting). Seasonal counts from animals on land are quite accurate (coefficients of variation in abundance (CVs) often < 10%). Because some unknown proportion of the population are at sea, the estimate would be precise but biased (Figure 1b). Estimates of the proportion at sea could be made to correct for the bias. Most whale and dolphin populations and some seal populations must be estimated with distance sampling techniques. Obtaining precise estimates is frequently difficult. A few examples will illustrate these difficulties.

The most common technique for abundance estimation is line-transect (Buckland et al. 1993). Observers on ships or planes traveling along survey lines record number of animals observed, species, and perpendicular distance (Figure 2). Not all animals are seen and observers have a better chance of seeing close than distant animals. Data are used to estimate the total number of animals. For a small population, few sightings will be made. If the survey were replicated, the resulting abundance estimate would be different (possibly substantially) due to many random factors. If you could repeat the survey many times, the distribution of resulting estimates would be relatively wide for rare species and would be narrow for common species. For vaquita, an endangered porpoise, Taylor and Gerrodette (1993) showed that the precision of the abundance estimate drops sharply with decreasing population size. Thus, one reason for poor precision is small population size.

A second reason for poor precision is that the species may be difficult to see. Consider again populations A and B. Assume A is blue whales and B is beaked whales. Blue whales are conspicuous. Not only are they large but blows can be seen for great distances. Thus, the probability of sighting does not decrease with distance until distance becomes quite large. Beaked whales surface quickly, often erratically, and have no conspicuous blow. Sighting probability decreases rapidly with distance. If numbers of these two species were equal, we would be able to estimate blue whales more accurately than beaked whales. Figure 3a shows

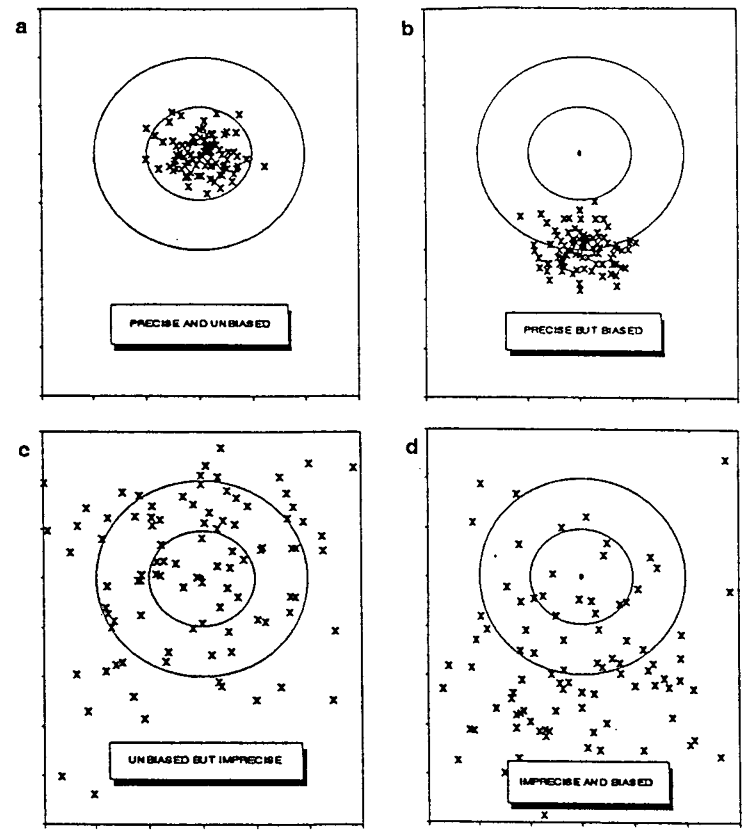

Figure 1. Archery targets demonstrating the meaning of precision and bias. Unlike the archer, an abundance estimate is like having one shot with no target to compare the shot to. Biologists must estimate the precision and bias of abundance estimates statistically.

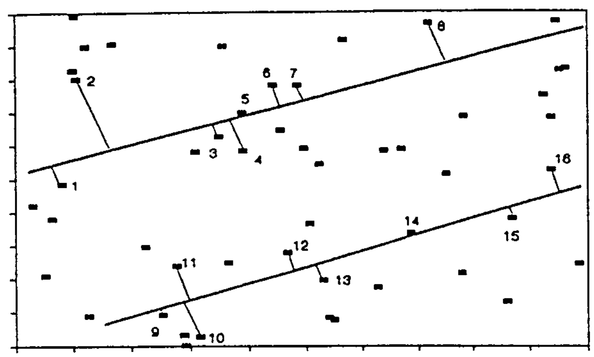

Figure 2. Schematic of a line-transect survey. Squares indicate animals (50). Sighted animals are indicated by numbers and are connected with perpendicular lines to the survey track-line (16). Total abundance in the area is estimated from the sighting data and would differ if the survey was conducted again.

two distributions which illustrate good precision (CV = 0.2) and poor precision (CV = 0.8). For the example, assume the true population size for A and B is 1,000 (the mean of the log-normal distributions of abundance estimates). For any single survey, there is a single best estimate of abundance (N_{MEAN}) which comes from the appropriate distribution with the probabilities shown. The "best" estimate tells us nothing about the confidence we have in our estimate. Best estimates for beaked whales will vary more than best estimates for blue whales. For blue whales, the estimated population would usually be between 600 and 1,600. For beaked whales estimates are less certain. There is a good chance of estimating abundance anywhere from 200 to 3,000.

After conducting a survey, we do not have the distributions shown in Figure 3b. Instead we have an abundance estimate (N_{MEAN}) and an estimate of the precision of our survey. For illustration, consider the case where both blue and beaked whales are estimated to number 1,200 with CVs of 0.2 and 0.8 respectively. Because N_{MEAN} is the same, both populations would be treated the same under the N_{MEAN} strategy. To incorporate uncertainty in our estimate into management, we need to focus on the tails of the distribution rather than on the measure of central tendency (the mean or best estimate) which is the same for both distributions. Take, for example, the abundance estimate for which 95% of all abundance estimates will be greater. For A, this value is 867 while for B it is 371 (Figure 3b). The mean or best estimate is the only point of similarity between these distributions. If we want to give importance to the difference

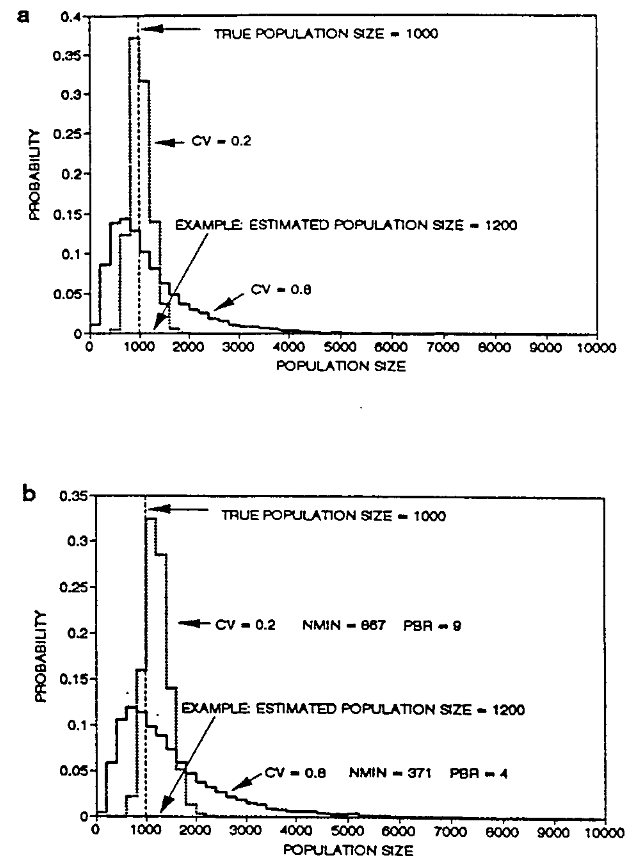

Figure 3. Probability distributions for abundance estimates where N(true population size) = 1,000 and distributions are assumed to be log-normal. "a" shows the distributions for the true population while "b" shows the distributions centered on an estimated abundance (N_{MEAN}) of 1,200.

in our degree of certainty, it behooves us to choose something other than the balance point (the mean). The actual percentage of the distribution chosen depends on our management objectives.

Line-transect abundance estimates can also be biased. It is usually assumed that all animals in the path of the ship (or plane) are seen. For animals which can dive for long periods, this assumption is false. If this problem goes uncorrected, the estimate would be too low (negatively biased). Animals which are attracted to or repelled from the ship will also bias abundance estimates. If abundance estimates are thought to be low and fisheries are being threatened with closure because incidental mortality is thought to be excessive, then there would be pressure to correct for potential bias. Although bias is an important problem, it is a problem for all management schemes based on population abundance. If there is bias, both N_{MEAN} and N_{MIN} will be biased. This paper contrasts incorporating uncertainty in precision into management decisions with not incorporating such uncertainty. The problem of bias should be dealt with as a scientific problem rather than enter directly into evaluation of a management scheme.

Management objectives. Management regimes can only be evaluated in the context of specific objectives. The Marine Mammal Commission (Robert Hofman, testimony to Senate Committee on Commerce, Science and Transportation, July 14, 1993) has defined objectives for marine mammal management: a) maintain the fullest possible range of management options for future generations, b) restore depleted species and populations of marine mammals to optimum sustainable level with no significant time delays, c) reduce incidental take to as near zero as practicable, and d) as possible, minimize hardships to commercial fisheries while achieving the previous objectives. These objectives are based on the recommendations of Holt and Talbot (1978).

To evaluate management, qualitative objectives must be converted to quantitative objectives. For example, "no significant time delays" was interpreted to mean time to recovery of a population with incidental mortality would not be > 10% longer than time without incidental mortality. The objectives also reveal that management must compromise between minimizing affects of fisheries on marine mammal populations and visa versa. Although it is easier to evaluate management strategies with quantitatively defined objectives, we can still compare and contrast management strategies in light of the qualitative objectives.

The management schemes. The NMFS-proposed regime is governed by the following equation:

$$PBR = N_{MIN} \, R_{MNPL} \, F_R \qquad (1)$$

where, PBR = potential biological removal,
N_{MIN} = minimum population estimate,
R_{MNPL} = population growth rate at MNPL, and
F_R = recovery factor.

N_{MIN} is defined as the minimum abundance estimate which is either the lower 95th percentile of an abundance probability distribution or an actual count. R_{MNPL} is either half the observed

highest growth rate or if unknown is a default value of 0.02 for cetaceans and 0.06 for pinnipeds. The recovery factor is 0.1 for endangered species, 0.5 for populations that are threatened, depleted, or of unknown status (most populations), and 1.0 for populations thought to be within OSP (Optimum Sustainable Population, N > 60% of carrying capacity). See Figure 3b for sample PBR values when population status is unknown. The N_{MEAN} strategy explored here employs the same equation with N_{MEAN} substituted for N_{MIN}. Use of N_{MEAN} rather than N_{MIN} is not merely a change of a number in Equation 1 but constitutes a very different management strategy because it does not incorporate uncertainty.

Methods

I use simulations to emulate the possible outcomes of management strategies on different population types. Worst case scenarios are used to reveal possible management model flaws. Description of the analysis is given in Appendix I.

Results and Discussion

Figures 4a-d contrast the N_{MIN} versus N_{MEAN} strategies for simulated populations with differing CVs. The case shown (robustness trial C2, Appendix 1) assumes (falsely) the population is always > 60% of carrying capacity. Results similar in flavor for the base case (no error assumed) and other types of errors are shown in Appendix 2. Strategies differ little when CVs are low, although time to recovery increases and N after 100 years decreases using N_{MEAN}. Results also differ little between low and high CVs using N_{MIN}. A higher CV results in shorter recovery time and higher N after 100 years. Thus, the population about which we are more uncertain is being managed more conservatively. Figure 4d contrasts sharply with the others and shows high variability, universally lower N after 100 years, and longer recovery times. This variability is due to the shape of the distribution shown in Figure 3a. Abundance estimates are often less than the true abundance, by as much as one third of the true abundance for CV = 0.8. In such cases PBRs would be low. Often, however, abundance estimates are alarmingly high. Estimates can be as much as four times higher than the true abundance for CV = 0.8. The probability of estimating a population > 1,500 (more than 50% larger than the true abundance) is 28% when CV = 0.8 compared to 2% when CV = 0.2 (Figure 3a). When the "best" estimate for abundance is high, PBRs will also be too high until abundance is next estimated. Detailed results are given in Appendix II.

Conclusion

Given the objective of preventing population declines while minimizing restrictions on fisheries, this modelling exercise has shown that including uncertainty in the management regime (the N_{MIN} strategy) is superior. Abundance estimation is difficult for many marine mammal species (Table 1). Management objectives are not met for species with high CVs using the N_{MEAN} strategy. If CVs could be reduced to low levels for all species, the N_{MIN} and N_{MEAN} strategies would be similar. Unfortunately, it is often difficult to reduce CVs. As population size decreases, CVs increase (Taylor and Gerrodette 1993). Therefore, threatened, endangered or depleted populations may be managed poorly using N_{MEAN}. Species which are difficult to sight (long dive times, surfacing with little splashing and no visible blow, etc.) may also suffer from chronically high CVs and thereby poor management using N_{MEAN}.

On the other hand, it may be argued that the critical value for N_{MIN} (the lower 95% of a two-tailed distribution) is too conservative and creates hardships on commercial fisheries. It should be noted that although using N_{MEAN} allows higher incidental kills, the year-to-year variability of PBRs will be high. Thus, using N_{MEAN} also contributes economic uncertainty for fisheries. Also, the probability of depleting a population is much higher using the N_{MEAN} strategy which can also adversely affect fisheries.

The choice of a critical value is a policy decision which should be based on the management objectives. If quantitative objectives were given, it is possible to solve for the value which maximizes the prioritized objectives. This was done in the Revised Management Plan (RMP) for commercial whaling management created for the International Whaling Commission (Donovan, 1989). The creation of a model to meet management objectives must consider the data available (past, present and future). Species managed by the RMP have historical catch data which allow a calculation of population status. Such data are not available for most marine mammals in United States' waters. Given less data, a model which requires less data to drive the management regime is appropriate. Although the models must differ, the principle of creating a model to meet performance standards based on quantitative management objectives remains sound. Performance of the NMFS-proposed regime could be improved by specifying quantitative objectives for each of the Marine Mammal Commission's qualitative objectives.

Acknowledgements

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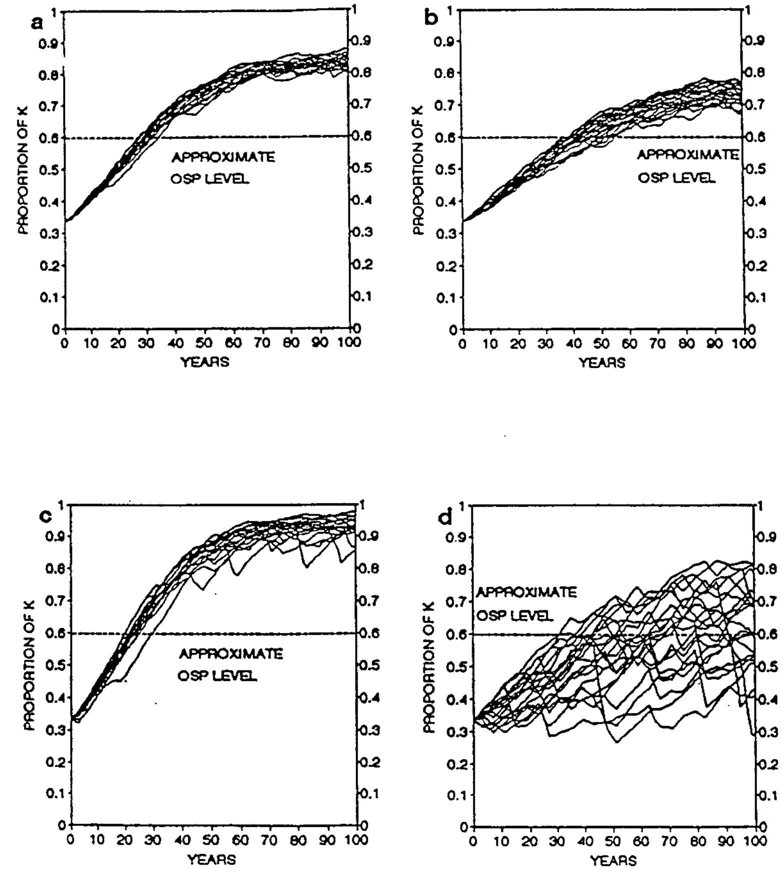

Figure 4. A sample of 30 simulations for base case 2 (initial population at one third of carrying capacity, CV = 0.2) for the N_{MIN} strategy (a) and N_{MEAN} strategy (b), and base case 4 (CV = 0.8) for the N_{MIN} strategy (c) and N_{MEAN} strategy (d). This example is for robustness trial C2 which assumes that the population is always at OSP. Hence, F_R = 1 in Equation 1. For other trials see Appendices I and II.

SPECIES	COEFFICIENT OF VARIATION (CVs)	SOURCE
short-beaked common dolphin	0.275	1
long-beaked common dolphin	0.706	1
striped dolphin	0.432	1
Pacific white-sided dolphin	0.557	1
northern right whale dolphin	0.41	2
bottlenose dolphin	0.472	1
harbor porpoise	0.31	3
Baird's beaked whales	1.004	1
mesoplodont beaked whales	0.924	1
Cuvier's beaked whales	0.864	1
pygmy sperm whales	0.813	1
Risso's dolphin	0.396	1
killer whales	1.207	1
humpback whale	0.409	1
blue whale	0.363	1
fin whale	0.591	1
minke whale	1.100	1
sperm whale	0.472	1

Table 1. Sample CVs for estimates of abundance in California. The lowest current CVs are given. Sources: 1 Barlow 1993, 2 Forney and Barlow 1993, 3 Barlow and Hanan.

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Appendix I. The Analysis.

To test the management schemes, I follow the structure used by the International Whaling Commission in testing the Revised Management Plan (Donovan 1989). Simulations are used to project the population sizes through time. The simulations can be subjected to different types of errors and the results examined in light of management goals. I will describe the models, the types of populations examined, and the types of errors tested. Statistics are saved from the simulations in order to evaluate model performance.

The underlying model is a θ-logistic model with maximum net productivity level at 0.6*K (Equation 2).

$$N_{t+1} = N_t + rN_t\left(1 - \left[\frac{N_t}{K}\right]^{\theta}\right) \qquad (2)$$

where N = population size,
t = time,
r = maximum growth rate (twice the value of R_{MNPL}),
K = carrying capacity (set at 10,000), and
θ = shaping parameter (set so MNPL/K = 0.6).

For each time step, the N_{MIN} strategy follows these steps:
1) N_{t+1} determined (Equation 2),
2) N_{MEAN} drawn from log-normal distribution with mean = N_{t+1}, CV as specified,
3) N_{MIN} calculated as the lower 95% of a 2-tailed log-normal distribution with mean = N_{MEAN}, CV as specified,
4) PBR calculated from Equation 1 (every 4 years),
5) kill drawn from a normal distribution with mean = PBR, and CV as specified, and
6) N_{t+1} adjusted by subtracting kill.

The N_{MEAN} strategy omits step 3 and uses N_{MEAN} in Equation 1 for step 4. Note that step 5 contributes to the worst case scenario strategy as it assumes that all PBRs are taken. The shape of the distribution is also unknown but could conceivably be skewed right. Such a skew would make the normal distribution a worse case. 1,000 replications are done of each base case/robustness trial.

Analysis of management schemes must consider different types of populations (different growth rates, initial population status, and with different abundance estimate CVs). These types are called base cases (Table 2). For each case, errors which could be made in model parameters are considered. Each error type is called a robustness trial (Table 3). For reference, I also include analysis of the base robustness trial (symbolized B) which includes no parameter errors. For simplicity I have chosen to only discuss cases which are 1) realistic for marine mammal management, and 2) highlight the difference between the N_{MEAN} and N_{MIN} strategies. Pinniped abundance CVs are usually low, so base cases 7 and 8 were considered unlikely.

BASE CASE	STARTING N	R_{MNPL}	SURVEY CV
1	K	0.02	0.2
2	**K/3**	**0.02**	**0.2**
3	K	0.02	0.8
4	**K/3**	**0.02**	**0.8**
5	K	0.06	0.2
6	K/3	0.06	0.2
7	K	0.06	0.8
8	K/3	0.06	0.8

Table 2. Base cases for management analysis. Cases referenced in Appendix II are given in bold type.

PROBLEM TYPE	SYMBOL	DESCRIPTION
DATA	D1	EST. N TWICE ACTUAL N
	D2	EST. ABUNDANCE CV 1/4 ACTUAL CV
	D3	EST. MORTALITY 1/2 ACTUAL MORTALITY
	D4	EST. MORTALITY CV 1/4 ACTUAL CV
CRITERIA	C1	EST. R_{MNPL} TWICE ACTUAL R_{MNPL}
	C2	CLASSIFIED AS WITHIN OSP (F_R =1) WHEN ACTUALLY BELOW (F_R = 0.5)
RESEARCH	R1	ABUNDANCE ESTIMATED EVERY 8 YEARS

Table 3. Robustness trials for management schemes.

Several statistics were saved from each simulation (100 years) and are listed below. Statistics discussed in Appendix II are in bold type. Letters for management objectives are given in parentheses where appropriate.

1) minimum N (a),
2) N_{10}, N_{30}, N_{100} (where subscripts denote time) (a),
3) cumulative PBR after 1, 10, 30, 100 years (d),
4) root mean square for PBRs between adjacent years after 10,30,100 years (d)
5) number of years N < OSP (a,b),
6) recovery year (first reaches OSP) (b).

It is assumed that hardship on the fisheries will correlate with the PBR statistics: the lower the cumulative PBRs and/or more variable the PBRs the higher the likelihood of fisheries being affected adversely.

Appendix II. Analytical Results.

Compare N_{100} in Figure 4 to Figures 5a and b (for CV = 0.2 and 0.8 respectively). The same information is available but all robustness trials can be viewed together with distributions represented by the mean and values which include 95% of the distribution. The base trial (no errors) always appears on the left. The magnitude of the effect of different errors (robustness trials) can be viewed along with the outcomes of the different management strategies (N_{MIN} versus N_{MEAN}). For both strategies, errors which have the greatest effect are those which directly effect parameters multiplied in Equation 1 [N_{MIN} (D1), PBR (D3), R_{MNPL} (C1), and F_R (C2)]. The first two can be minimized through scientific scrutiny of abundance and mortality estimation techniques. The latter two parameters caution that criteria for changing from default growth rate parameters and changing population status to OSP should be carefully considered.

As shown in Figure 4, N_{MIN} and N_{MEAN} differ only in degree when CVs are low but perform very differently for high CVs (Figure 5b). The N_{MIN} strategy manages the population more conservatively while the N_{MEAN} strategy always results in populations attaining lower population sizes in 100 years and is highly variable. Recovery times are long and highly variable for populations with high CVs using the N_{MEAN} strategy (Figure 6). Recall the goal of not increasing percent increase in recovery time by > 10%. This goal is never met (Figure 7) and is probably too stringent. Given a no-harvest recovery time of 18 years, a 10% increase is less than 2 years.

Hardship on fisheries is difficult to assess but should be correlated with the cumulative PBRs and the variance in PBRs. As expected, the N_{MIN} strategy allows fewer PBRs than the N_{MEAN} strategy particularly with high CVs (Figure 8). The variance in PBRs (Figure 9) is also high for N_{MEAN} with high CVs. This is an undesirable feature for fisheries as PBRs may change dramatically from year to year reducing economic predictability.

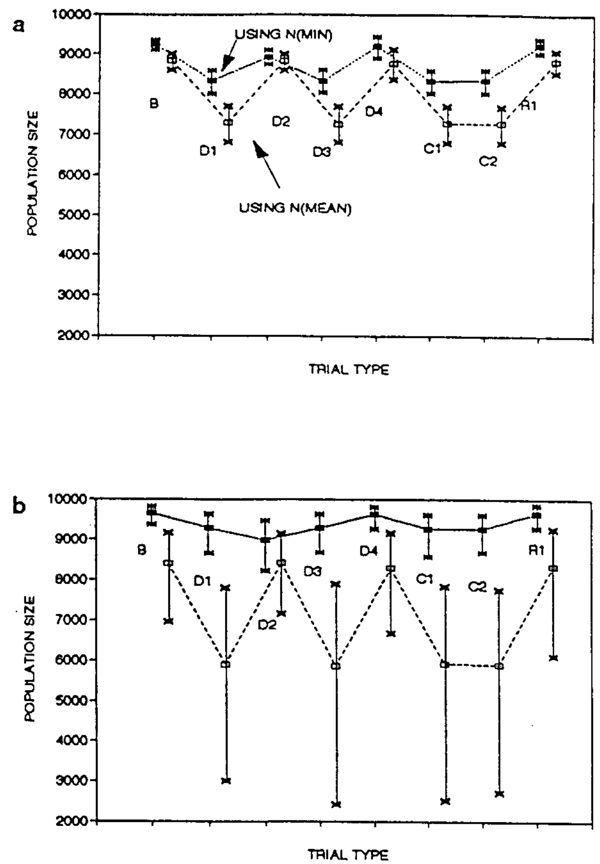

Figure 5. Distributions of populations size after 100 years (N_{100}). The N_{MIN} strategy is symbolized with solid squares, the N_{MEAN} strategy with empty squares. "a" shows base case 2 (CV = 0.2). "b" shows base case 4 (CV = 0.8). Trial type symbols as in Table 2. Vertical bars include 95% of the distribution.

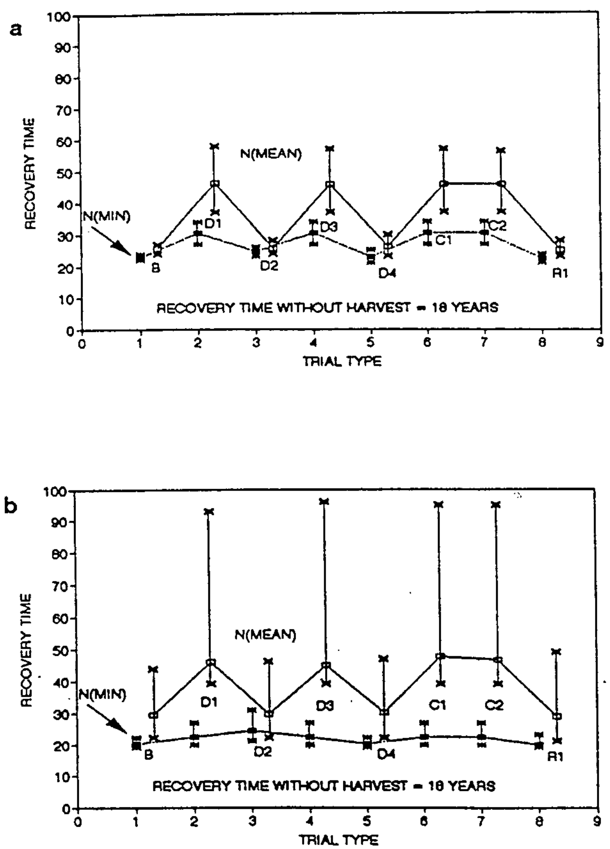

Figure 6. Distributions for recovery time. The N_{MIN} strategy is symbolized with solid squares, the N_{MEAN} strategy with empty squares. "a" shows base case 2 (CV = 0.2). "b" shows base case 4 (CV = 0.8). Trial type symbols as in Table 2. Vertical bars include 95% of the distribution.

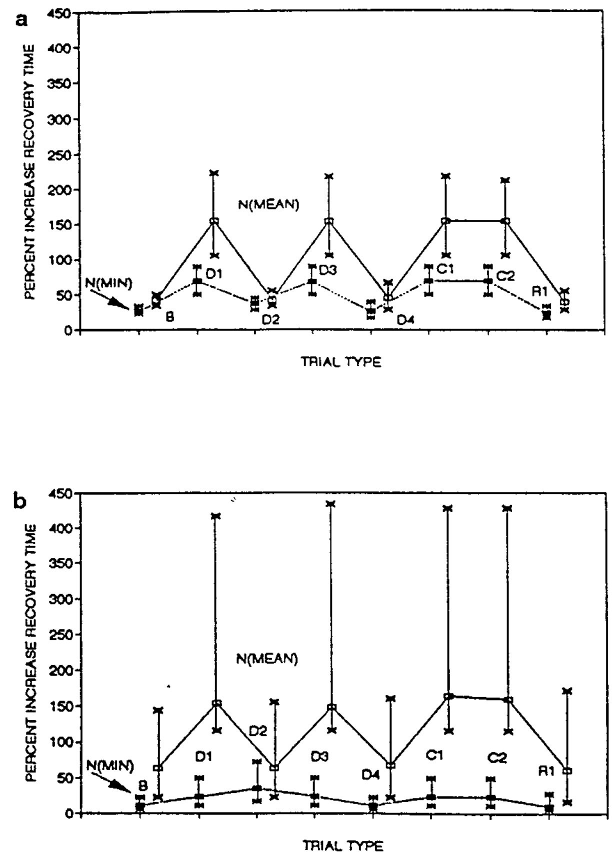

Figure 7. Distributions for percent increase in recovery time [(recovery time with PBRs removed / recovery time without harvest) - 1]. The N_{MIN} strategy is symbolized with solid squares, the N_{MEAN} strategy with empty squares. "a" shows base case 2 (CV = 0.2). "b" shows base case 4 (CV = 0.8). Trial type symbols as in Table 2. Vertical bars include 95% of the distribution.

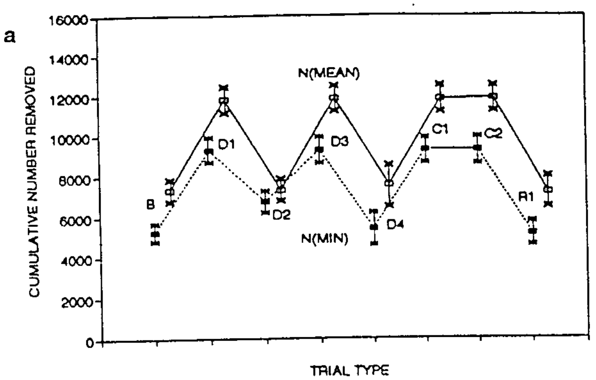

Figure 8. Cumulative PBRs removed after 100 years. The N_{MIN} strategy is symbolized with solid squares, the N_{MEAN} strategy with empty squares. "a" shows base case 2 (CV = 0.2). "b" shows base case 4 (CV = 0.8). Trial type symbols as in Table 2. Vertical bars include 95% of the distribution.

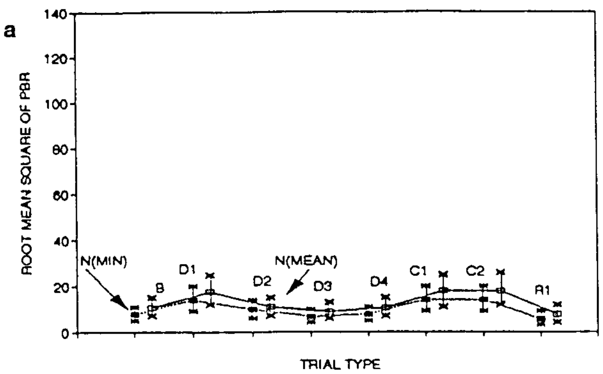

Figure 9. Root mean square error of sequential PBRs after 100 years. The N_{MIN} strategy is symbolized with solid squares, the N_{MEAN} strategy with empty squares. "a" shows base case 2 (CV = 0.2). "b" shows base case 4 (CV = 0.8). Trial type symbols as in Table 2. Vertical bars include 95% of the distribution.

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Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985–1992

David N. Wiley
Regina A. Asmutis
International Wildlife Coalition
70 East Falmouth Highway, East Falmouth, Massachusetts 02536

Thomas D. Pitchford
Virginia Marine Science Museum
717 General Booth Boulevard, Virginia Beach, Virginia 23451
Present address: Florida Department of Natural Resources
Florida Marine Research Institute, Marine Mammal Section
Southwest Field Station, 1418-G Market Circle, Port Charlotte, Florida 33954

Damon P. Gannon
Plymouth Marine Mammal Research Center
P.O. Box 1131, Plymouth, Massachusetts 02362

Marine mammal strandings are a result of, or result in, mortality that may be attributed to natural or anthropogenic factors. As such, stranding data can provide insight on spatial distribution, seasonal movements, and mortality factors pertaining to marine mammal populations (Woodhouse, 1991; Mead[1]).

The general distribution and migratory movements of humpback whales, *Megaptera novaeangliae*, in the western North Atlantic are well known from numerous studies based on the identification of individual animals and on other techniques. Humpbacks feed in high latitude areas during the summer months, including waters of the Gulf of Maine, eastern Canada, West Greenland, and Iceland (Hain et al., 1982; Martin et al., 1984; Perkins et al., 1984; Katona and Beard 1990). In the winter, whales from all populations migrate to breeding grounds in the West Indies (Balcomb and Nichols, 1982; Mattila and Clapham, 1989; Mattila et al., 1989; Katona and Beard 1990). Between these migratory end points, little is known of the distribution of the species. In recent years, however, there has been an apparent increase in the frequency of sightings of humpback whales off the mid-Atlantic coast of the United States (Swingle et al., 1993). Furthermore, a considerable number of strandings have been documented along the mid-Atlantic and southeast coasts, many in midwinter, a time when the majority of humpbacks are thought to be located in tropical waters. In this paper, we analyze data from these strandings, discuss implications regarding distribution and possible spatial segregation by age class, and examine apparent causes of mortality.

Methods

Study area and period

The study covers the coastal area of eastern North America extending from New Jersey(40°28'5N, 74°00'0W) to southern Florida (25°12'N, 80°13'W), consisting of 2,319 km of coastline (Fig. 1). The eight-year period from 1 January 1985 through 31 December 1992 was investigated. Stranding data were obtained from the United States Museum of Natural History, Smithsonian Institution's Marine Mammal Events Program (MMEP). This information was confirmed and augmented by comparison with data from stranding response personnel involved with the Northeast and Southeast Regional Stranding Networks and with data published in newspaper reports. Organizations involved in the regional stranding networks operate under a permit issued by the National Marine Fisheries Service. The names and organizations of investigators responding to specific stranding events are on file.

Analyses

The following data were recorded for each stranding: date, location, sex, body length, and the presence or absence of body markings that may indicate a possible anthropogenic cause of mortality (e.g. ship strike or fishery interaction).

Stranding incidents among states were compared by using a ratio of the number of strandings in the state to the length of coastline along the state. This is referred to as the stranding incidence ratio (SIR). Length of coastline was calculated from Ringold and Clark (1980).

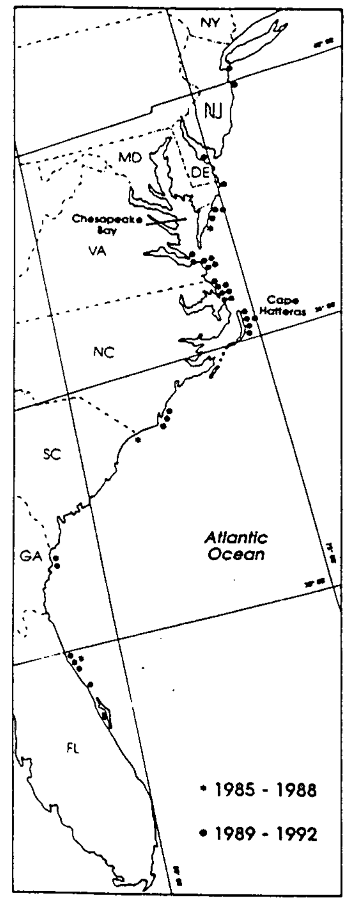

Figure 1
Locations of humpback whale, *Megaptera novaeangliae*, strandings from New Jersey to southern Florida, 1985 through 1992.

Reproductive class was inferred from body-length data. Animals of less than 8 m in length were considered to be dependent, nursing calves (Nishiwaki, 1959; Rice, 1963). We considered newly independent calves to be animals greater than 8.0 m but less than 9.9 m (calculated from Katona et al., 1983[2]). Males between 9.9 m and 11.6 m and females between 9.9 m and 12.0 m were considered sexually immature but not newly independent. Animals greater than 11.6 m (males) and 12.0 m (females) were considered sexually mature (Nishiwaki, 1959; Rice, 1963).

The Mann-Whitney *U*-test (Sokal and Rohlf, 1981) was used to test for differences between the number of strandings that occurred in the period 1985–88 versus 1989–92. Time periods were chosen to coincide with reported changes in observations of live animals in the same region (Swingle et al., 1993). The hypothesis that strandings occurred randomly throughout the study area was tested by chi-square analysis in a 2×2 contingency table (Sokal and Rohlf, 1981). The hypothesis that stranding events were not influenced by season was tested by chi-square analysis. Seasons were winter (January–March), spring (April–June), summer (July–September) and fall (October–December). Seasonal groupings were constructed so that the winter season would approximately coincide with the period of peak humpback occupancy of the breeding grounds, as reported by Mattila and Clapham (1989). The hypothesis that stranding occurrence was not influenced by sex was tested by chi-square analysis in a 2×2 contingency table.

Factors relating to mortality were taken from the written reports of on-site stranding response personnel from the Northeast and Southeast Regional Stranding Networks or, when not available, from the synthesis of such reports contained in the MMEP. The experience of stranding network response personnel is variable, and factors contributing to death or interpretation of bodily injury can be subject to debate. If on-site investigators recorded references to rope marks, propeller marks, broken bones, large gashes, etc., or directly suggested ship strike or entanglement as a potential cause of death, we attributed the death to possible anthropogenic causes. All mortality not suggesting anthropogenic trauma were grouped into a "natural" mortality category. This included animals that were euthanized but showed no other indications of human interaction. If a necropsy was conducted and no mention was made of body trauma, we assumed natural mortality. Carcasses that were reported to be in advanced stages of decomposition were eliminated from consideration.

[1] Mead, J. G. 1979. An analysis of cetacean strandings along the eastern coast of the United States. *In* J. R. Geraci and D. J. St. Aubin (eds.), Biology of marine mammals: insights through strandings, p. 54–68. Report to U.S. Marine Mammal Comm. Contract MM7AC020. U.S. Dep. of Commer., Natl. Tech. Info. Serv. PB-293 890.

[2] Calculated as length at birth, 4.5 m; growth rate, 45 cm per month; 12 month growth period = 9.9 m.

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Results

A total of 38 stranded humpback whales were recorded between 1 January 1985 and 31 December 1992 (Table 1). One animal (4/14/85) was not included in the analyses because body condition ("mummification") indicated death or stranding, or both, occurred prior to the study period. The number of strandings by year was as follows: 0 in 1985, 2 in 1986, 0 in 1987, 1 in 1988, 3 in 1989, 8 in 1990, 7 in 1991, and 16 in 1992. Significantly more animals stranded during the period 1989 to 1992 (n=34), than from 1985 to 1988 (n=3) (Mann-Whitney U: Z=–2.32, P=0.02). Of the strandings recorded in our database, 92% (34/37) occurred after January 1989.

Significantly more strandings occurred along 170 km of coastline between Chesapeake Bay, Virginia, and Cape Hatteras, North Carolina (χ^2=70.67, df=1, P<0.01), than occurred in the rest of the study area. In this region, which represents 7.3% (170 km/2,319 km) of the coastline within the study area, 43% (16/37) of all strandings occurred. A second cluster of strandings occurred along the coast of northern Florida; however, this grouping was not found to be significant (χ^2=5.98, df=1, P=0.25). The region, which represents 4.7% (110 km/2319 km) of the study area's coastline, contained 13.5% (5/37) of all strandings.

The number of strandings per state was highly variable (Table 2). Numerically, the highest number of strandings occurred in North Carolina (n=15), but the incidence of strandings (strandings per kilometer of coastline) was greatest in Virginia (SIR=0.055, n=10), followed by North Carolina (SIR=0.031). South Carolina had the lowest incidence of strandings (SIR=0.003, n=1). The stranding incidence ratio for the entire study area was 0.016. All states recorded at least one stranding.

There were no significant differences in stranding occurrence by season (χ^2=4.22, df=3, P=0.24) (Fig. 2). However, only 8% (3/37) of all strandings occurred during the summer (July–September). Strandings occurred with the greatest frequency in April (n=6) followed by February, March, and October (n=5 each), and least in July and August (n=0 each). In 1992 (the most recent year of the study), strandings were spread over a greater number of months than any of the seven previous years.

Data on body length were available for 25 animals. Body length indicated all animals were sexually immature but none were dependent calves. Sixty-eight percent (17/25) of the animals were considered newly independent calves. Information on gender was available for 26 animals. Fifty percent (13/26) were female and 50% (13/26) were male.

Mortality

Of the 37 animals, an advanced stage of decomposition eliminated 13 from analysis for potential cause of death. Four additional animals were insufficiently examined or information was inadequately reported to determine a cause of death or the presence or absence of injury or scars. Of the 20 remaining animals, 30% (6/20) had major injuries potentially attributable to a ship strike and 25% (5/20) had injuries consistent with possible entanglement in fishing gear. One animal exhibited scars consistent with past entanglement or ship strike, or both, and was emaciated at the time of stranding. Thus, up to 60% (12/20) of the sufficiently inspected animals showed signs that anthropogenic factors may have contributed to or been directly responsible for their death. However, the possibility that some animals sustained body trauma after death can not be ruled out. Unfortunately, few animals were sufficiently necropsied to establish an unequivocal cause of death.

Discussion

These results suggest that stranding of humpback whales along the mid-Atlantic and southeast coastal areas of the United States has increased. All stranded animals were sexually immature and males and females stranded with equal frequency. However, natural mortality may show a gender bias that has been obscured by the high number of deaths potentially due to anthropogenic factors. Strandings occurred throughout the fall, winter, and spring seasons, but few strandings occurred during the summer months.

There are several possible explanations for the apparent increase in strandings, including changes

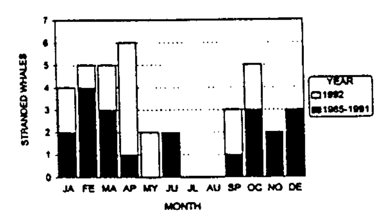

Figure 2
Humpback whale, *Megaptera novaeangliae*, strandings by month, 1985 through 1992.

Table 1
Humpback whale, *Megaptera novaeangliae*, strandings, New Jersey to south Florida, 1985–1992. unk = unknown, est = estimated.

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
14 Apr 85	Carolina Beach, NC 34°02'--" N 078°53'--" W	unk	unk	no	old carcass (mummy or skeleton) not included in analyses	unknown
15 Feb 86	Cobb Island, VA 37°2-'--" N 075°4-'--" W	F	10.8 m	partial	fresh, no obvious sign of external trauma or disease	natural
07 Mar 86	N. Myrtle Beach, SC 33°48'--" N 078°44'--" W	F	11.7 m	yes	live stranding; euthanized	natural
08 Dec 88	St. Johns, FL 29°54'--" N 081°20'--" W (est)	unk	7.8 m (est)	no	advanced decomposition	unknown
14 Jan 89	St. Augustine, FL 29°55'3-" N 081°17'3" W	F	7.6 m (est)	unknown	advanced decomposition	unknown
18 Sep 89	Monmouth Beach, NJ 40°19'55" N 073°57'17" W	unk	8.0 m (est)	no	entangled in gear, apparently anchored by gear to bottom	entanglement
18 Dec 89	Assateague Island, VA 37°50'--" N 075°20'--" W	F	8.7 m[1]	yes	live stranding, no external injuries noted	natural
27 Jan 90	New Smyrna Beach, FL 29°00'0-" N 080°52'2-" W	M	7.9 m	yes	advanced decomposition	unknown
05 Feb 90	Nags Head, NC 35°56'5-" N 075°36'5-" W	unk[2]	11.1 m	partial	broken jaw bone, head damaged[3]	ship strike
24 Feb 90	Corolla Beach, NC 36°15'--" N 075°46'--" W	unk	9.0 m (est)	unknown	fresh, insufficient information	unknown
24 Mar 90	Sanderling, NC 36°11'5-" N 075°45'2-" W	unk	7.6 m – 8 m (est)	no	advanced decomposition	unknown
01 Apr 90	Virginia Beach, VA 36°4-'--" N 075°5-'--" W	F	9.6 m	yes	fresh, net/line marks on tail stock, right half of fluke had line marks	entanglement
19 Jun 90[4]	Virginia Beach, VA 36°56'15" N 076°03'30" W	F	8.3 m	yes	fresh, no evidence of scars or injuries	natural
20 Jun 90	Virginia Beach, VA 36°45'15" N 075°56'30" W	F	8.2 m	yes	live stranding; euthanized, rope marks on flukes, emaciated	entanglement

APPENDIX H

Table 1 (continued)

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
19 Nov 90	Norfolk, VA 36°56'00" N 076°11'30" W	M	9.5 m	no	various rope burns, abrasions on tail stock, rope scars on left flipper	entanglement
05 Feb 91	St. Johns, FL 29°59'06" N 081°18'48" W	M	9.4 m	partial	moderately decomposed, no external injuries noted	natural
02 Mar 91	Bald Head Island, NC 33°55'0-" N 077°56'4-" W	M	8.5 m	no	inaccessible	unknown
15 Oct 91	Kill Devil Hills, NC 36°01'–" N 075°39'–" W	unk[5]	9.3 m[6]	partial	no external injuries noted	natural
25 Oct 91	Nags Head, NC 35°56'5-" N 075°37'0-"	M	9.1 m (est)	no	no external injuries noted	natural
27 Oct 91	Bodie Island, NC 35°46'0-" N 075°29'1-" W	unk	10.0 m	no	advanced decomposition	unknown
08 Nov 91	Island Beach State Park, NJ 39°50'00" N 074°05'12" W	M	9.0 m	yes	four propeller cuts, one through the occipital condyle, were cause of death	vessel strike
25 Dec 91	Carolina Beach, NC 34°01'–" N 077°54'–" W	F	9.9 m	no	insufficient information	unknown
03 Jan 92	Salvo, NC 35°20'9-" N 075°21'8-" W	M	10.4 m	no	no external injuries noted	natural
30 Jan 92	Oregon Inlet, NC 35°46'5-" N 075°31'9-" W	unk	unk	no	inaccessible	unknown
14 Feb 92	Virginia Beach, VA 37°01'–" N 076°07'–" W (est)	M	8.5 m[1]	yes	left eye socket and left mandible fractured, signs of healing from injuries at point of fractures	vessel strike
10 Mar 92	Avon, NC 35°20'–" N 075°21'–" W	F	10.7 m	partial	left fluke "scalloped" possibly due to ship strike or entanglement, evidence of healed rope/net scars on caudal peduncle	past entanglement or ship strike
19 Mar 92	North Core Banks, NC 35°01'1-" N 076°06'0-" W	M	11.0 m	no	advanced decomposition	unknown

Table 1 (continued)

Date	Location	Sex	Length	Necropsy	Carcass analyses	Potential cause of death
14 Apr 92	St. Johns, FL 29°45'–" N 081°10'–" W (est)	unk	8.6 m existing length	no	advanced decomposition	unknown
16 Apr 92	Assateague Island, MD 38°12'–" N 075°08'–" W	F	8.9 m	yes	no external trauma, but skull disarticulated, blunt trauma to left side	vessel strike
18 Apr 92	Southport, NC 33°42'8-" N 77°55'4-" W	M	9.5 m	no	advanced decomposition	unknown
22 Apr 92	Hatteras, NC 35°11'4-" N 075°46'3-" W	F	8.9 m	yes	no external trauma, but extensive skeletal damage, "probably struck by boat"	vessel strike
30 Apr 92	Nags Head, NC 35°22'–" N 075°29'–" W	unk	9.2 m (est)	no	advanced decomposition inaccessible	unknown
16 May 92	Ossabaw Island, GA 31°45'7-" N 081°05'0-" W	M	> 7.2 m	no	advanced decomposition	unknown
17 May 92	St. Catherines Island, GA 31°38'2-" N 081°08'2-" W	unk	unk	partial	advanced decomposition	unknown
22 Sep 92	Prime Hook National Wildlife Refuge, DE 38°55'–" N 075°05'–" W	F	8.3 m (est)	yes	advanced decomposition	unknown
28 Sep 92	Assateague Island, VA 37°53'–" N 075°22'–" W	M	8.9 m (est)-part of head buried	yes	advanced decomposition	unknown
09 Oct 92	Metompkin Island, VA 37°46'–" N 075°32'–" W	F	8.7 m	yes	"probably boat strike," 3 areas of hemorrhage noted	vessel strike
22 Oct 92	Virginia Beach, VA 36°46'15" N 075°57'02" W	M	9.1 m	yes	"obvious entaglement scars" on leading edge of fluke and around caudal peduncle	entanglement

[1] Animal towed prior to measurement, therefore measured length may be greater than actual length.
[2] Discrepancy in reported gender. Original stranding report stated female. MMEP reported male.
[3] Discrepancy in reported body condition. Original stranding report stated broken jaw bone and head damage. MMEP had no report of body condition.
[4] Discrepancy in reported date. Original stranding report stated 19 June 1990. MMEP reported 19 May 1990.
[5] Discrepancy in reported gender. Original stranding report stated female. MMEP reported as unknown.
[6] Discrepancy in reported body length. Original stranding report stated 9.3 m. MMEP reported an estimated length of 660 cm.

Table 2

Humpback whale, *Megaptera novaeangliae*, strandings by state: 1985 through 1992.

State	Number of strandings	Kilometers of coastline	SIR: Number of strandings / km of coastline
Virginia	10	180.6	0.055
North Carolina	15	485.5	0.031
Delaware	1	45.2	0.022
Maryland	1	50.0	0.020
Georgia	2	161.3	0.012
New Jersey	2	209.7	0.010
Florida	5	935.5	0.005
South Carolina	1	301.6	0.003

in observer effort, mortality factors, and whale distribution. That increased observer effort could account for the increase seems unlikely. The size of stranded humpback whales and both the public and media interest in such events results in few carcasses escaping notice. Additionally, strandings of finback whales, *Balaenoptera physalus*, over the same time period have remained relatively constant (1985 to 1988, $n=10$; 1989 to 1992, $n=9$)) (calculated from MMEP, Smithsonian Institution). An increase for this large baleen species might also be expected if the reported humpback change were due solely to increased observer effort.

If the reported increase in strandings is not an artifact of observer effort, it may be due to an increase in factors resulting in mortality, an increase in the number of animals inhabiting the study area, or both. While the tonnage of cargo moving through Atlantic ports in 1989 showed a 9% increase over the mean of the previous four years (calculated from Anon., 1991), the number of vessels using the Chesapeake Bay area, and probably the rest of the Atlantic coast, has decreased because ships capable of carrying greater tonnage are being used (Pringer[3]). While a decline in vessel traffic may result in a decreased risk to whales, it is possible that these larger, faster, deeper draft vessels pose a greater danger than the slower, shallower draft vessels of the past. In addition to commercial shipping, some areas, such as near Chesapeake Bay and northern Florida, are subject to substantial use by military vessels. However, data pertaining to trends in military vessel traffic were not available.

Evidence also indicates that as much as 25% of the reported mortality may be attributable to interaction with commercial fishing activity, such as gill netting. North Carolina's coastal sink gillnet fishery expanded dramatically during the 1980's (Ross[4]). South Carolina, the state with the lowest SIR, banned the commercial use of gill nets in 1987 (with the exception of a tended shad net fishery) (Moran[5]). However, fishing effort in the entire study area is inadequately monitored to determine trends (Read, in press; Bisack[6]).

While changes in shipping and commercial fishing activity may represent increased hazards to animals inhabiting the study area, they seem inadequate to account for the dramatic change in stranding levels reported. Each of these hazards existed prior to 1989, the period when strandings began to increase. The most likely explanation for the reported increase in mortality appears to be increased use of this area by juvenile humpback whales that are then exposed to such hazards.

Although few standardized marine mammal surveys consistently cover the study area, anecdotal and published observations point to a recent increase in live sightings of humpback whales in coastal waters of Florida and Georgia (Kraus[7]), North Carolina (Barrington[8]), Virginia (Swingle et al., 1993), and Maryland (Driscoll[9]). Although reliable estimation of the length of free-swimming whales is difficult, there is general agreement among observers that most, if not all, of the animals frequenting the area are small.

Changes in humpback whale distribution in relation to changes in prey composition and abundance have been demonstrated elsewhere (Payne et al., 1986; Piatt et al., 1989; Payne et al., 1990), and such a prey shift may account for or be an important factor in the change in whale distribution suggested here. While data on changes in prey distribution were not available, the first observations of winter feeding humpbacks were documented in the nearshore waters of Maryland (deGroot[10]) and Virginia (Swingle et al., 1993), during the winters of 1991 and 1992.

An additional possibility is that the humpback whale population in the western North Atlantic may be increasing and expanding its range such that habitats historically occupied are being recolonized. Several authors (Katona and Beard, 1990; Sigurjonsson and Gunnlaugsson, 1990) have reported numerical increases for this population, although this may be due to increased effort resulting in more accurate estimates of abundance.

Humpback whales may have always been present during winter in offshore waters of the study area, but a shift in prey abundance or distribution, or both, may have brought them into areas where death would result in stranding, rather than have caused them to be lost at sea. However, offshore concentrations were not detected during 1978–82 aerial surveys (CeTAP[11]) or during 1980–88 ship board surveys (Payne et al.[12]).

While juvenile whales can be expected to exhibit higher mortality than adults (Sumich and Harvey, 1986; Kraus, 1990a), the absence of adult animals from the stranding record may provide support for the suggestions of Swingle et al. (1993) that winter or migratory segregation, or both, is occurring. Foraging opportunities on the breeding grounds are rare (Dawbin, 1966; Baraff et al., 1991), and it may be adaptive for some juvenile animals to remain and feed in mid-latitude areas, rather than to migrate with adults. If occupying the breeding grounds is the preferred behavior, individuals remaining in higher latitude areas may be those that failed to obtain sufficient resources during the feeding season. Such nutritionally stressed animals may be more susceptible to all forms of mortality, natural or anthropogenic. Nutritionally stressed juveniles and newly weaned calves in particular may be vulnerable to the effects of the parasitic nematode *Crassicauda boopis* (Lambertsen, 1992).

If winter foraging opportunities are sufficient, juveniles may delay their return to traditional feeding areas and may eventually occupy new habitat. This may be one mechanism by which a species establishes itself in new areas or reoccupies historic sites. This process may be reflected in the stranding record. There seems to be a progressive trend not only for an increased number of strandings but for strandings to take place in a greater variety of months.

A high percentage of animals exhibited signs that anthropogenic interactions could be implicated in their death. However, there are reasons to believe that mortality estimates based on available stranding data could under- or overestimate the impact of human interaction. For example, stranded animals on 16 and 22 April 1992 exhibited no external signs of trauma. However, necropsies indicated internal injuries consistent with a ship strike (McLellan[13]; Thayer[14]), suggesting that such injuries could have escaped notice during more cursory examinations. The lack of external body trauma on animals which thorough necropsy revealed to have been killed by a ship strike has also been noted for the northern right whale, *Eubalaena glacialis* (Kraus[15]).

Alternatively, references to rope or net marks did not always specify whether such marks were of recent origin or due to past entanglement from which the animal escaped. Baleen whale entanglement does not always lead to immediate mortality (Kraus, 1990a); however, the effect of escaped entanglement on long-term survivorship or reproductive success, or both, is unknown. If rope or net marks noted in the stranding reports were of past origin, they may have been independent of the animal's death or the animal may have succumbed to the long-term effects of past entanglement. Reduced foraging efficiency during the entanglement period may be a factor influencing animals to engage in winter feeding behavior, such as that observed in the study area by Swingle et al. (1993).

The apparent high rate of interaction with commercial fishing and shipping, may be due, in part, to the age class inhabiting the area. Juvenile animals, and newly independent calves in particular, may be more susceptible to ship strikes or fishing gear entanglements, or both, owing to a lack of experience with either factor (Lien, in press). Commercial shipping and military traffic to and from the Chesapeake Bay passes by much of the area where strandings

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[6] Bisack, K. 1992. Sink gill net fishing activity in the North Atlantic as reflected in the NEFSC weightout database: 1982–1991. U.S Dep. Commer., NOAA, Natl. Mar. Fish.Serv. Northeast Fish. Sci Cent., Woods Hole, MA 02543. Unpubl. manuscr., 4 p.

[7] Kraus, S. New England Aquarium, Boston, MA 02110. Personal commun., March 1993.

[8] Barrington, P. North Carolina Aquarium, Fort Fisher, Kuri Beach, NC 28449. Personal commun., April, 1993.

[9] Driscoll, C. NMFS, Office of Protected Resources, Silver Spring, MD 20910. Personal commun., March 1993.

[10] deGroot, G. 1992. A fluke of nature. The Annapolis Capital-Gazette. 10 March, p. 1.

[11] CeTAP. 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U. S. outer continental shelf. Final Rep. to the Cetacean and Turtle Assessment Program, Univ. Rhode Island, Bur. Land Manage., Contract AA551-CT8-48. U.S. Dep. Int., Wash., DC, 450 p.

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[14] Thayer, V. Natl. Mar. Fish. Serv., Beaufort, NC 28516. Personal commun., March 1993.

[15] Kraus, S. New England Aquarium, Boston, MA 02110. Personal commun., March 1993.

occur most frequently (Virginia and North Carolina), often in water depths of less than 20 m. In Florida, the concentration of strandings occurs in the vicinity of active commercial and military shipping and where ship strikes have been reported to represent a hazard to northern right whales (Kraus and Kenney, 1991).

Entanglement in commercial fishing gear has been the most frequently identified anthropogenic cause of injury and death in humpback whales; gillnet-type gear most often was implicated (O'Hara et al., 1986). Coastal gillnet fisheries exist in the study area on a year-round basis, but effort may peak in late winter/spring (NMFS, 1992; Swingle et al., 1993; Brooks[16]). Over 2,200 gillnet licenses have been issued for the mid-Atlantic coastal region. However, fishermen may hold more than one permit and some coastal fisheries do not require permits (NMFS, 1992). In the study area, coastal gill nets and whales concurrently occupy waters of less than 15 m in depth (observed by RAA and DPG), and whales have been observed trailing such gear (Swingle[17]). The association of young, inexperienced whales with gill nets in shallow waters may increase the potential for entanglement incidents. Since entanglement mortality is inversely related to body size (Lien et al., 1989; Kraus 1990b), juvenile humpbacks may be more susceptible to fatalities.

Data contained in this paper suggest that mid-Atlantic and southeast coastal areas of the United States are becoming increasingly important habitat for juvenile humpback whales and that anthropogenic factors may negatively impact these animals. However, there are a number of factors that suggest caution should be used in interpretation of these data. The site of stranding is not necessarily the site of death, as the body of a large whale can be carried considerable distances by wind and currents before beaching occurs. Cause of death in the stranded animals was rarely determined with certainty and in most cases was inferred from observations of the presence or absence of surface body trauma, not from thorough necropsy by experienced individuals. A greater emphasis should be placed on complete necropsies of stranded animals to determine not only the immediate cause of death but also whether there is an underlying factor in the fatality. This would allow a more reliable investigation into mortality and provide greater ability to evaluate and alleviate the impact of anthropogenic interactions. This is particularly important for an endangered species, such as the humpback whale.

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Marine Mammal Commission
Written Comment, August 12, 1996

Navy Response:

H1. Section 4.0 of the FEIS has been revised to address this issue.

H2. Statements in the FEIS regarding the lack of mortalities and injuries during the JOHN PAUL JONES shock trial have been reworded as suggested in comment H7. Regarding the adequacy of the 48-hour post-detonation monitoring period, see response H12.

H3. Text and table have been changed as suggested.

H4. The central problem is that aerial surveys miss a certain portion of the population. There are two general approaches to resolving this problem. One way is to account for undetected individuals by using correction factors, as was done in the DEIS. This approach involves a number of assumptions and calculations which are explained in Appendix B. A second approach is to use uncorrected data but choose a more "conservative" value than the mean. For example, in the Taylor (1993) paper, the lower tail of the 95% confidence interval is used to provide a minimum population estimate. For the EIS, the upper tail of the 95% confidence interval would be the corresponding choice. This approach has the advantage of simplicity; there is no need for "correction factors" and their underlying assumptions. However, this approach does not explicitly account for all undetected individuals; rather, it assumes that the 95% upper limit is high enough to make up for them.

Information has been added to Appendix B of the FEIS to address this issue. For all species at both Mayport and Norfolk, the Adjusted Mean Density used in the FEIS exceeds the upper 95% confidence limit for the observed mean. Also, for total marine mammals and nearly every individual species, the Adjusted Mean Density exceeds the 95th percentile of the individual observations (in fact, for many species, 95% of the observed densities were zero). This comparison shows that the Adjusted Mean Densities used in the FEIS as a basis for mortality/injury estimates are greater than or equal to those calculated by the "best management" approach (Taylor, 1993).

For sea turtles, the FEIS approach using "correction factors" is much more conservative than using the upper 95th percentile of survey observations. Because sea turtle counts are not highly clumped, the coefficient of variation is low and the 95% confidence limit is fairly narrow. Even the highest density ever observed at Mayport during 1995 and 1997 surveys is much lower than the Adjusted Mean Density used for FEIS calculations (see Appendix B).

H5. Supporting material has been added to Appendix B. In the FEIS, values involved in "detectability" calculations are supported to the extent possible by literature citations. A few values were changed, but most were kept the same based on this review.

H6. Papers cited in the footnotes to Tables 3.1 and 3.2 were used to establish the possible presence of marine mammals and turtle species at the Mayport and Norfolk areas. Some of these papers make reference to historical strandings. However, the stranding database was not queried for the DEIS.

In response to this comment, the Navy contacted the stranding coordinators and obtained historical data. This information is summarized in Section 3.0 of the FEIS. Based on this review, there are no additional species in the stranding database which are not already listed as "presence possible" at Mayport or Norfolk. Most of the stranded individuals at both locations are bottlenose dolphins. The only species which occurred frequently in the stranding records but was not seen during aerial surveys was the pygmy sperm whale. Stranding records also generally support the relative abundance of pilot whales at Norfolk (compared with zero strandings inshore of Mayport).

H7. Text has been revised as recommended.

H8. The quoted text has been revised to provide a better explanation. A better description of marine mammal abundance would be "clumped" rather than "patchy." Because of this clumped distribution, a site picked at random would most likely have zero visible marine mammals. For example, for most species, over 95% of potential sites would have zero visible animals (see response H4). Further, the Navy would not be selecting a site at random; rather, site-selection surveys would be used to choose an area with the lowest possible density of marine mammals and turtles. Thus, the mean density is clearly an overestimate of the expected number of visible animals within a site.

H9. Section 4.0 has been revised to address this issue.

H10. The 1 nmi (1.85 km) figure cited in the DEIS was incorrect. The minimal visibility requirement is 3 nmi (5.6 km) for fixed wing aircraft. Section 5.0 of the FEIS cites the correct value.

H11. Section 5.0 of the FEIS has been changed to state observer qualifications and explain how animal distance from the detonation point would be determined.

H12. Section 5.0 of the FEIS has been expanded to explain post-detonation monitoring and coordination with the stranding networks in more detail. The post-detonation monitoring period following the last shot has been extended to seven days. Marine mammal and sea turtle stranding networks along the east coast would continue to investigate any stranded animals for evidence of injury related to shock testing for one year after the tests. Necropsies would be performed by trained stranding network technicians following NMFS protocols, and tissue samples would be forwarded to the Armed Forces Institute of Pathology (AFIP).

If a marine mammal were killed by a blast, it would likely suffer lung rupture which would cause it to float to the surface immediately due to air in the blood stream. If an animal were mortally wounded, but the lungs not ruptured, time until it floats is likely to be 2-5 days depending on animal size and water depth. In either case, these animals could be detected by the mitigation/monitoring program, which would not be limited to 48 hours post-detonation, as explained below. Over the longer term, the stranding networks are the only feasible means of monitoring for marine mammal deaths.

The search for dead or injured marine animals would not be limited to 48 hours post-detonation. Since the Navy would attempt to test in the same area, the mitigation effort for each subsequent shot would effectively serve as post-detonation mitigation for each previous effort. (Over the planned 33 days from the first detonation until the final post-detonation day, the mitigation team would be on-site in either surface vessels or aircraft for 19 days). Subsequent to shot 5, dedicated post-detonation mitigation would continue for seven days. Marine mammal and sea turtle stranding networks along the east coast would have been previously alerted to shock test activity and timing, and would continue to investigate any stranded animals for evidence of injury related to shock testing.

Every effort would be made to determine cause of death of all animals found near the test site. The MART vessel would be capable of collecting all but the largest of cetaceans (mysticetes and sperm whales), and would be prepared to do so. The Navy would attempt to collect tissues in accordance with NMFS necropsy protocol. Should any large cetaceans be found dead near the site, a partial necropsy focusing on those tissues particularly important in determining blast injury (ears, lungs, brain) would be attempted on that animal on-site. Large dead animals would not be towed ashore as it would allow advanced deterioration of vital tissues. The MART veterinarian would be prepared to chemically euthanize any animals that are judged to be mortally wounded. Necropsies would be performed on any animals that are euthanized.

H13. Minimum qualifications of the veterinarian have been added to Section 5.0 of the FEIS. The requirements are a D.V.M. in Veterinary Medicine with a minimum of 10 years of experience with marine mammals.

H14. The Navy has obtained the stranding network data (see response H6). The data are summarized in Section 3.0 of the FEIS. Also, Section 5.0 of the FEIS has been modified to explain that arrangements would be made beforehand to recover and necropsy any marine mammals killed during the tests (see response H12).

H15. Description of requirements of section 101(a)(5)(A) of the Marine Mammal Protection Act has been added as recommended.

H16. A separate reference subsection has been prepared which briefly summarizes personal communications and other unpublished information sources.

H17. A table has been added to Appendix B listing species and number of individuals by survey. Survey dates are included. Further detail would unnecessarily increase the size of the FEIS. Raw data are available in the Summary Survey Report, which is cited in the FEIS.

H18. See response H5. Supporting material has been added to Appendix B. Values involved in "detectability" calculations are supported to the extent possible by literature citations.

H19. Text addressing this issue has been added to Appendix D.

H20. There is no assumption that the smallest animal would be 100 kg. Rather, predictions for a 100 kg animal were cited as an example. The text has been changed to cite ranges for a calf dolphin (12.2 kg or 27 lb), which is the basis for the mortality criterion.

H21. The rationale for inferring that data from human volunteers can be applied to marine mammals is given in the first paragraph of D.1. The explanation of the data seems straightforward. The worst-case scenario would be actual injury, which is discussed extensively in the same appendix.

H22. The text in question has been deleted due to an extensive rewrite of Appendix E. The revised appendix includes a much more detailed review of auditory threshold shifts in humans and other terrestrial mammals.

The Wright et al. (1950) paper gives little information on the type of hood used. From the descriptions given (the hoods are fitted with non-flexible windows) and pictures shown (very poor), these suits and hoods were very likely made of some kind of rubberized fabric, not neoprene or anything even closely resembling modern-day neoprene wetsuits. Some of the hoods were fitted with "ear defenders" (not described). It seems highly likely that any attempts to estimate attenuation would only provide one more source of uncertainty.

H23. This figure has been deleted due to an extensive rewrite of Appendix E.

NMFS

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

OCT 9 1996

Mr. L.M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division, Naval
Facilities Engineering Command
P.O. Box 190010
North Charleston, North Carolina 29419-9010

Dear Mr. Pitts:

This is in response to your June 5, 1996, letter requesting comments on the Draft Environmental Impact Statement (DEIS) for shock testing the USS SEAWOLF submarine off the U.S Atlantic coast in 1997. On that same day, the U.S. Navy submitted to the National Marine Fisheries Service (NMFS) a Biological Assessment under the Endangered Species Act (ESA) requesting formal consultation under section 7. In addition, the U.S. Navy submitted an application for a small take of marine mammals under section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA).

On August 24, 1995, NMFS agreed to be a cooperating agency (as that term is defined by the Council on Environmental Quality (40 CFR 1501.6)), in the preparation of the DEIS. In that letter, NMFS stated its support of the U.S. Navy's determination to do a DEIS on this activity and as a result NMFS has been participating in the scoping process under the National Environmental Policy Act (NEPA) and the more recent public meetings on the DEIS and proposed small take rule. We continue that support and congratulate the U.S. Navy for offering the public a comprehensive and informative document to judge the environmental impacts of the shock trial.

In cooperating with the U.S. Navy on this activity, NMFS has stated that it will have a dual role, both through (and limited to) review and comment on the document's preparation and through the regulatory process involved with the issuance of an incidental small take authorization under section 101(a)(5)(A) of the MMPA. Therefore, although NMFS agreed to be a fully cooperating agency in the preparation of the DEIS, because of its regulatory role, we stated that it would be inappropriate for NMFS to be a signatory agency on the document. As a result, NMFS reserved the ability to review the DEIS when it is released to the general public, and to provide the U.S. Navy with appropriate comments. Provided the comments contained in this letter are either addressed in the Final EIS (FEIS) or adequately responded to by letter, NMFS would consider using the U.S. Navy FEIS as the appropriate NEPA document for making the final decision on the issuance of the small take authorization.

To begin our review of the DEIS, NMFS concurs with the U.S. Navy that the Mayport, FL site is the preferred location for conducting the shock trial. The Norfolk, VA site is less preferable to NMFS because of the greater potential for impacting marine mammals. Additional comments follow.

1. NMFS notes that our recommendation on the pre-release draft of the DEIS that the U.S. Navy add to the requested small take authorization those species of marine mammals not seen during the 5 survey months, but anticipated due to historic presence, has been accepted and incorporated in the DEIS. Because these animals may appear in the area, incorporation of these species into the requested authorization was appropriate in order to avoid potential unauthorized takings of these species. However, the addition of these species to the list of requested species should in no way infer that NMFS expects them to be present during the proposed 1997 shock trial. In that regard, NMFS considers the U.S. Navy's April through September, 1995, offshore marine mammal abundance surveys to be the best scientific information available for determining the species and numbers of marine mammals that can be expected to be taken. (NMFS-1)

2. NMFS notes that the DEIS does not provide sufficient information, or references, on the characteristics of the sound/shock waves that will be generated as a result of the explosive detonations. NMFS is concerned because the data is not available for independent review of the estimated effects of explosives on marine life, but also because Tables 4-4 through Table 4-9 contain mathematical errors (e.g., 0.01 x 5 is given as 0.02 rather than 0.05). Basic information on HBX-1 may have allowed reviewers to independently assess the accuracy of the U.S. Navy calculations for the safety ranges. The FEIS should be revised to address this concern. (NMFS-2)

On a related issue, during early discussions with the Navy, NMFS suggested that the DEIS contain a comparison between the method for determining acoustical harassment under the small take authorization for shock testing the DDG-53 JOHN PAUL JONES in 1994, and the method employed in this DEIS that uses a new term "acoustic discomfort." This comparison would have facilitated the Navy's introduction of this new concept. This was not done. Therefore, while NMFS believes that the term "acoustic discomfort" may be an appropriate descriptor of the potential harassment caused by the 0.05-second acoustic signal, a comparison (either in the text or contained in a footnote) with an impulse noise signal would improve the FEIS. As such, the FEIS could show that the area of potential "acoustic discomfort" (6 nmi radius) would be expected to have a sound pressure level less than 180 dB (re 1 µPa @ 1 m) (Young 1992, Lehto 1992). However, because the shock test will be conducted in fairly shallow water (500 ft) and the charge will be at 100 ft, surface and bottom reflection may result in somewhat greater distances

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for sound pressure levels to attenuate. This needs to be clarified further by the U.S. Navy. From these same references, the Navy could indicate that "...180 dB/Hz occurs only below 50 Hz, 170 dB/Hz occurs only below 100 Hz, and 160 dB/Hz occurs only below 300 Hz." Noise at these frequencies and amplitude is presumed to be below the hearing threshold of all but the large whale species. Also, as Lehto (1992) notes, it is questionable whether odontocete species can even hear the pulse generated from underwater detonations because it is too brief (ca. 0.05 sec).

NMFS-3

3. The section on weather limitations (5.5.2, p.5-3) is in error. It states that "weather conditions begin to adversely impact mitigation effectiveness in a sea state of Beaufort 5...." However, experience conducting aerial surveys, including the papers cited in the DEIS, indicate that sighting effectiveness drops off rapidly in conditions of high Beaufort 3. These considerations are for observing marine mammals. It is therefore, highly unlikely that an observer could effectively spot smaller cetaceans (except in large pods) or individual sea turtles from aerial surveys conducted in states of Beaufort 4 or above. Furthermore, there is no support that aerial surveys can be effective at Beaufort 4 simply because the number of aerial and shipboard observers is greater than that used for the DDG-53 shock trial. NMFS notes that (1) the 1995 aerial surveys were not conducted above Beaufort 3; (2) the 1995 aerial surveys had, and the pre-detonation mitigation will have two observers viewing the water surface at any one time, not 3 observers as suggested on page 5-3; and (3) the DEIS presumes that the Marine Mammal Acoustic Tracking System (MMATS) will be effective for all species, including sea turtles. The purpose of the pre-detonation survey is to detect each and every individual animal to prevent injury or mortality. Therefore, there is a great need to ensure that mitigation measures will be as effective as practicable. The mitigation plan for the SEAWOLF shock trial should indicate, therefore, that no shock testing will be conducted under conditions greater than Beaufort 3.

NMFS-4

4. It appears that the Navy has developed a mitigation plan that will avoid takes to the maximum extent practical (or possible). However, we have concerns about the calculations used to estimate the number of takes for each marine mammal species. For example, Goertner's (1982) model is based on terrestrial mammals and bases its calculations on a 3 percent ratio between lung volume (in liters) to body weight (in kilograms). However, as shown in the attached graph, the lung volume for some marine mammals is relatively larger than comparably sized terrestrial mammals (Kooyman, 1973). In addition, the anatomical structure and physiological characteristics of marine mammals (light, oil-filled bones; highly reinforced lung tissues; reductions in or near loss of certain skeletal structures; partial or total lung collapse for certain marine mammals at depth; etc) will also affect comparisons between terrestrial mammals and marine mammals

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and sea turtles. As a result, NMFS recommends the U.S. Navy reassess the basic assumptions made by Goertner (1982). Recognizing that these recalculations may affect the determinations for appropriate safety zones, NMFS recommends that the safety zones be conservatively redesignated (if necessary) in order to protect marine mammals.

In this regard, NMFS has two concerns:

NMFS-4a

a. The ability for aerial or shipboard observers or the MMATS to subjectively determine that marine mammals within the buffer zone will not enter the safety zone prior to detonation. As a precaution, NMFS recommends that no detonations take place whenever marine mammals or sea turtles are detected within the buffer zone;

NMFS-4b

b. The information provided in Part A of Appendix D of the DEIS (and Appendix C of the Small Take Application) appear to have been taken out of context and are for the most part unreferenced. NMFS believes that the DEIS would be improved by redrafting this part of Appendix D with more up to date scientific information. A list of references will be forwarded to the U.S. Navy separately.

NMFS-5

5. There is a scarcity of data on the actual pathology of underwater blast/concussive trauma on diving mammals such as cetaceans. It is hypothesized that their inherent physiology may impose some differences on tissue evidence of such trauma. It is therefore vitally important that the U.S. Navy make every effort to do full necropsies on any marine animals which are found during the shock trial and for the 1 month period that the U.S. Navy will be cooperating with the stranding networks. The necropsies should be performed by qualified pathologists experienced with marine mammals, particularly cetaceans. These necropsies should be reviewed by barotrauma specialists. NMFS recommends that samples (including histopathology) be sent to two predetermined laboratories chosen for their expertise in the particular analyses. We also recommend that the U.S. Navy provide written documentation of the necropsy findings for review by NMFS. We need to be building our knowledge in this field every time we can and not miss opportunities to better understand the pathology and biology of marine animals. This will work with all the small cetaceans and the sea turtles. In addition, there are very important life history data that should be collected from any marine animal killed as a result of this action. NMFS can provide the protocols for collections so that comparisons can be made with other existing data and meet NMFS' needs for future assessments and impact statements and match existing databases. In that regard, it would be beneficial if NMFS pathologists or necropsy people be on board the Marine Animal Recovery Team (MART) boat. More specific comments follow:

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Page 5-6. When MART tags and records dead animals prior to detonation, we recommend that skin samples be taken for NMFS' forensics lab and that a photo of the animal be taken for identification purposes.

Page 5-9. Ensure that a veterinarian with experience of marine mammals and sea turtles and marine mammal/sea turtle pathology be on board the boat. It is imperative that we have tissue samples taken and sent to labs for evaluation.

Page 5-18. What constitutes practical recovery? We know from recent experience the size of dead animal that can be recovered by zodiacs and brought aboard ships for necropsies. What facilities are available on this ship for large whale necropsies? Will the U.S. Navy be ready to do this (i.e., have everything on board for retrieval and necropsy)? The U.S. Navy should discuss logistics with experienced NMFS personnel.

Page-5-21. It states that there will be full cooperation with stranding network personnel. It should note that there will be prior notification of detonation timeframes to stranding coordinators so they can notify appropriate personnel. Again the U.S. Navy needs to ensure that the protocols for response, collection and distribution have been sent to the stranding network personnel. The U.S. Navy should develop these protocols in conjunction with NMFS' Marine Mammal Health and Stranding Response Program and the Armed Forces Institute of Pathology.

For large whales, NMFS recommends the immediate tagging of carcasses. The U.S. Navy should be responsible for retrieval of whales to designated areas for necropsy. Blair Mase, the SE U.S. regional stranding coordinator, or Pat Gerrier, the NE U.S. regional stranding coordinator, should be notified so that members of the NMFS large whale necropsy team can assist the Navy in the examination of such animals. Protocols/samples are handled as stated above for the small cetaceans.

Thank you for the opportunity to review this DEIS. If you have questions on the contents of this letter or need additional information, please contact Ken Hollingshead, at 301/713-2055.

Sincerely,

Stephen Waite for
Patricia Montanio
Deputy Director
Office of Protected Resources

Enclosure

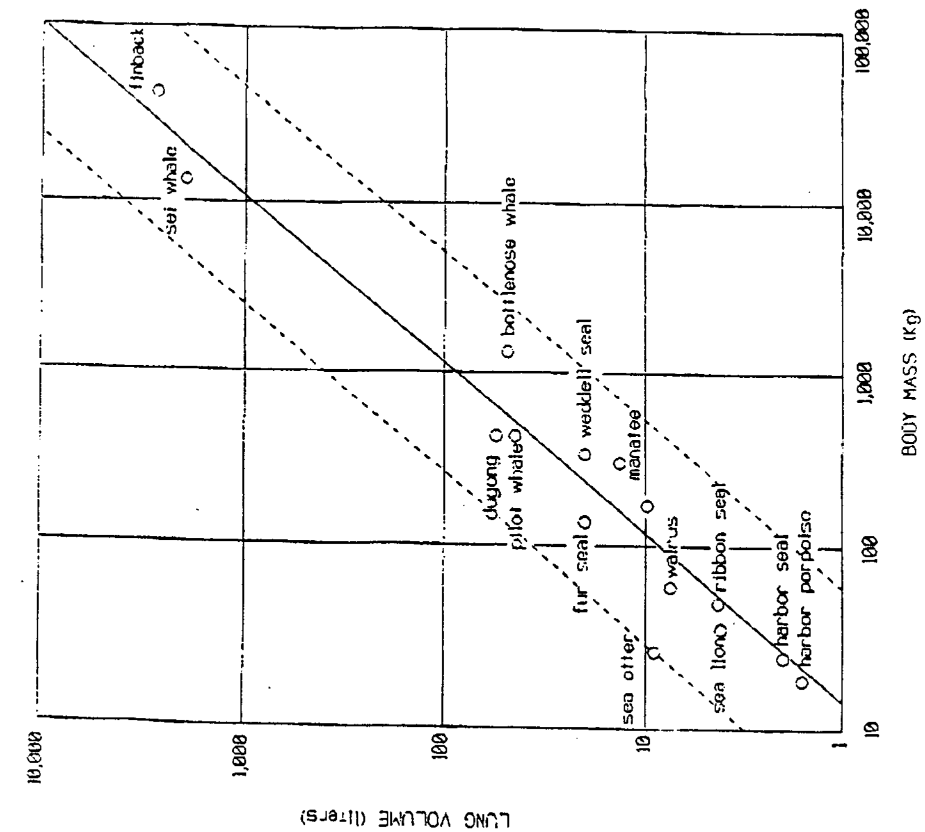

Figure 18

National Marine Fisheries Service

Patricia Montanio, Deputy Director, Office of Protected Resources
Written Comment, October 9, 1996

NMFS-1. Comment noted.

NMFS-2. Appendix E of the FEIS provides more information on shock wave characteristics, as requested. This includes figures showing a waveform and a pressure-time history. Additional information on HBX has been forwarded separately to NMFS.

The apparent discrepancies cited in the impact tables are due to rounding, not mathematical errors. The tables list all numbers to two decimal places, but the calculations were done by spreadsheet using unrounded numbers. Thus, in some cases numbers listed for a single detonation, when multiplied by five, would be slightly different from the actual five-detonation total. However, totals listed for five detonations are correct. In the FEIS, the single detonation numbers are shown to three decimal places. Also, all numbers in the impact tables have been rechecked for the FEIS.

The "acoustic discomfort" criterion referred to in this comment has been replaced by a criterion based on temporary threshold shift (TTS) in bottlenose dolphins. The FEIS provides information to help the reader compare the TTS criterion with the 160 dB (pressure) acoustic harassment criterion used for the DDG 53 shock trial. This includes additional text explaining why the TTS criterion is an improvement over the 160 dB criterion and a tabular comparison of the two criteria.

NMFS-3. The Navy recognizes that mitigation procedures can only be effective in favorable weather and sea state conditions. Following further discussions with the NMFS on this issue, the Navy has adopted the minimum weather criteria specified in the incidental take statement attached to the Biological Opinion (Appendix G). Accordingly, the FEIS states that mitigation efforts will be conducted in sea states no greater than no. 3 on the following scale:

0 = flat calm, no waves or ripples
1 = small wavelets, few if any whitecaps
2 = whitecaps on 0 to 33% of surface; 0.3 to 0.6 m (1 to 2 ft) waves
3 = whitecaps on 33 to 50% of surface; 0.6 to 0.9 m (2 to 3 ft) waves
4 = whitecaps on > 50% of surface; > 0.9 m (3 ft) waves

In addition, the Navy has refined its aerial mitigation procedures at the recommendation of the NMFS Southeast Fisheries Science Center (SEFSC) to enhance detection of individual sea turtles and marine mammals. The aerial transect lines to be flown 2.5 hr prior to each detonation have been tightened to 0.46 km (0.25 nmi) spacing instead of 1.85 km (1 nmi). Further, at the recommendation of the NMFS Southwest Fisheries Science Center (SWFSC), the Navy is arranging for the use of Partenavia aircraft (or equal) which has an additional viewing port (belly port). This additional viewing port allows for three observers versus the two who flew the April-September 1995 surveys in support of SEAWOLF; the total number of aerial and surface observers supporting the SEAWOLF test is five times greater than that used during the 1995 aerial surveys. As already noted in the DEIS, the operating altitude would be 198 m (650 ft), instead of 229 m (750 ft) as used for the 1995 surveys. The reduced altitude, the tightening of the pre-detonation aerial transect lines, and the use of an aircraft which can accommodate a third aerial observer, combined with the full complement of shipboard and acoustic monitoring will make mitigation as effective as practicable.

NMFS-4. For the FEIS, lung injury ranges in Appendix D have been recalculated using a higher ratio of lung volume to body weight (3.9% instead of 3%), based on the Kooyman (1973) paper. This assumption slightly reduces the calculated lung injury ranges. The actual injury estimates in the EIS were not affected by this change because an eardrum rupture criterion was used, which does not depend on the ratio of lung volume to body weight.

The other anatomical and physiological characteristics cited for marine mammals would either have no effect in the Goertner model or would tend to reduce the risk of injury. Skeletal characteristics (light, oil-filled bones, near loss of certain skeletal structures) *per se* have no direct effect in the Goertner model. A reduction in lung volume with hydrostatic pressure is taken into account; partial or total lung collapse at depth would further reduce the risk of lung injury. As stated in Appendix D, "large, uninflated lungs are less prone to be damaged by underwater shock waves than small, fully inflated lungs" (Hill, 1978). Highly reinforced lung tissues would tend to decrease the risk of lung injury.

NMFS-4a. Animals within the buffer zone at the time of detonation are not at risk of death or injury. Therefore, it is not appropriate to postpone detonation just because a marine mammal or turtle is detected there. This would effectively expand the safety range to 5.6 km (3 nmi), more than doubling its area and greatly increasing the likelihood of unnecessary delays.

However, the Navy recognizes the NMFS' concern that deep-diving species such as the sperm whale or beaked whales could appear in the buffer zone, then dive and swim submerged into the safety range. Therefore, a protocol has been developed for animals detected in the buffer zone, based on their swimming speeds and dive durations (see Section 5.0). The protocol would allow the Lead Scientist to evaluate on a species-by-species basis whether an animal in the buffer zone could enter the safety range prior to detonation, and to postpone the test if necessary. Further, in accordance with the incidental take statement attached to the Biological Opinion (Appendix G), if a listed marine mammal is detected within the buffer zone and subsequently cannot be detected, sighting and acoustic teams would search the area for 2.5 hours (approximately three times the typical large whale dive duration) before assuming the animal has left the buffer zone. If a northern right whale were seen, the shot would not occur until the animal is positively reacquired outside the buffer zone and at least one additional aerial survey of the safety range and buffer zone shows that no other right whales are present.

NMFS-4b. The first part of Appendix D has been revised. Introductory material has been added to place the discussion in context. Citations have been added for unreferenced statements and quotes. More up-to-date information has been added.

NMFS-5. The Navy concurs that it is very important to make every effort to do complete necropsies in accordance with NMFS Collection Protocols on any marine mammals or turtles which are found during the shock test. The Mammal Recovery Plan details that the Navy would perform complete necropsies, preserve tissue samples, and forward them to the Armed Forces Institute of Pathology (AFIP) for evaluation. The necropsy findings would be provided by the Navy for NMFS review. In addition, the Navy concurs and has outlined in its plan that skin samples would be taken as well as photographs for identification purposes. The necropsy protocol to be used by the Navy was provided by SEFSC in coordination with the marine mammal stranding network coordinator.

The Navy also agrees that qualified necropsy people should be onboard the MART Vessel. The veterinarian would possess a D.V.M. in Veterinary Medicine with a minimum of 10 years experience with marine mammals and necropsy procedures. His assistant would have extensive experience in field study, tissue collections and necropsy procedures. Supporting them onboard the MART Vessel would be an experienced turtle expert and capture specialist.

A brief description of the plan to coordinate with stranding networks has been added to Section 5.0 of the FEIS. Each stranding network has qualified technicians who have been trained at NMFS-sponsored workshops in correct necropsy and preservation techniques for marine mammals and sea turtles. They would be requested to forward tissue samples to the AFIP for analysis.

I

STATE OF FLORIDA

DEPARTMENT OF COMMUNITY AFFAIRS

EMERGENCY MANAGEMENT • HOUSING AND COMMUNITY DEVELOPMENT • RESOURCE PLANNING AND MANAGEMENT

LAWTON CHILES, Governor — JAMES F. MURLEY, Secretary

August 7, 1996

Mr. Will Sloger
Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina 29419-9010

RE: Department of the Navy - Basic and Applied Scientific Research - Draft Environmental Impact Statement - Shock Testing the Seawolf Submarine - Statewide
SAI: FL9606140468C

Dear Mr. Sloger:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of Environmental Protection (DEP) recommends that the applicant provide a detailed survey and avoidance plan to reduce potential impacts to marine mammals, marine turtles, and right whales. The DEP provides detailed recommendations which should be incorporated in the mitigation plan. Please refer to the enclosed DEP comments. (I1)

Based on the information contained in the draft environmental impact statement and the enclosed comments provided by our reviewing agencies, the state has determined that the above-referenced project is consistent with the Florida Coastal Management Program. (I2)

2555 SHUMARD OAK BOULEVARD • TALLAHASSEE, FLORIDA 32399-2100

FLORIDA KEYS AREA OF CRITICAL STATE CONCERN FIELD OFFICE, Marathon, Florida — SOUTH FLORIDA RECOVERY OFFICE, P.O. Box 4022, Miami, Florida 33159-4022 — GREEN SWAMP AREA OF CRITICAL STATE CONCERN FIELD OFFICE, 155 East Summerlin, Bartow, Florida 33830-4641

Mr. Will Sloger
August 7, 1996
Page Two

Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Keri Akers, Clearinghouse Coordinator, or Ms. Jasmin Raffington, Florida Coastal Management Program, at (904) 922-5438.

Sincerely,

Ralph Cantral, Executive Director
Florida Coastal Management Program

RC/cc

Enclosures

cc: Jim Wood, Department of Environmental Protection

FLORIDA

Department of Environmental Protection

Lawton Chiles
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Virginia B. Wetherell
Secretary

July 26, 1996

RECEIVED
JUL 3 0 1996
State of Florida Clearinghouse

Keri Akers
State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

RE: USN/Draft Environmental Impact Statement (EIS), Shock Testing the SEAWOLF Submarine
SAI: FL9606140468C

Dear Ms. Akers:

The Florida Department of Environmental Protection has concluded its review of the draft EIS regarding the above referenced project. The proposed action includes shock testing of the SEAWOLF submarine either offshore of Mayport, Florida or Norfolk, Virginia. Shock testing will entail a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity. The series of five detonations would be conducted at a rate of one detonation per week to allow time to perform detailed inspections of the submarine's systems. If conducted offshore of Mayport, the shock testing will be accomplished between May 1 and September 30, 1997. The specific location of the test will be contingent upon several parameters which include; 500 foot water depth, within 100 nautical miles from port, and results from pre-test marine mammal/turtle surveys to avoid areas which sustain these species. Based upon our review, the proposed activities are consistent with our authorities in the Florida Coastal Management Program. The Department's Bureau of Protected Species Management (BPSM), does, however, offer the following comments.

To reduce potential impacts to marine mammals and marine turtles a detailed survey and avoidance plan is proposed (defined as mitigation by the authors). This plan includes:

> Approximately three weeks prior to the shock test, aerial surveys would be conducted to select a primary and two secondary-test sites which have the fewest numbers of marine mammals and marine turtles. Two to three days prior to the test, additional aerial surveys will be accomplished to select a final test site. In the hours before each test, aerial and shipboard observers would search for marine mammals and turtles at the test site. Passive acoustic surveys would also be used to detect marine mammal calls. If any marine mammals or turtles were detected within the safety range of 2.05 nautical mile radius around the detonation point,

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> testing would be postponed until there are no marine mammals or turtles within the safety range. In addition, the mitigation plan identifies that the MART vessel should "investigate" any "large" accumulations of Sargassum identified by the aerial surveys. Any identified smaller juvenile turtles would be net captured and held onboard the MART vessel until conclusion of the test blast. After the explosion, aerial and shipboard observers would survey the test site. If survey results identify injury or mortality of marine mammals or turtles, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary.

With exception of the comments below, the draft EIS was considered overall to be thorough in identification of resources and identification of measures to reduce impacts to marine resources. The aerial survey data that was collected and provided in the document has proved very useful in our evaluation of the potential impacts to marine mammals and turtles.

The alternatives analysis with respect to timing and location of the test identified a time schedule of May through September if Mayport was the selected site. While no marine mammal or turtle survey activity was accomplished during winter months, the authors have identified the requirement to conduct the test during April through September 1997 due to vessel availability (after April 1997) and prior to the ships scheduled Post Shakedown Availability for unrestricted fleet operations in 1998. Additionally, winter months (between October and March) were considered to sustain unfavorable weather conditions to allow for safe testing of the vessel.

Impacts to Manatees: Due to the geographic location of the proposed shock testing, we have determined that the activity should have no effect on manatees. (13)

Right Whales: The following information is provided to augment the information contained within the draft EIS. (14)

> Within Florida waters, right whales have been observed from September to April (Mead, 1986, Kraus, et. al.,1986). Peaks in abundance occur between January and March. Alvarez, Lehman and Associates (1988) stated that 85% of the [winter] sightings occur between January and March. Mead (1986) describes seasonality in Florida "in the winter and early spring (November - April)." Studies conducted in 1988 and 1990 (Valade, 1988, and Slay, 1991) have documented some use in October and November.
>
> Between 1970 and 1996, there have been 40 documented right whale deaths (New England Aquarium Right Whale Mortality Database). Sixteen of the mortalities were calves; thirteen of the 40 were attributed to ship collisions, and two of the 40 were from net entanglements. Of these 40 documented mortalities, ten were in

Florida and six in Georgia. Since 1970, three of 16 mortalities in the southeast U.S. were attributed to ship strikes and all three have occurred since 1991. In addition, there have been other documented non-lethal collisions and recent fishing gear entanglements on the calving grounds. Two right whale carcasses were recovered in September 1989, one near St. Augustine and the other near Crescent Beach.

We approve of the proposed mitigation plan with regard to right whales. We do, however, recommend that tests not be conducted during the month of September based on the two recorded mortalities that occurred in September. (15)

Marine Turtles: Based upon aerial survey data and adjusted densities, the proposed action is assessed to result in mortality of 6 turtles, injury to 30 turtles, and acoustic discomfort to up to 293 turtles. While these figures are-considered to be "conservative estimates", due to the limited ability to sight marine turtles through aerial surveys, the potential for the assessed impacts are considered realistic.

Measures to reduce marine turtle impacts were not fully considered in the draft EIS. Specifically, shock testing during winter months was not considered due to scheduling and optimal weather conditions. In the absence of specific aerial survey data, it is anticipated that marine turtle congregations offshore of Norfolk, Virginia would be significantly low during the winter months. The EIS should fully evaluate the feasibility and impacts associated with winter testing in the Alternatives Analysis. (16)

If mortality to marine turtles is identified subsequent to an individual test event, it is requested that consultation with Department of Environmental Protection's Bureau of Protected Species Management staff be initiated prior to additional testing. (17)

Additionally, the following measures are considered necessary and appropriate to reduce impacts to marine turtles and maintain consistency.

1. The "mitigation" plan does not adequately protect hatchling and juvenile turtles associated with sargassum rafts. Dependent upon the time of testing, significant numbers of hatchlings could occur in association with these sargassum rafts. Additionally, detection of hatchlings from the MART vessel is anticipated to be limited due to the camouflage and concealment nature of the sargassum. It is specifically recommended that shock testing occur only in areas devoid of large sargassum rafts within the "Safety Zone". (18)

2. A federal Endangered Species Act, Section 7 consultation with the National Marine Fisheries Service (NMFS) has been initiated by the Department of the Navy. To date, a NMFS Biological Opinion with incidental take statement has not been issued.

Consistency with Chapter 370.12, Florida Statutes is contingent upon issuance of a federal incidental take statement for the anticipated marine turtle mortality, injury and disturbance. (19)

The Department appreciates the opportunity to review the proposed activities. If you have any questions regarding the above comments, please contact Mike Sole or Carol Knox of BPSM at (904) 922-4330. If I may be of further assistance, please contact me at (904) 487-2231

Sincerely,

Jim Wood
Office of Intergovernmental Programs

/jw
cc: Carol Knox, BPSM
Mike Sole, BPSM
Fritz Wettstein, Division of Marine Resources

COUNTY: State INTY

Message:

DATE: 06/17/96
COMMENTS DUE-2 WKS: 07/01/96
CLEARANCE DUE DATE: 07/29/96
SAI#: FL9606140468C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection X Game and Fresh Water Fish Comm State Transportation	South Florida WMD St. Johns River WMD RECEIVED JUN 21 1996 State of Florida Clearinghouse	Environmental Policy/C & ED RECEIVED BY GFC JUN 19 1996 OFFICE OF ENVIRONMENTAL SERVICES

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Navy - Draft Environmental Impact Statement - Shock Testing the Seawolf Submarine.

To: Florida State Clearinghouse
Department of Community Affairs
2740 Centerview Drive
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA
- ☒ No Comment
- ☐ Comments Attached
- ☐ Not Applicable

Federal Consistency
- ☒ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From: GFWFC
Division/Bureau: Environmental Services
Reviewer: Douglas B. Bailey
Date: 6-20-96

SENT BY: : 8- 2-96 : 1:02PM : Bureau of Folklife→ 904 414 0479:# 6

COUNTY: State

Message:

DATE: 06/17/96
COMMENTS DUE-2 WKS: ~~07/01/96~~ 7/24
CLEARANCE DUE DATE: 07/29/96
SAI#: FL9606140468C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Game and Fresh Water Fish Comm X State Transportation	South Florida WMD St. Johns River WMD	Environmental Policy/C & ED ALLFLA SAI-EIS-NAVY 962404 xref: 951065

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Federal Consistency
- ☑ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: Division of Historical Resources
Reviewer: Robin Jackson
Date: 7/31/96

COUNTY: State

Message:

DATE: 06/17/96
COMMENTS DUE-2 WKS: 07/01/96
CLEARANCE DUE DATE: 07/29/96
SAI#: FL9606140468C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Game and Fresh Water Fish Comm State X Transportation	South Florida WMD St. Johns River WMD	Environmental Policy/C & ED

RECEIVED JUN 25 1996 State of Florida Clearinghouse

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Project Description:

Department of the Navy - Draft Environmental Impact Statement - Shock Testing the Seawolf Submarine.

To: Florida State Clearinghouse
Department of Community Affairs
2740 Centerview Drive
Tallahassee, FL 32399-2100
(904) 922-5438 (SC 292-5438)
(904) 487-2899 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: Environmental Management
Reviewer: Gary Evink
Date: 6/21/96

COUNTY: State

Message:

DATE: 06/17/96
COMMENTS DUE-2 WKS: 07/01/96
CLEARANCE DUE DATE: 07/29/96
SAI#: FL9606140468C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Game and Fresh Water Fish Comm State Transportation	South Florida WMD X St. Johns River WMD	Environmental Policy/C & ED

RECEIVED JUL 05 1996 State of Florida Clearinghouse

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Project Description:

Department of the Navy - Draft Environmental Impact Statement - Shock Testing the Seawolf Submarine.

To: Florida State Clearinghouse
Department of Community Affairs
2740 Centerview Drive
Tallahassee, FL 32399-2100
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- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: Division of Policy and Planning
Reviewer: Margaret H. Spontak
Date: June 28, 1996

COUNTY: 'State '

Message:

DATE:	06/17/96
COMMENTS DUE-2 WKS:	07/01/96
CLEARANCE DUE DATE:	07/29/96
SAI#:	FL9606140468C

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Game and Fresh Water Fish Comm State Transportation	X South Florida WMD St. Johns River WMD	Environmental Policy/C & ED RECEIVED JUN 25 1996 State of Florida Clearinghouse

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evaluation and is categorized as one of the following:

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- Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.
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Project Description:

Department of the Navy - Draft Environmental Impact Statement - Shock Testing the Seawolf Submarine.

To: Florida State Clearinghouse
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- ☐ Inconsistent/Comments Attached
- ☒ Not Applicable

THIS ACTIVITY IS NON-JURISDICTIONAL TO THE SFWMD

From:
Division/Bureau: REGULATION DEPT.
Reviewer: JIM GOLDEN
Date: 6/21/96

State of Florida, Department of Community Affairs

Florida State Clearinghouse
Written Comment, July 29 and August 7, 1996

Navy Response:

I1. Recommendations from the Florida Department of Environmental Protection are addressed in the separate response to the agency's comment letter.

I2. As explained in Section 11.7 of the DEIS, shock testing would not have any impact on the resources or uses of the coastal zone of any state. Therefore, a consistency determination under Section 307 of the Coastal Zone Management Act is not necessary.

Florida Department of Environmental Protection

Written Comment, July 26, 1996

Navy Response:

I3. Comment noted.

I4. Additional information on right whales has been incorporated into the Existing Environment, Section 3.0 of the FEIS.

I5. Although two right whale strandings did occur in September 1989, the possibility of a right whale being present in the Mayport area during the potential test period (May through September) is remote. Right whales generally occur off Mayport from November/early December to April, with peak abundance between January and March (Kraus et al., 1993). Of 401 right whale sightings between 1950 and 1995, none occurred during May through September (R.D. Kenney, personal communication, Univ. Rhode Island). No right whales were seen during the April-September aerial surveys in 1995 or May-September surveys in 1997.

Even if a right whale were present, it would almost certainly be detected by pre-detonation monitoring, as described in Section 5.0 of the FEIS. According to recent aerial observations in the Mayport area during the calving season, right whales spend 15-87% of their time on the surface, with averages of 36% for single juveniles, 72% for mother/calf pairs, and 79% for surface active groups (Hain and Ellis, 1995). Therefore, during the 2.5 hours preceding detonation, a right whale could be on the surface for a total of 22 minutes to over 2 hours. Mean dive times are a few minutes. The probability of at least one aerial or surface observer detecting large animals which spend so much time at the surface is near 100%.

I6. Winter testing off Norfolk is not a reasonable alternative because weather conditions would preclude conducting the tests. This alternative would not meet operational requirements. Information supporting this conclusion has been added to the FEIS. There is no point in analyzing environmental impacts of a winter alternative, because the Navy cannot conduct the test under those conditions.

I7. If events including the mortality of any species warrant it, the Navy will suspend shock testing and consult as necessary with the appropriate parties.

I8. The FEIS includes changes to the mitigation program (Section 5.0) designed to improve protection of juvenile and hatchling sea turtles. These include avoidance of sargassum-rich areas during test site selection (to the extent possible) and postponement of detonation if large sargassum rafts are observed within the safety range. As suggested by the comment, these changes shift the emphasis to avoidance of sargassum rafts rather than detecting and removing juvenile or hatchling turtles from them.

I9. Comment noted. The Navy has complied with the requirements of the Endangered Species Act (ESA) and has included the Biological Opinion as Appendix G. The Navy will continue to comply with all requirements of the ESA.

J

Georgia Department of Natural Resources
One Conservation Way, Brunswick, Georgia 31523-8600
Lonice C. Barrett, Commissioner
Duane Harris, Director
Coastal Resources Division
912/264-7218
FAX 912/262-3143

July 30, 1996

Mr. Will Sloger (Code 064WS)
Department of the Navy
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406

Dear Mr Sloger:

Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement (DEIS) that evaluates the environmental effects of shock testing the SEAWOLF off the east coast. Comments regarding marine mammals and turtles are being deferred to our agency's Wildlife Resources Division, Nongame-Endangered Wildlife Program.

On April 30, 1995 we responded to your request to identify significant issues that should be addressed in the DEIS. Based on our recent review of the draft document, most of our marine fisheries concerns have been alleviated. There are, however, two areas of concern which remain. The first deals with the conclusion that no hardbottom areas exist along the 152m depth contour. In spite of limited survey data for this depth zone, we feel that hardbottom and other habitats which may occur in the test sites need to be better identified. One potential source of information is the regional database developed by the Atlantic component of the Southeast Area Monitoring and Assessment Program (SEAMAP-SA). The contact is: Ms. Robin Peuser, SEAMAP-SA Coordinator, Atlantic States Marine Fisheries Commission, 1444 Eye Street, N.W., 6th Floor, Washington, D.C. 20005. (J1)

Our second concern is the inability of site surveys to locate sub-surface aggregations of fish, especially groupers. Found over sand areas as well as rocky bottom, these highly overfished and stressed stocks cannot withstand further disruption if they are to recover under current management regimes. Being demersal but often occurring well up into the water column, they will not be detected through visual observations on the surface but will likely be killed or injured by the detonations. It would be appropriate to conduct bottom surveys for the presence of hard bottom a few days prior to testing. Remote sensing equipment could be used to detect significant bottom aggregations or indications of hardbottom that should be further investigated. (J2)

For a more detailed description of these significant issues and precautions, I have attached a memorandum from Henry Ansley, our Outer Continental Shelf Program Leader. He is well

Mr Will Sloger
July 30, 1996
Page Two

acquainted with impacts to Georgia's marine fish species and has carefully reviewed the DEIS. Should your agency require any additional information, please do not hesitate to contact Henry or me.

Sincerely,

Susan Shipman

Susan Shipman, Chief
Marine Fisheries Section

attachment

cc: South Atlantic Fishery Management Council
Duane Harris
Henry Ansley
Ron Michaels
Mike Harris

Georgia Department of Natural Resources
One Conservation Way, Brunswick, Georgia 31523-8600
Lonice C. Barrett, Commissioner
Duane Harris, Director
Coastal Resources Division
912/264-7218
FAX 912/262-3143

July 27, 1996

MEMORANDUM

TO: Ron Michaels

FROM: Henry Ansley

SUBJECT: Seawolf DEIS Comments

I agree with your assessment that most fishery concerns have been addressed. Regarding our earlier comments regarding marine mammals and sea turtles, I think it best to defer to WRD's Non-Game Section.

The conclusion regarding the non-existance of hardbottom (ie., rock bottoms, not coral reefs) along the 152m depth contour (pp. 2-14 , 3-1, & 3-4) site seems broad, but generally reflects earlier reports regarding this depth zone. From a review of the FMP/FEIS for Coral and Coral Reefs and recent information on the Oculina HAPC, it does appear that typical coral reefs are generally within the 100m contour, although other intense coral assemblages do occur in very deep water (200m +).

Overall, it appears that actual survey data for this depth zone are limited. A potential source of survey information that should be considered prior to determination of the final test site are bottom survey data currently being synthesized by the Bottom Mapping Work Group assigned to the Atlantic component of the Southeast Area Monitoring and Assessment Program (SEAMAP-SA), Atlantic States Marine Fisheries Commission. This regional database is designed to identify and compile survey coordinates on hard bottom and other habitats on the continental shelf from Florida to North Carolina out to 200m in depth. To date, reports have been prepared for Georgia, South Carolina, and North Carolina; current program survey activities are ongoing off Florida. J1

The Seawolf DEIS also correctly references the possible presence of tilefish resources in the potential test site, but does not reference the possible presence of deepwater groupers. According to FAO sources, species that may occur in the 152m depth zone include graysby, speckled/red hinds, and marbled, yellowedge, misty, warsaw, snowy, and yellowmouth groupers. Some of these groupers represent commercially important fisheries or, worse, represent extremely overfished and stressed stocks. Species like the yellowedge and red groupers can be found over sand areas, as well as rocky bottom. J2

Long-lived, many species of groupers form highly structured spawning aggregations, which are extremely susceptible to fishing pressure. For example, Nassau grouper were at one time one of the the most abundant South Atlantic groupers; however, this species also formed intense spawning aggregations that were heavily exploited. As a result, the aggregations have virtually disappeared and the stock has essentially collapsed - today, harvest of Nassau grouper is prohibited. A similar story is true for jewfish. In fact, some scientists have suggested that these species may in fact be endangered.

The SAFMC has concluded that many, if not most, of the deepwater grouper stocks are overfished and stressed, including speckled hind and warsaw, snowy, yellowmouth, yellowedge, and misty groupers. For these and any other species already stressed, disruption of any remaining spawning aggregations could have significant impacts on stock recovery.

As far as I could tell, the Seawolf DEIS did not address our concerns regarding possible spawning or other aggregations of demersal species, although significant attention was paid to schooling surface fish. The DEIS evidently feels that demersal species will not be impacted (p.4-35) since these fish are associated with the bottom, where the effects of an explosion are minimized; however, earlier observations of grouper spawning activities have shown that aggregations typically extend well up in the water column, presumably where they would be more subject to the effects of an explosion.

While the Seawolf DEIS has proposed site surveys to detect surface schools, it is unlikely that these surveys would be able to locate sub-surface aggregations, even though these aggregations may extend well up into the water column. Since the DEIS did not specifically deal with aggregations, however, it is not suprising that monitoring considerations have similarly been left out.

In order to avoid impacts to potentially critical spawning aggregations, as well as to identify possible hardbottom, it seems that it would be appropriate to conduct a thorough bottom surveys of the specific test site(s?) identified within the potential testing area. The survey would be conducted a few days prior to testing (formation of aggregations evidently occur over several weeks) and may simply utilize fathometers, colorscopes, and other remote sensing equipment that will detect the presence of any significant bottom aggregations or indications of hardbottom that should be further investigated. This requirement is not unusual - oil and gas development interests must conduct intensive surveys of bottom resources prior to rig placement. Especially in light of the relatively limited size of the potential impact area within the specific test site and if the same site is utilized for all tests (at least as regards the presence of hardbottom), conducting this type of site specific survey does not seem to be an unreasonable precaution.

Please let me know if you feel these concerns are legitimate or not. Overall, the DEIS does address most fisheries concerns and I feel that we should not just submit comments for commenting's sake. Thanks.

cc: Susan Shipman

Georgia Department of Natural Resources
Nongame/Endangered Wildlife Program Coastal Office
One Conservation Way, Brunswick, Georgia 31523-8600
Lonice C. Barrett, Commissioner
David Waller, Director
Wildlife Resources Division
912/264-7218
FAX 912/262-3143

September 17, 1996

L. M. Pitts
Head, Environmental Planning
Department of the Navy
SD/NFEC
POB 190010
N Charleston, SC 29419-9010

Dear Mr. Pitts:

The Department has reviewed the draft Environmental Impact Statement Shock Testing the Seawolf Submarine. The Navy proposes to detonate five 10,000 pound explosive charges offshore of Mayport Florida, or Norfolk Virginia, as part of a shock test of the USS Seawolf Submarine. The detonations will occur at approximately one week intervals with increasing intensities. If offshore of Mayport Florida is chosen as the testing site, tests are proposed to occur between May 1 and September 30, 1997. Whether offshore of Mayport or Norfolk, the final specific test site would not be selected until two to three days prior to testing and will be based on the results from marine mammal and sea turtle surveys. However, all points along the 500' depth contour line will be considered as a test site.

A. Marine Mammals

The department is concerned that the detonating 10,000 pound explosive charges offshore of Norfolk Virginia in April may threaten migrating endangered right whales. Right whales have been documented in the calving critical habitat area off of Georgia and Florida as late as April prior to migrating north to the coasts of Maine and Canada. Therefore, it seems prudent to assume that right whales may remain in the calving area through April before migrating northward past Virginia. For this reason, the Department highly recommends that shock tests offshore of Virginia not be commenced until June 1 and be completed by September 30, prior to right whales migration route for the winter. (J3)

B. Sea Turtles

Under Environmental Consequences 4.0, Indirect Impacts pg. 4-33, juvenile loggerhead sea turtles would be searched for prior to any detonations. It would be logistically unfeasible to even attempt to locate juvenile loggerheads associating with sargassum weed flotsam. The animals are small and extremely cryptic. By the time even small areas of the sargassum had been searched for turtles, the weed mats would have floated out of the target area. A much more efficient way to avoid high juvenile mortality would be to select an area devoid of and sargassum (J4)

Under Mitigation and Monitoring 5.0, Marine Mammal and Sea Turtle Mitigation Plan pg. 5-2, an addition should be made. Leatherback sea turtles migrate along the Georgia coast in significant numbers during April and May. A delay in testing until June 1 is recommended. Leatherback behavior, density, and lines of travel appear to be closely tied to the movements of cannonball jellyfish (*Stomolophus*). Shoals of these pelagic drifting jellyfish can indicate the presence of other sea turtles including both loggerheads and Kemp's ridleys. It would be prudent for the Mitigation Components/Teams to watch for shoals of jellyfish during the pre-detonation monitoring phase, and recommend a delay in detonation when large concentrations of jellyfish float through the target area. (J5) (J6)

Thank you for your considering our concerns with the Seawolf Shock Testing project.

Sincerely,

Mike Harris
Senior Wildlife Biologist

cc: Terry Johnson

Susan Shipmen

Georgia Department of Natural Resources

Written Comment, July 30, 1996

Navy Response:

J1. The original conclusion of no hard bottom was based on computer searches of National Ocean Service (NOS) data files (Department of the Navy, 1995a). In response to this comment, the Navy reviewed reports on the SEAMAP bottom mapping program for Georgia and South Carolina (Van Dolah et al., 1994) and North Carolina (Moser et al., 1995) and conducted a computer search of the SEAMAP database. The database includes information from trawl sampling, side-scan sonar, and underwater television surveys.

SEAMAP data for the Mayport area confirm that the seafloor is predominantly soft bottom. Of 26 points within 9.3 km (5 nmi) of the 152 m (500 ft) depth contour, 21 points are soft bottom, 3 are hard bottom, and 2 are potential hard bottom. More importantly, of 10 points located within 1.85 km (1 nmi) of the Mayport area, all are soft bottom. Based on the 1.85 km (1 nmi) buffer zones for hard bottom used in the EIS, there is no indication that portions of the Mayport area need to be excluded from testing.

SEAMAP data for the Norfolk area also confirm that the seafloor is predominantly soft bottom. No hard bottom points are located within 1.85 km (1 nmi) of the area. Four points classified as *potential* hard bottom are located within 1.85 km (1 nmi) of the Norfolk area and have been excluded from testing.

J2. Information on grouper spawning aggregations has been added to the FEIS. However, there is no definitive evidence that such aggregations could be present at the test area or that they would extend high enough into the water column to be significantly affected. If such aggregations were present in the region, they would most likely be associated with hard bottom, but the Mayport area is predominantly soft bottom (see response J1). Therefore, the Navy does not consider it necessary to conduct additional surveys with fathometers or fish-finders prior to shock testing.

The comments on grouper spawning aggregations come from published accounts for the Nassau grouper (Smith, 1971; Olsen and Laplace, 1978; Colin et al. 1987; Colin, 1992, 1996). However, Nassau grouper is very rare in continental U.S. waters. It is a shallow (<100 m), reef-dwelling grouper occurring primarily in waters of the Bahamas, Antilles, and Caribbean. This grouper is not currently nor was it historically an important fishery species in U.S. waters. All significant U.S. landings of Nassau grouper could be traced to the Bahamas or Caribbean locations.

Of the eight grouper species cited in this comment letter, only the speckled hind, Warsaw grouper, snowy grouper, and yellowedge grouper would be expected to occur in appreciable numbers at the Mayport area. Red hind and misty, yellowmouth, grasby, and marbled groupers are not common in U.S. continental waters. The four deepwater species that would be expected in the area are of fishery importance and the South Atlantic Fishery Management Council considers them to be overfished. The available information (published, unpublished, anecdotal), does not support or refute the claim that spawning aggregations of any deepwater groupers occur in the test area off Mayport. The only information on grouper spawning from the U.S. east coast comes from submersible observations made by Harbor Branch scientists working near *Oculina* reefs offshore of Ft. Pierce, Florida (Gilmore and Jones, 1992). Their study subjects were two shallow water species, gag and scamp. Neither species formed aggregations *per se* and neither made extended forays into the water column.

Groupers are generally associated with hard bottom. As noted above, the seafloor at the Mayport site is predominantly soft bottom. Of the four deepwater species cited above, the yellowedge grouper is known to occur over soft bottom; they have been documented to cohabitate with burrow-dwelling tilefish (Jones et al., 1989) which occur off the Georgia coast. But there is no information on spawning aggregations.

Even if grouper aggregations were present and extended some distance into the water column, few if any are likely to be killed. A calculation of tilefish mortality contours for a 4,536 kg (10,000 lb) charge detonated at a depth of 61 m (200 ft) was made for a previous environmental assessment (Department of the Navy, 1981). For an explosion at a depth of 30 m (100 ft), the contours would move upward by 17 m (55 ft). Only the 10% mortality contour approaches the bottom. Therefore, few if any groupers would be killed by the detonations even if an aggregation were present.

J3. With regard to right whales, the most important scheduling consideration is to avoid the calving season off Mayport (generally, December through March). The original time frame of April through September avoided the calving season, and the decision to not test in April at Mayport (based on high turtle densities) provided additional protection. Although right whales do migrate along the North Carolina and Virginia coast during early spring, the Navy believes that shock testing could be conducted at the Norfolk area during this time without risk to right whales, for the following reasons:

- No right whales were seen at Norfolk during April or May 1995 aerial surveys (in fact, none were seen during April through September at either Mayport or Norfolk).

- During the spring migration, right whales are believed to transit offshore North Carolina in <u>shallow</u> water immediately adjacent to the coast (Lee and Socci, 1989).

- If any right whales were present, they would almost certainly be detected by mitigation because they are large and spend a lot of time on the surface (Hain and Ellis, 1996). See response I5 for further information.

In addition, deleting April from the Norfolk schedule would weaken the Norfolk alternative as a whole because marine mammal and turtle densities were low during this month. Therefore, the schedule at Norfolk is unchanged in the FEIS (April through September).

J4. The FEIS includes changes to the mitigation program (Section 5.0) designed to improve protection of juvenile and hatchling sea turtles. These include avoidance of sargassum-rich areas during test site selection (to the extent possible) and postponement of detonation if large sargassum rafts are observed within the safety range. As suggested by the comment, these changes shift the emphasis to avoidance of sargassum rafts rather than detecting and removing juvenile or hatchling turtles from them.

J5. A delay until June 1 (i.e., omitting May) at Mayport is not appropriate. Although leatherbacks may migrate along the Georgia coast during April and May, there is no indication that they are present in higher numbers at the offshore Mayport test area during this time. During the 1995 aerial surveys, no leatherbacks were seen there during April or May, and only one leatherback was seen during May 1997 surveys.

The FEIS includes changes to the mitigation program (Section 5.0) which should further reduce potential impacts to leatherback turtles if they are present. These include tighter line spacing for aerial monitoring, addition of a third aerial observer, and postponement of detonation if large concentrations of jellyfish are present within the safety range. These are in addition to the measures cited above for juvenile and hatchling turtles (see response J4).

J6. The mitigation program (Section 5.0) has been revised to address this comment. Aerial observers would report jellyfish shoals to the Lead Scientist as a possible indicator of sea turtle presence. Detonation would be postponed if large concentrations of jellyfish are present within the safety range.

K

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Coastal Management

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
Roger N. Schecter, Director

DEHNR

July 30, 1996

Mr. Will Sloger (Code 064WS)
Department of the Navy
Southern Division, NFEC
2155 Eagle Drive
Charleston, SC 29406

Reference: DEIS Shock Testing the SEAWOLF Submarine

Dear Mr. Sloger:

The Division of Coastal Management has reviewed the referenced document for the proposed shock testing of the SEAWOLF Submarine in waters of the Atlantic Ocean. The document states that the preferred alternative is to test the submarine in waters off of the coast of Mayport, Florida. The other primary alternative considered is a location offshore from the Norfolk area. If the Mayport alternative is selected, the project is not likely to have any impact on the resources or uses of the coastal zone of North Carolina. Therefore, no formal consistency determination pursuant to 15 CFR 930 Subpart B will be required. (K1)

We appreciate the opportunity to review this document, and we request that we be provided a copy oft the final EIS when it becomes available. Thank you for your consideration of the North Carolina Coastal Management Program.

Sincerely,

Stephen B. Benton
Consistency Coordinator

cc: Dennis Spitzbergen, NC Division of Marine Fisheries

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Raleigh, North Carolina 27611-7687
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State of North Carolina

Department of Environment, Health and Natural Resources
Division of Coastal Management
Written Comment, July 30, 1996

Navy Response:

K1. Comment noted.

L

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY

George Allen
Governor

Becky Norton Dunlop
Secretary of Natural Resources

Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 10009, Richmond, Virginia 23240
Fax (804) 698-4500 TDD (804) 698-4021
http://www.deq.state.va.us

Thomas L. Hopkins
Director

(804) 698-4000
1-800-592-5482

July 24, 1996

Mr. L. M. Pitts
Head, Environmental Planning
Department of the Navy
Southern Division
Naval Facilities Command
P.O. Box 190010
2155 Eagle Drive
North Charleston, South Carolina 29419-9010

RE: Draft Environmental Impact Statement for the Seawolf Ship Shock Test

Dear Mr. Lantz:

The Commonwealth of Virginia Agencies have completed their review of the Draft Environmental Impact Statement (DEIS) for the noted action. The Department of Environmental Quality is responsible for coordinating Virginia's review of federal environmental documents and responding to the appropriate officials on behalf of the Commonwealth. The following planning district and agency participated in this review:

Department of Environmental Quality; and
Hampton Roads Planning District Commission.

In addition, the Marine Resources Commission, the Institute of Marine Sciences and the City of Norfolk were invited to comment through the Department of Environmental Quality.

The proposed action is to shock test the Seawolf submarine at an offshore location well outside of territorial seas. The two preferred sites are Mayport, Florida and Norfolk, Virginia (approximately 80 to 100 nautical miles from Naval Base Norfolk). The submarine would be subjected to a series of five 4,536 kg (10,000 lb) explosive charge detonations of incrementally increasing intensity sometime between April 1 and September 30, 1997.

An Agency of the Natural Resources Secretariat

Mr. L. M. Pitts
Page Two

The Commonwealth offers the following comments and recommendations:

- It appears that the project will not have a significant adverse environmental impact; and (L1)
- Based on precautions described in the DEIS, it appears that no impact to Federally listed species will occur; and (L2)
- Accordingly, the Commonwealth finds the proposed action to be consistent with the Virginia Coastal Resources Management Program. (L3)

Thank you for the opportunity to comment on the DEIS for the proposed activity. The comments of the reviewing agencies are attached for your review and consideration.

Sincerely,

Michael P. Murphy
Director, Grants Management
and Intergovernmental Affairs

Attachments

cc: Arthur L. Collins, Hampton Roads PDC
James B. Oliver, Jr., City of Norfolk
Traycie West, DEQ-TRO

Environmental Quality

JUL 16 1996

Public & Inter-governmental Affairs

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YORK COUNTY
Sheila S. Noll County Supervisor
Daniel M. Stuck County Administrator

July 11, 1996

Mr. Thomas M. Felvey
Environmental Technical Services
Virginia Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23219

Re: Seawolf Shock Testing EIS
(ENV:GEN)

Dear Mr. Felvey:

Pursuant to your request of June 27, 1996, the staff of the Hampton Roads Planning District Commission has reviewed the Draft Environmental Impact Statement: Shock Testing the Seawolf Submarine.

Based on this review, it appears that the proposed exercise will not have a significant adverse environmental impact in or near the Hampton Roads Region. The proposal does not appear to conflict with any local or regional plans.

We appreciate the opportunity to participate in this review. If you have questions, please do not hesitate to call.

Sincerely,

Arthur L. Collins
Executive Director/Secretary

JMC/lw

HEADQUARTERS · THE REGIONAL BUILDING · 723 WOODLAKE DRIVE · CHESAPEAKE, VIRGINIA 23320 · (804) 420-8300
PENINSULA OFFICE · HARBOUR CENTRE, 2 EATON STREET · SUITE 502 · HAMPTON, VIRGINIA 23669 · (804) 728-2067

If you cannot meet the deadline, please notify ELLIE IRONS at 804/698-4325, THOMAS M. FELVEY at 804/698-4315, or R. THOMAS GRIFFIN AT 804/698-4337 prior to the date given. Arrangements will be made to extend the date for your review if possible. An agency will not be considered to have reviewed a document if no comments are received (or contact is made) within the period specified.

REVIEW INSTRUCTIONS:

A. Please review the document carefully. If the proposal has been reviewed earlier (i.e. if the document is a federal Final EIS or a state supplement), please consider whether your earlier comments have been adequately addressed.

B. Prepare your agency's comments in a form which would be acceptable for responding directly to a project proponent agency.

C. Use your agency stationery or the space below for your comments. IF YOU USE THE SPACE BELOW, THE FORM MUST BE SIGNED AND DATED.

Please return your comments to:

DEPARTMENT OF ENVIRONMENTAL QUALITY
OFFICE OF ENVIRONMENTAL IMPACT REVIEW
629 EAST MAIN STREET, SIXTH FLOOR
RICHMOND, VA 23219
FAX #804/698-4319

Thomas M. Felvey
Environmental Technical
Services Administrator

COMMENTS

TRO has no Comments

(signed) Tracy West (date) 7/15/96
(title) Environmental Specialist Senior
(agency) Department of Environmental Quality

PROJECT # 96-106 F

12/95

APPENDIX H

Commonwealth of Virginia

Department of Environmental Quality
Written Comment, July 24, 1996

Navy Response:

L1. Comment noted

L2. Comment noted.

L3. As explained in Section 11.7 of the DEIS, shock testing would not have any impact on the resources or uses of the coastal zone of any state. Therefore, a consistency determination under Section 307 of the Coastal Zone Management Act is not necessary.

M

Equal Opportunity/Affirmative Action Employer

REGULATORY & ENVIRONMENTAL
SERVICES DEPARTMENT
Air & Water Quality Division

CITY OF JACKSONVILLE, FLORIDA

July 10, 1996

Mr. L. M. Pitts
Environmental Planning
Department of the Navy - Southern Division
Naval Facilities Engineering Command
Post Office Box 190010
North Charleston, SC

Dear Mr. Pitts:

The City of Jacksonville Air and Water Quality Division (AWQD) has reviewed the Draft Environmental Statement (DEIS) for the Seawolf Ship Shock Test. Based upon the information presented in the DEIS, the AWQD is in agreement that testing offshore of Mayport, Florida is the most responsible alternative. Shock testing offshore Mayport would allow the Navy to meet the requirements of 10 USC 2366, and minimize potential environmental damage (specifically, harm to marine mammals). (M1)

AWQD supports shifting the testing schedule to avoid higher sea turtle concentration in April. AWQD encourages the Navy to take every reasonable precaution to avoid injury to marine mammals in the test area. (M2)

AWQD appreciated the opportunity to review the DEIS for the Seawolf Ship Shock Test and wishes the Navy a successful test. (M3)

Very truly yours,

James L. Manning, P.E.
Chief

JLM/ns

File: Manning\pitts.nav

421 West Church Street - Suite 422
Jacksonville, Florida 32202-4111

Air Quality	630-3484
Water Quality	630-3461
Ground Water	630-4900
Hazardous Materials	630-3404

City of Jacksonville, Florida

Regulatory & Environmental Services Department
Air & Water Quality Division
Written Comment, July 10, 1996

Navy Response:

M1. Comment noted.

M2. Comment noted.

M3. Comment noted.

N

Cetacean Society International

P.O. Box 953
Georgetown, CT 06829 U.S.A.

Phone/Fax: 203-544-8617
E-Mail: 71322.1637@compuserve.com

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29 July 1996

Attn: Mr. Will Sloger (Code 064WS)
Department of the Navy,
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive.
North Charleston, SC 29406

Dear Mr Sloger:

The following comments are submitted by Cetacean Society International concerning the Draft Environmental Impact Statement "SHOCK TESTING THE SEAWOLF SUBMARINE". We ask that they be forwarded and considered in the DEIS review

We commend the authors on an apparent effort to consider all aspects and to consult with experts with a view to minimize the negative impacts of the shock testing on the marine environment, particularly marine mammals. However, we respectfully submit that there may be additional considerations that are appropriate.

The mitigation and monitoring program proposed before, during and after each explosion can not be certain of detecting the majority of cetaceans and other large marine animals within the exclusion zone. Numerous studies of aerial and shipboard survey techniques demonstrate that a significant percentage of target organisms will remain visually undetected. MMATS will be useless for finding silent baleen whales. The critically endangered North Atlantic right whale may not be known to be a frequent visitor to the test waters during the scheduled period, perhaps because of inadequate observer effort, but this species is known to remain underwater for considerable periods and not all individuals in studied baleen whale popuations follow standard migration patterns. Any potential impact to this species must be reason to develop an assured exclusion protocol or to delay a test detonation because, with a population lower than 300 individuals, the loss of one whale is extremely significant. (N1)

The major risk to organisms from the proposed test is from direct trauma caused by the explosions. Long term.detrimental effects such as population displacement caused by "noise pollution" seem of less concern, given the brief but traumatic events temporally spaced about once per week. It is the "no warning" aspect of these tests that concerns us the most, and we therefore urge any and all means to alert organisms and cause them to leave the exclusion zone. We also refer you to Ketten (1995), who stated that, given uncertainties about the protection afforded to marine mammal auditory systems by aquatic adaptations, 5 km is a more reasonable safe range for a 10,000 lb explosion. Then add the 1.8 km to define the exclusion zone. We concur with the contention that "a deaf whale is a dead whale". Give them a chance. (N2)

Therefore, we strongly urge further active mitigation in the form of a **soft start**. As employed elsewhere during maritime seismic surveys, as in Goold (1996), the proposed **soft start** could be produced from an array of pneumatic sleeve guns arranged in clusters suspended from floats or auxillary vessels. A **soft start** protocol would begin when the exclusion zone was observed clear, with a repeated firing of one gun , followed by a cluster of perhaps three guns, increasing with numbers of guns and resultant sound levels over a period of minutes suitable to cause the slowest swimming relevant species to exit the exclusion zone, and certainly be alerted to further acoustic impacts. Air gun pressure pulse rise time is slower than high explosives, and as such carries less impulse. After the peak air gun crescendo it may also be prudent to detonate medium sized chemical explosive charges as a bridging deterrent between the soft start and the test detonation If relevant animals are detected in the exclusion zone during the soft start the test detonation should be postponed (N3)

If the true intent of the test detonation includes minimal impact on large marine animals then the soft start protocol would actually assist the test by causing relevant species to exit the area. In the referenced example an array of 38 sleeve guns, fired simultaneously, produced a combined source level of some 215dB re 1uPa at 50 Hz. High frequencies (kHz) were also present, but at lower levels. No evidence of injury was found, and continual monitoring suggested avoidance behavior of the blast area by, in this case, common dolphins. Mate (1994) noted a similar reaction by sperm whales to seismic surveying; if anything a more extreme avoidance

While larger species may be presumed to be more sensitive to lower frequencies, some species such as the the right whale might be inured or tolerant of initial soft start levels as the species may often be subjected to high human-induced sound levels in their normal habitat. Indeed, it must be determined that their individualized avoidance behavior is not merely a hovering state at a depth where conditions minimize the sound levels. The critical North Atlantic right whale population demands both a soft start protocol and a determination that avoidance behavior results in exiting the area. Any potential for an undetected right whale in the exclusion zone during a test should postpone the test.

Further specific comments to the DEIS include:

5-3 The Norfolk and Mayport sites along the 500m depth contour still represent shallow water ducts, in that proposed lateral safe distances for cetaceans are considerably greater than the water depth. Further, it is stated (3-1) that the seabed at both sites is primarily sand. Urick (1982, chapter 9) presents data for shallow water propogation across different bottom substrates, where transmission loss over sand at between 12 kHz and 24 kHz is less than over mud or rock. In addition, the energy spectra for the 10,000 lb explosion, even at 6 NM from source, exceeds the extrapolated auditory safety limit for cetaceans at high frequencies (E-15, E-18). Together these factors suggest a greater potential for trauma and we urge that choices of test sites consider them. (N4)

4-11 Sound levels where quoted in dB with no reference units are meaningless. And what band of frequencies are included in the "sound pressure levels of 180 dB (again unreferenced) could occur within a radius of about 2.6 to 3.7 km" comment? (N5)

5-7 Given the nature of the discussion, more operational information is needed on the Marine Mammal Acoustic Tracking System. Is it a manual system, automatic threshold/triggering system, or an advanced signal processor for detection of cetacean calls? Does it include a multi-channel differential arrival-time processor for bearing and range? The "transient acoustic signals" localized by the MMATS are unclear. If "transient" is not meant in a general sense, but rather in the usual way it is applied to dolphin clicks, there may be a contradiction here. (N6)

5-21 The post-event one month coordinated effort to determine the potential for acoustic trauma as a cause for strandings (and presumably deaths and/or aberrant behavior reported at sea) is not a realistic minimum. It assumes that the effects are almost immediately fatal. I have witnessed a humpback that stranded and died perhaps a year after a net entanglement made swimming nearly impossible. This whale, perhaps like a deaf whale, could not feed and survived on blubber stores. He actually died from dehydration. If there is trauma that results in infection, disorientation, dehydration or starvation death may take a terribly long time. Another realistic factor to be considered is continuing logistical and funding support for an immediate professional pathological inspection of the ear structures in a stranded cetacean. This procedure requires considerable skill and experience, and a rapid response from a very short list of qualified experts is essential to prevent loss of data from deterioration or technique. (N7)

Thank you for the opportunity to review the referenced DEIS

Respectfully submitted,

William W. Rossiter
President

Literature Cited

Goold J.C. (1996) "Acoustic assessment of populations of common dolphin, Delphinus dephis, in conjunction with seismic surveying." Journal of the Marine Biological Association of the UK76(3), 813-822

Ketten D. (1995) "Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions." Sensory Systems of Aquatic Mammals (1995)

Mate B.R., Stafford, K.M. and Ljungblad D.K. (1994) " A change in sperm whale (Physter macrocephalis) distribution correlated to seismic surveys in the Gulf of Mexico." Journal of the Acoustical Society of America 96(5), 3268-3269

Urick R.J. (1982) "Sound propogation in the sea." Peninsula Publishing ISBN 0-932146-08-2

Cetacean Society International

William W. Rossiter
Written Comment, July 29, 1996

Navy Response:

N1. Mitigation cannot be certain of detecting all marine mammals. However, based on the low marine mammal densities at Mayport and the previous experience of the USS JOHN PAUL JONES shock trial in 1994 (conducted in an area with about 25 times higher marine mammal densities than at Mayport, based on 1995 survey data), the Navy believes the testing can be done with very little risk of harming these animals. The extensive monitoring/mitigation effort described in Section 5.0 is designed to reduce the risk of impact to all marine mammals and turtles to the lowest possible level.

Right whales are of special concern because of their highly endangered status. However, the possibility of a right whale being present in the Mayport area during the May through September time period is remote. And even if a right whale were present, it would almost certainly be detected by pre-detonation monitoring. See response I5 for information supporting these conclusions.

The mitigation plan in Section 5.0 of the FEIS incorporates additional requirements specified in the Biological Opinion issued by the NMFS (Appendix G). If a northern right whale were sighted, detonation would be postponed until the animal was positively determined to be outside the buffer zone and at least one additional aerial survey of the safety range and buffer zone showed that no other right whales were present.

N2. The total radius of the "Safety Range" and "Buffer Zone" is 5.6 km (3 nmi), which exceeds Ketten's (1995) recommendation of a 5 km (2.7 nmi) safe range and is more than adequate to protect against marine mammal mortality and injury. The 3.7 km (2 nmi) Safety Range is three times the mortality range predicted in the FEIS and twice the predicted injury range. The 5.6 km (3 nmi) buffered Safety Range is five times the predicted mortality range and three times the predicted injury range. Both ranges are much greater than the distances for mortality (0.07 to 0.8 km) and serious injury (0.15 to 0.9 km) estimated by Ketten (1995).

As explained in Section 5.0 of the FEIS, detonation would occur only when there are no marine mammals or turtles detected within the safety range of 3.7 km (2 nmi). The Biological Opinion issued by NMFS in December 1996 specified additional criteria regarding site selection to minimize potential impacts, wave and sea state for effective mitigation, and postponement if sargassum rafts or jellyfish shoals are present in the safety range. The Biological Opinion also specified postponement if listed marine mammals are detected in the buffer zone, with species-specific waiting times based on their dive durations. Thus, there is essentially a 5.6 km (3 nmi) "go/no-go" range for these listed marine mammals.

N3. A "soft start" involving the use of progressively larger sleeve guns, sleeve gun arrays, and medium sized chemical explosives is not advisable, for several reasons:

- There is no conclusive evidence that all marine mammals move away from loud sound sources, whether impulsive or progressive (Chapter 11 in Richardson et al., 1995). Some studies have reported a "startle response" to sudden loud noises from whales and, as noted, whales have avoided areas of seismic surveying. But whales have also been reported to remain in the immediate area of loud noises. There is no assurance that all animals would move out of the area.

- Using staggered charges or warning blasts in sequence as part of a "soft start" procedure could be problematic since animals could be attracted to the site of the charge detonation either out of curiosity or to take advantage of fish killed during the warning blasts (Chapter 11 in Richardson et al., 1995).

- Sleeve guns are directional; noise is generally directed downward and does not propagate evenly (Chapter 6 in Richardson et al., 1995). There is no assurance that the noise generated from such sources would be evenly distributed around the source.

- The extremely high noise level associated with the initial discharge and subsequent reverberation from the sleeve guns, sleeve gun arrays, and smaller explosives would effectively mask whale calls that would otherwise be detectable by MMATS and would therefore eliminate a crucial component of the mitigation program. Instead of effective monitoring for submerged calling animals via MMATS, the mitigation team would be left wondering if there were any whales present and hoping that they were leaving the area in response to the loud noise.

The Marine Mammal Commission held a workshop on Acoustic Deterrence in Seattle in March 1996. Among the principal workshop findings and conclusions cited in the Workshop Proceedings (Reeves et al., 1996) are the following statements:

- "Many uncertainties surround all aspects of acoustic deterrence as applied to marine mammals."

- "A basic principle that must underlie all use of acoustic deterrence devices... is that any introduction of artificial sound into the underwater environment is potentially harmful to marine mammals and other biota."

- "Other management strategies... should always be sought, even after an acoustic solution appears to have been found."

Although the Navy does not intend to use a "soft start" protocol, the detonations would not occur entirely without warning. There would be significant vessel activity in the exclusion zone prior to the test. Three vessels (operations vessel, tether vessel, and T-ATF) would be within the exclusion zone, joined at times by as many as four zodiacs involved in deploying the MMATS sonobuoy array and searching for sea turtles. The activity and noise levels generated by these vessels could alert marine mammals and turtles in the area.

N4. Mortality, injury, and acoustic harassment calculations took bottom substrate (sand) into account where appropriate. Cavitation and lung hemorrhage (the basis for the mortality criterion used in the FEIS) occur mainly in the upper water column, where substrate would have little or no influence on the results in this water depth. The injury (eardrum rupture) calculations took substrate into account, using the first bottom reflection. Subsequent bottom reflections would be received as separate, but less intense events; therefore, incorporation of additional bottom reflections would not increase the maximum range predicted for eardrum rupture. Auditory threshold shift calculations in Appendix E also assumed the appropriate substrate (sand).

Regarding the energy spectrum at high frequencies exceeding the threshold at 6 nmi from the source: due to the extensive rewrite of Appendix E, the comment no longer applies. In the revised Appendix E, the TTS range has been defined such that the criterion would not be exceeded in any 1/3 octave energy band.

N5. The dB levels are re 1 μPa (water standard). This has been added to the text. The 180 dB statement refers to frequencies less than 50 Hz.

N6. Information on MMATS has been added to Section 5.0 of the FEIS. MMATS is a digital signal processing system which is configured to passively detect and localize transient acoustic signals such as marine mammal calls. The phrase "transient acoustic signals" is used to refer to the wide variety of sounds made by various species of marine mammals, with durations ranging from less than a second to as much as 30 seconds.

The current version of MMATS computes and displays the spectra of up to 16 channels of acoustic data in real time. Operators identify the cetacean species by examining the spectral displays. A time difference of arrival algorithm is used to determine the location of calling animals.

Operation is partly manual and partly automatic, with operator control over automatic features. Signal processing parameters are chosen to maximize the detection and localization of marine mammal calls. Analog acoustic data from 10 to 15 sensors would be sampled at 25 kHz, providing a useful bandwidth of 10 kHz. Data from each sensor would be displayed in at least two frequency bands: a low band for mysticetes and a high band for odontocetes. Processing within each band includes suppression of relatively constant sounds, such as those generated by ship engines, in order to maximize the visibility of transient sounds, such as marine mammal calls. Processed data are displayed on a pair of high resolution color monitors.

N7. The mitigation plan (Section 5.0) has been expanded to explain post-detonation monitoring and coordination with the stranding networks in more detail. The post-detonation monitoring period following the last shot has been extended to seven days. Marine mammal and sea turtle stranding networks along the east coast would continue to investigate any stranded animals for evidence of injury related to shock testing for one year after the tests. Necropsies would be performed by trained stranding network technicians following NMFS protocols, and tissue samples would be forwarded to the Armed Forces Institute of Pathology (AFIP). See response H12 for related information.

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Robert F. Deegan
Sierra Club Virginia Chapter
340 Ramapo Road
Virginia Beach, VA 23462

VIRGINIA CHAPTER SIERRA CLUB

"When we try to pick out anything by itself, we find it hitched to everything else in the universe."
John Muir

August 24, 1996

Mr. Will Sloger, Code 064WS
Southern Division
Naval Facilities Engineering Command
P.O Box 190010
North Charleston, SC 29419

Dear Mr. Sloger:

Thank you for this opportunity to comment on the Navy's Draft Environmental Impact Statement (EIS) on Shock Testing the Seawolf Submarine. The Sierra Club Virginia Chapter is an environmental group of about 11,000 members throughout Virginia.

Please put my name on the mailing list for all future documents pertaining to this EIS and any related matters.

(O1) We strongly oppose conducting the submarine shock testing off the coast of Virginia. By the Navy's own analysis in the Draft EIS, the harm to marine mammals from the explosions would be eight times greater off the coast of Virginia than if the shock testing were conducted off the coast of Florida. There is a keen public interest in Virginia in the wellbeing of marine mammals (whales and dolphins) near our coast. Numerous residents and tourists in Virginia take commercial boat trips for "whale watching" and "dolphin watching". This wholesome family activity has become an integral part of the tourist and recreation business in the coastal region of Virginia.

(O2) The Navy's analysis in the Draft EIS may understate the number of marine mammals in the coastal waters off Virginia. There are numerous reports that the number of whale and dolphin sightings is increasing each year off Virginia. Thus, the harm to marine mammals from underwater explosions off Virginia may be even greater than that estimated in the EIS.

(O3) If this shock testing must be done, let it be done at the location where the harm to sealife is minimized.

Yours respectfully,
Robert F. Deegan
Robert F. Deegan

Robert F. Deegan
Sierra Club Virginia Chapter
340 Ramapo Road
Virginia Beach, VA 23462

Sierra Club, Virginia Chapter

Robert F. Deegan
Written Comment, August 24, 1996

Navy Response:

O1. Comment noted.

O2. Comment noted. The Navy believes the abundance estimates for marine mammals and turtles in the EIS are sufficiently accurate to estimate the magnitude of potential impacts and to compare alternative areas (Mayport and Norfolk). The National Marine Fisheries Service has stated that the 1995 aerial surveys provide the best scientific information available (see comment NMFS-1).

O3. Comment noted.

P

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HS

Will Sloger (Code 064WS)
Department of the Navy
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406

13 September 1996

Dear Mr. Sloger,

On behalf of the more than 4 million members and constituents of The Humane Society of the United States, the American Society for Prevention of Cruelty to Animals, Earth Island Institute, International Wildlife Coalition, Natural Resources Defense Council, Society for Animal Protective Legislation, South Carolina Association for Marine Mammal Protection, and the Sierra Club, I would like to offer the following comments on the Draft Environmental Impact Statement (DEIS): "Shock Testing the SEAWOLF Submarine".

We commend the Navy on its attempt to address the many concerns raised in the scoping sessions and on the scope of its review of the range of issues and information relevant to the proposed tests. We agree that testing should not occur at the Norfolk site. The information presented in the DEIS appears to substantiate the undesirability of locations in the Florida Keys and elsewhere. Of the sites that are proposed in the DEIS, the Mayport site appears to be the most suitable. However, we are concerned that there are additional considerations that must be weighed in this proposal before testing can be undertaken. These concerns support the "no action" alternative at this time. (P1)

Our concerns relate to issues surrounding the design of the operation, inadequacies in the monitoring, inadequacies in sea turtle protection, insufficient information to appropriately assess potential for injury and mortality of marine mammals, fish and turtles, and the potential impact on marine mammal stocks.

Operational Concerns

There is little information provided on the effect of substrate on the transmission of sound. It is stated that the substrate near Mayport is (P2)

The Humane Society of the United States
2100 L Street, NW, Washington, DC 20037
(202) 452-1100 FAX (202) 778-6132

"primarily sand", with no known hard bottom or reefs within 1 nautical mile of Norfolk (3-1). It is generally acknowledged that there is less transmission loss in relatively shallow water over sand substrate than over mud or rock. We question whether this factor has been considered when speculating on the distances within which mortality and injury are likely to be sustained.

The DEIS has not addressed the rationale for five detonations rather than a lesser number. We note that the USS John Paul Jones required only two detonations in its shock trials (4-13). We suggest that this trial, similarly, may be conducted with fewer detonations, and thereby reduce the possible environmental impacts. (P3)

The DEIS has not addressed some of the concerns raised by the National Marine Fisheries Service (NMFS), Southeast Region in its scoping comments (C 6-11). Specifically we note that, while the Navy proposes to conduct the tests from May through September, the Region recommended that proposed testing be confined to the months of June through August to limit potential interactions with right whales. Because the right whale population is so small and therefore fragile, we concur with this recommendation. Testing during these months is also likely to assist in protecting sea turtles (see comment below under sea turtles). (P4)

We note that there is a 3.8 kilometer zone of concern for marine mammals despite the acknowledgment (D-44) that based on terrestrial mammal eardrum rupture, between 10% and 50% of animals within this range might be expected to experience ear drum rupture. Ketten (1995) has stated that given the uncertainties about the protection afforded to marine mammal auditory systems by aquatic adaptations, a 5 kilometer range is more reasonable for a 10,000 pound explosive. Clearly the zone of exclusion for marine mammals needs significant extension. (P5)

We are not entirely convinced of the inadequacy of computer models, especially in light of the previous hull tests. It would seem that useful information from previous tests might assist in making the models more predictive, and we recommend that the Navy give additional consideration to the use of modeling with computers or other simulations. (P6)

Additionally, we feel strongly that all tests should cease immediately if any death or injury of a marine mammal, turtle or protected bird speces is observed, and no further testing should be done. (P7)

Inadequacy in Monitoring

We agree that stranding networks need to be advised of the testing so that they can monitor levels of mortality immediately following the tests. However, we are concerned that the detonations by themselves, or in combination with other sound sources, may cause temporary or even permanent shifts in hearing thresholds that may impact the viability of individual animals by affecting their ability to forage or navigate effectively. Mortality resulting from impairment of an animal's auditory system may not occur for quite some time after the actual insult. This may make it difficult to assess the actual cause of the mortality. The mitigation and monitoring measures used in prior tests are suggested to have been sufficient to avoid or detect mortality in (P8) marine animals (5-2), but the monitoring may simply have failed to detect causes of later mortality in animals. If the Sea Wolf tests are to be conducted, we strongly urge the Navy to fund the necropsy efforts of stranding networks, and specifically the analysis of auditory processes in turtles and marine mammals that are found dead within a one year period. While thorough necropsy will not be able to definitively determine whether or not the SEAWOLF hull testing caused mortality, it will be able to further our understanding of potential effects of sound on the hearing and viability of marine animals.

P9 We again raise the unaddressed concerns of the NMFS, Southeast Region in its scoping comments (C 6-11). The Region recommended post-test monitoring for a period of two to four weeks to assess impacts that might not be immediate. This comment was not addressed in the DEIS, although we concur with its import. Furthermore, as stated above, we suggest an even longer monitoring period. A period of 4 -6 weeks would seem more appropriate, followed by monitoring of stranded animals for one year.

Inadequate Protection of Sea Turtles

P10 Sea turtles do not have the charisma of marine mammals, and this appears to be reflected in the DEIS, which has devoted a substantial portion of its content to dealing with potential impacts to marine mammals, but relatively little to impacts on turtles. We note an entire appendix devoted to potential impacts on marine mammals, and another devoted to acoustic discomfort in marine mammals, with no similar appendix dealing with endangered turtles, many more of which are expected to be adversely affected if testing is sited in Mayport[1]. In part, this may be due to even less information on physiological effects of blasting on turtles, but this does not obviate the need to more directly address the potential impacts.

P11 While we concur with the Navy's determination that testing in the vicinity of Mayport should occur only after the month of April, to avoid the time when the largest number of turtles was seen on aerial surveys, we wish to emphasize that the tests are still proposed to occur at a time which is apparently critical to at least two species of sea turtles. The loggerhead sea turtle (*Caretta caretta*) is a threatened species. As is stated in the DEIS (B-27), nesting occurs from May-September "on beaches of southeast Florida, with other nesting areas located in northeast Florida, Georgia....". Furthermore, incubation lasts "about 54 days in Florida and 63 days in Georgia". Following hatching, hatchlings swim out to *Sargassum* algae rafts offshore. Leatherback turtles (*Chelonia mydas*)nest in Florida as late as February or March and have a 65 day incubation (B-29) after which they swim to unknown pelagic areas. Thus hatchlings enter the sea as late as May. Clearly testing should be avoided at this time, as tiny hatchlings are unlikely to be detected during aerial surveys. Leatherbacks are an endangered species and all nesting sites are considered critical habitat. Their pelagic habitat also requires protection, and survival of hatchlings is critical to the species. Scheduling tests during the time of May-September coincides with the nesting of the loggerhead turtles and with the hatching of leatherback turtles. Concerns about these species make more critical our earlier comments on minimizing the number of tests and scheduling tests during the three summer months.

[1] See Table 4-7 of EIS noting up to 7 potential mortalities and 30 injuries as well as close to 300 "discomforts" for turtles near Mayport, versus Table 4-4 for marine mammals in Mayport.

Lack of Information to Assess Potential for Injury and Mortality

P12 Characteristics of the sound likely to be produced by the explosion are poorly addressed in the DEIS (e.g. 4-11). Statements that do not reference the band of frequencies included in sound pressures levels are not sufficient to assist in understanding potential impacts.

P13 In the section on cumulative impacts (6.0), the DEIS dismisses cumulative impacts as a major concern, as no future shock tests are planned in the immediate future, and oil and gas drilling in the area has been indefinitely postponed. This omits consideration of other acoustic impacts on the animals that use this area. For example, the DEIS has not addressed the cumulative impacts of this testing combined with increased Naval gunnery and ordnance activity such as was conducted near Mayport in the early part of 1996 in the vicinity of right whale critical habitat. Neither has the Navy's Low Frequency Active Sonar (LFAS) proposal been addressed relative to its potential to affect these same species. All of these activities singly or in combination may contribute to temporary or permanent threshold shifts in hearing that might impact the viability of individual animals. Although it should have been, this type of cumulative impact was not addressed. We also reiterate our comment above on the necessity of examining auditory systems of stranded marine mammals.

P14 Regarding the potential impacts of the testing on animals, we feel strongly that the potential for adverse impacts has been underestimated. A report by the National Research Council's Committee on Low Frequency Sound and Marine Mammals(1994) states "at this time, essentially nothing is known about the auditory after-effects of exposure to intense sound in marine mammals, fish, or invertebrates". The DEIS acknowledges the paucity of information on the effects of sound on hearing and viability of marine mammals. We note that the verbiage in Appendix D consistently relies on words such as "may", "appears to", "possibly", and "might be" These words reflect the uncertainly attached to all statements on physiological effects. Much of the information on injury mechanism and tolerance is based on tests of terrestrial animals, specifically humans. In addition to the lack of information on acute or chronic effects of the sounds, the "effects of cavitation on marine mammals is unknown." (D-59). The paucity of information on effects and the uncertainty surrounding the little information that is available, mandates that the precautionary principle be used whenever possible. This does not appear to be the principle guiding the preparation of this document. For example, we note on page D-26 the statement "Extensive lung hemorrhage is an injury which would be debilitating and not all animals would be expected to survive (1% mortality)". We suggest that mortality from "extensive lung hemorrhage" is likely to be much higher than one percent. We also note (on the same page) the statement that following "contusions with ulcerations throughout the G.I. tract...includ[ing] ruptures of the G.I. tract", "[t]he expected mortality level associated with these combined serious injuries would be significantly higher than 1%." Indeed. These types of statements indicate that the number of animals that may be severely impacted by the testing may have been inappropriately downplayed.

Furthermore, the Navy has inappropriately distanced itself from the potential for lethality due to auditory system injury as described by both Todd and Ketten during the 1993 meeting of the Acoustical Society of America. The DEIS states that whales that died in the area around the Canadian construction site were resident, whereas animals in the Mayport area are likely to be transients. However, there is no clear statement in the 1993 papers that a specific number of explosions were required to cause the damage that resulted in the death of animals. There is also a notation in the DEIS that the construction project used only a 1.9 kilometer safety range, whereas the Navy proposes a 3.8 kilometer "safety zone". As noted above, this too may not be sufficient.(Ketten 1995) The DEIS also notes that the construction blasts occurred in a highly reflective rock bottom, whereas this area has a sandy bottom. As we have previously commented, this sandy bottom may minimize sound loss in shallow water. Thus the dissimilarity of some aspects of the explosions does not necessarily mean that the Navy's use of explosions will be more benign. (P15)

Potentially Detrimental Levels of Impact on Marine Mammal Stocks

We note that the Navy has listed (Table 4-4) a number of species as being potentially affected by the SEAWOLF tests in Mayport although these species are not listed in the NMFS stock assessments (Blaylock et al, 1995) as present in the area. Dwarf sperm whales, false killer whales, Fraser's dolphins, Gervais' beaked whales, melon-headed whales, pygmy sperm whales, rough-toothed dolphins and Clymene dolphins are listed as Gulf of Mexico stocks by NMFS. While we applaud the Navy's caution in assessing possible impacts on these animals that may be transient in the area, we believe that the DEIS should address the discrepancy between the Navy's list and that of the NMFS. (P16)

We also wish to point out that Clymene, spinner and striped dolphins are lumped together in the estimate of impacts on species, whereas they are three separate species. This has also been done to bottlenose/Atlantic spotted dolphins, and to long and short finned pilot whales, all of which are separate species and none of which should be combined for purposes of assessing impacts of mortality on the species or stock. We assume that this is because it was difficult for observers to differentiate the species during aerial surveys. It is likely, therefore, to be equally difficult to determine which species may have been adversely affected. This can pose a problem if, for example, a dead dolphin is seen after the detonation. The relative concern of the mortality to a specific stock can be gauged by calculating what portion of the Potential Biological Removal (PBR) level the mortality represents. For each stock, PBR has been calculated using a formula (Wade and Angliss, 1996; Blaylock et al 1995) that considers population abundance, reproductive potential and a conservation factor. The Marine Mammal Protection Act (MMPA) mandates that mortality occur at levels under the PBR. Due to the uncertainty of data relative to the status of the population, the PBR for Atlantic spotted dolphins can not be calculated, but for offshore bottlenose dolphins the PBR is 92. Thus the loss of a single offshore bottlenose dolphin may be of a different degree of concern than the loss of a single Atlantic spotted dolphin. This is similarly true of the other species that are aggregated in the sightings. (P17)

Bottlenose dolphins are listed as though they are a single stock, whereas offshore bottlenose and coastal bottlenose dolphins are separate stocks for management purposes, though the range may overlap to some extent in the area in which testing is proposed (Blaylock et al. 1995). The coastal stock is considered a depleted stock under the MMPA. Impacts to this stock are of great concern. (P18)

Furthermore several of these species are considered "strategic stocks" by the NMFS, because human related mortality exceeds the PBR for the stock. These include: Cuvier's beaked whales, Gervais beaked whales, both long and short finned pilot whales, common dolphins, offshore bottlenose dolphins, and Atlantic spotted dolphins. Realistically, a mortality estimate of greater than zero animals, but less than one, should be considered one mortality as an animal cannot be partially killed. Thus if we combine mortality and injury (the MMPA defines a "take" as a serious injury), we see that takes of Atlantic spotted dolphins, and both stocks of bottlenose dolphins are likely. Furthermore, one take of an Atlantic spotted dolphin is likely although no safe PBR can be calculated for this stock. One take is likely of a bottlenose dolphin (stock unspecified) from either the offshore stock (PBR 92) or coastal stock (PBR 25). We note with concern that many more of these animals are subject to "acoustic discomfort" although this has been poorly defined. Given our earlier comment on the lack of information on the damage or threshold shifts likely to occur from sound of this type, and given the Navy's apparent disregard of the precautionary principle when predicting impacts, we are concerned that up to 67 bottlenose dolphins[2] are being subjected to "acoustic discomfort" with no means of determining either the affected stock or whether or not the "discomfort" impacts their viability. We note that both the offshore and coastal stocks are strategic stocks, and mortality from fishery interactions already exceeds their PBR. Both stocks are, or will be, subject to take reduction teams to reduce this fishery related mortality. We believe that the Navy's addition of one mortality or even as much as 67 mortalities to the already high fishery related mortality is unacceptable. This is especially true if the coastal stock is impacted, as this is also a depleted stock under the MMPA. (P19)

As we have already stated, we consider the Norfolk site to be inappropriate, but if it is selected, then harbor porpoise, Sowerby's beaked whales, True's beaked whales, Atlantic white sided dolphins, and northern bottlenose whales are additional strategic stocks whose deaths should not be permitted. (P20)

We are also concerned at the relatively large numbers of "unidentified dolphins" that are likely to be killed, injured or "acoustically discomforted" by the testing. Depending on the actual species, their death or injury may be of significant concern to their species. (P21)

Other Concerns

We understand that other conservation organizations have submitted comments, and they have additional concerns such as the necessity for "ramping" up the sounds prior to the actual testing. We strongly urge the Navy to consider these concerns in plans to modify mitigation proceedures. (P22)

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[2] This number is derived by combining the 50.37 bottlenose dolphin estimate with the 16.79 combined bottlenose/Atlantic spotted dolphin estimate, as there is no way to assure that all 17 animals will not be bottlenose dolphins. We also note that there are 121 "unidentified dolphins" listed, and we have no way of assuring that these will not include bottlenose dolphins, though for purposes of calculation they were not included in the count of 67.

Summary

Our concerns with the operational design of the project, the inadequacy of the proposed monitoring, the inadequacy of protection for sea turtles, the paucity of information to assess the potential risk of injuring or killing animals, and the possibly inappropriate levels of impact on strategic stocks of marine mammals lead us to urge the Navy to consider the "No Action" alternative or to substantially redesign the testing at the Mayport site to provide greater levels of conservatism in protecting those species likely to be affected by the testing. (P23)

Thank you for the opportunity to comment on the draft DEIS. We look forward to working with you to assure the greatest feasible level of protection for animals likely to be affected by Naval actions.

Sincerely,

Sharon B. Young
Marine Mammal Specialist

cc. John Twiss, Marine Mammal Commission
Michael Payne, NMFS

References Cited

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Humane Society of the United States, American Society for Prevention of Cruelty to Animals, Earth Island Institute, International Wildlife Coalition, Natural Resources Defense Council, Society for Animal Protective Legislation, South Carolina Association for Marine Mammal Protection, and Sierra Club

Sharon B. Young
Written Comment, September 13, 1996

Navy Response:

P1. Comment noted.

P2. See response N4.

P3. The SEAWOLF is a submarine and the test must be conducted with the submarine submerged. In order to provide the maximum assurance of ship and crew safety, the severity of the shock experienced by the submarine is gradually increased over five shots to the maximum test severity.

P4. The Navy considered the NMFS recommendation but determined that shock testing could be conducted at the Mayport area (the preferred alternative area) during the May through September period with the lowest possible risk of impacts to right whales. The possibility of a northern right whale being present in the Mayport area during the May through September time period is remote. And even if a right whale were present, it would almost certainly be detected by pre-detonation monitoring. See response I5 for information supporting these conclusions.

P5. The probability of eardrum rupture at the edge of the safety range (3.7 km or 2 nmi) is low, estimated at 10% in the DEIS. The 50% rupture probability would apply much closer to the detonation, about 1.85 km (1 nmi). Eardrum rupture *per se* is not necessarily a serious or life-threatening injury; rather, it serves as an index of possible injury. Also, for injury calculations, it is conservatively assumed that 100% of animals within this range would be injured. Regarding the adequacy of the safety range and the 5 km (2.7 nmi) safe range recommended by Ketten (1995), see the response to the Cetacean Society (response N2).

P6. Data from previous shock tests have been incorporated into computer models which are used to help predict the survivability of SEAWOLF class submarines. However, this modeling is only one of three components of the SEAWOLF Live Fire Test & Evaluation program which together provide the data necessary to assess the SEAWOLF's survivability. The components are computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. As explained in Section 1.0, this project is needed because computer modeling and component testing on machines or in surrogates do not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366.

Shock testing the manned submarine at sea is the only way to evaluate the response of the entire ship, including the interaction of its systems and components. Although computer models and component testing are helpful, combat experience has demonstrated that they cannot predict the broad range of complex failure mechanisms which could occur inside sophisticated electronic components or complex mechanical systems.

P7. With the mitigation measures described in Section 5.0, it is unlikely that any marine mammal, turtle, or protected bird species would be killed or injured. However, the EIS states that if post-detonation surveys showed that marine mammals or turtles were killed or injured, testing would be halted until procedures for subsequent detonations could be reviewed and changed as necessary. It is not reasonable to cancel further testing altogether. The project purpose and need would still exist, and the review could identify changes to the mitigation plan that would prevent further deaths or injuries on future detonations.

P8. The mitigation plan (Section 5.0) has been expanded to explain post-detonation monitoring and coordination with the stranding networks in more detail. The post-detonation monitoring period following the last shot has been extended to 7 days. Marine mammal and sea turtle stranding networks along the east coast would continue to investigate any stranded animals for evidence of injury related to shock testing. See response H12 for related information.

P9. See response P8.

P10. There is much less information available for sea turtles than for marine mammals. However, the DEIS did directly address potential impacts based on the available information. Additional discussion of the limited data available to estimate effects of underwater explosions on sea turtles has been added to Appendix D of the FEIS.

P11. The FEIS includes changes to the mitigation program (Section 5.0) designed to improve protection of sea turtles. These include tighter line spacing for aerial monitoring, addition of a third aerial observer, avoidance of sargassum-rich areas during test site selection (to the extent possible) and postponement of detonation if large sargassum rafts or jellyfish shoals are observed within the safety range. Also, it is important to note that animals at the surface (such as juvenile turtles in sargassum rafts) are unlikely to be affected unless they are very close to the detonation point (see Appendix D, Section D.6).

The testing schedule at Mayport has already been adjusted (in the DEIS) to minimize potential impacts to sea turtles (i.e., no testing in April). Additional schedule changes are not warranted based on the available data (see response J5). Regarding the number of detonations, see response P3.

P12. Information on the characteristics of the sound source have been added to Appendix E of the FEIS. All citations of sound pressure or energy levels have been revised to state the frequency band (if known).

P13. Discussion of the LFA sonar is not appropriate because it is not being used in the Mayport area at this time and any future use is speculative. Before LFA is used off Mayport, the Navy would prepare appropriate documentation regarding environmental impacts, including cumulative impacts. Regarding the need to examine auditory systems of stranded animals, see response P8.

Cumulative impacts result from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions. The discussion of cumulative impacts focused on those types of actions that would result in the same types of effects as the shock testing. The concern raised by the commenter on the impacts of dissimilar actions is addressed by the Navy's assumptions and calculations on potentially affected mammals and turtles.

The comment is based on the assumption that either (1) the auditory impacts of exposure to either sustained noise or lower level noise can weaken the auditory systems of marine mammals or turtles, making them more vulnerable to injury or more likely to be injured if in the area of the shock tests; or (2) the marine mammals or turtles that might be impacted by the shock tests would be more vulnerable to future noise. However, the Navy's assumptions and characterizations of the impact of injuries to the auditory systems of marine mammals already take into account the possibility that mammals in the area are more vulnerable to injury by deliberately overestimating the risk of both lethal takes and injuries. Similarly, the calculations would be adequate to include mammals weakened by shock testing and therefore more vulnerable to future exposure, since the calculations maximize lethal takes over injuries.

In summary, by using conservative assumptions on the impact of injuries to marine mammals and relying on existing information on the impact of threshold shifts, the Navy has adequately described the potential cumulative impacts of the shock testing to individual marine mammals or turtles that are or may reasonably be expected to be exposed to noise or shocks in addition to the shock tests in its overall analysis. The section on cumulative impacts addresses only those actions that would have similar impacts to the shock testing to the populations in general.

P14. Potential impacts have not been downplayed. On the contrary, assumptions to overestimate impacts have been used at every step. For example:

- Adjusted mean densities used for impact calculations are higher than the 95th percentile of observed densities.

- Throughout Appendices D and E, "conservative" assumptions were made which overestimate the maximum range for each potential impact.

- For purposes of impact analysis, it was assumed that 100% of the marine mammals within the lethal range would be killed, even though the probability of mortality from extensive lung hemorrhage is estimated to be only 1% at the outer edge of this range.

- For purposes of impact analysis, it was assumed that 100% of marine mammals within the injury range would be injured, even though the probability of eardrum rupture at the outer edge of this range is only 50% (and less in near-surface waters).

Regarding the 1% mortality statement on page D-26, this is a misunderstanding of the data presented. In the preceding pages, a criterion for "*onset* of extensive lung injury" was developed and shown to be correlated with a "predicted 1% mortality" curve from Yelverton (1981). So, as an animal approaches the detonation source, the point at which the *onset* of extensive lung injury would occur is the point at which 1% mortality would be predicted. The later statement about expected mortality levels greater than 1% refers to conditions as one moves closer to the detonation point, where "the severity of extensive lung hemorrhage increases beyond the onset level..." Appendix D has been revised to clarify these points.

P15. The humpback whale mortalities reported by Ketten et al. (1993), Ketten (1995), and Todd et al. (1996) were caused by explosions (including a 10,000 pound detonation) during a Canadian construction project in a shallow, rocky fjord. The project used a safety range that was about half of the one proposed for SEAWOLF [1.85 km (1 nmi) instead of 3.7 km (2 nmi)], even though mortality and injury ranges could be greater due to the shallow water depth and highly reflective substrate. Energy levels received by the whales could not be calculated with any confidence, but the extent of auditory system injuries implied they were close to the blast site during one or more of the many explosions (Ketten, 1995). The only reasonable inferences are (1) that the Canadian safety range was inadequate, or (2) that the animals were present but not detected within the safety range. This event provides no information to either validate or refute the adequacy of the safety range proposed for SEAWOLF.

The comment makes reference to transmission loss being less over sand bottom. This statement apparently is based on Urick (1982) and refers to high frequencies. Most of the energy from a 10,000 pound detonation is in low frequencies (see Appendix E). The proposed detonations for SEAWOLF shock testing would occur in the open ocean in a water depth of 152 m (500 ft), over sand bottom. There is no doubt that attenuation of the shock wave with distance would be greater for the SEAWOLF detonations.

The ultimate question is whether the SEAWOLF safety range is adequate. See the response to the Cetacean Society (response N2) for discussion of this issue.

P16. The species list was developed in consultation with the NMFS. Papers cited in the footnotes to Tables 3.1 and 3.2 were used to establish the possible presence of marine mammals and turtle species at the Mayport and Norfolk areas. These papers make reference to historical sightings and strandings in each area. For example, dwarf sperm whales, pygmy sperm whales, false killer whales, and Gervais' beaked whales have all stranded along the southeast coast in recent years even though they were not seen during the 1995 or 1997 aerial surveys. All species that could reasonably be expected to occur at the Mayport or Norfolk areas were included.

P17. "Lumping" was necessary in some cases where species could not be differentiated in the aerial surveys. However, Atlantic spotted dolphin and bottlenose dolphin are separate categories in the impact analysis (see Table 4-4 and 4-5), in addition to the pooled category bottlenose/Atlantic spotted dolphin. Similarly, there is a spinner dolphin category in addition to the pooled clymene/spinner/striped group. Assigning unidentified individuals to species would require additional, questionable assumptions. Total predicted mortalities and injuries would not change.

P18. Bottlenose dolphins are listed as a single stock because calculations are based on aerial surveys. It is impossible to determine from aerial observations whether an individual dolphin belongs to the coastal or offshore stock.

CETAP surveys north of Cape Hatteras showed a disjunct distribution between inshore and offshore bottlenose dolphin populations at the 25 m (82 ft) depth contour, suggesting that the stocks are separated by depth or distance from shore (Kenney, 1990). This pattern has been seen on later surveys (Hansen, 1996) and suggests that bottlenose dolphins at the Norfolk site (water depth of 152 m or 500 ft) would most likely belong to the offshore stock. South of Cape Hatteras, no separation of sightings by depth or longitude has been detected (Blaylock and Hoggard, 1994). However, data from survey cruises in 1985 and 1992 suggest that the deep-water ecotype inhabits waters along and beyond the outer continental shelf south of Cape Hatteras (Blaylock and Hoggard, 1994). It is reasonable to assume that the bottlenose dolphins seen at the Mayport area, which is at the shelf edge, are mainly from the offshore stock. Discussion has been added to Section 3.0.

P19. Section 3.0 of the FEIS has been modified to indicate which species are considered by NMFS as strategic stocks. However, if shock testing is conducted at Mayport (the preferred alternative area), then it is unlikely that any mortalities of a species belonging to a strategic stock would occur. The reasoning in the rest of this comment, implying that 67 mortalities could occur, is incorrect for several reasons:

- Mortality and injury should not be combined. Injury is defined as non-lethal injury from which the animal is expected to recover on its own.

- The total number that may be killed is indicated by the total at the bottom of the impact tables, which is rounded up to a whole number of individuals (e.g., 1 individual for Mayport, Table 4-4). The small fractions given for individual species indicate the relative risk to those species. Rounding up every non-zero entry for individual species would lead to an absurd overestimate of potential mortality (i.e., far more than the total number expected to be present).

- The Navy overestimated potential risk at every stage of calculations (see response P14).

- The "acoustic discomfort" criterion used in the DEIS was based on experiments with human divers (volunteers) exposed to brief tones of increasing intensity until the divers wanted to go no further. This exposure did not result in any injury or mortality. In the FEIS, "acoustic discomfort" has been replaced by temporary threshold shift, a standard auditory safety criterion. There is no reason to expect that such a temporary, reversible effect would kill or injure individual marine mammals or affect the viability of their species stocks.

P20. Comment noted. None of these species was seen during six 1995 aerial surveys, and they are considered very unlikely to be present during testing. The EIS calculates no deaths or injuries of these species.

P21. "Unidentified dolphins" is a category from the aerial surveys. These dolphins cannot be assigned to species without making further, questionable assumptions. In any case, total predicted mortalities and injuries would not change.

P22. "Ramping up" the sounds prior to detonation is not proven to be effective at causing all marine mammals to leave the area and would interfere with passive acoustic monitoring. See the response to the Cetacean Society (response N3).

P23. Comment noted. The FEIS includes changes to the mitigation program (Section 5.0) designed to improve protection of marine mammals and sea turtles. These include tighter line spacing for aerial monitoring, addition of a third aerial observer, avoidance of sargassum-rich areas during test site selection (to the extent possible) and postponement of detonation if large sargassum rafts or jellyfish shoals are observed within the safety range.

Q

2007 Carrhill Road
Vienna, VA 22181
July 31, 1996

Department of the Navy
Southern Division, Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406
Attention: Mr. Will Sloger, Code 064WS
Regarding: DEIS for the SEAWOLF Ship Shock Test

Dear Mr. Sloger:

In response to the solicitation for comments on the DEIS for SEAWOLF Shock Testing, we feel it is important for us to bring several inconsistencies to your attention. Our comments are attached as an Enclosure.

Our principal motive is to help make the EIS as credible and legally supportable as reasonably possible.

It is evident that a good deal of time and effort have already gone into the SEAWOLF shock test preparation and EIS development. Although the issues we raise are important, we believe that they can be resolved without undue disruption of the program.

Our best wishes to you with the SEAWOLF project.

Sincerely,

Raymond C. Cavanagh
Ernest T. Young

Enclosure: Comments on the DEIS for SEAWOLF Shock Testing

ENCLOSURE

COMMENTS ON THE DEIS FOR SEAWOLF SHOCK TESTING

July 31, 1996

The Draft Environmental Impact Statement (DEIS) for the SEAWOLF Shock Testing program of June 1996 was made available on 14 June 1996 for review and comment by 31 July 1996. Comments follow.

These reviewers are motivated by the conviction that a credible, scientifically sound, and legally defendable EIS is important to the success of SEAWOLF, the reputation of the Navy, and, of course, the protection of the marine environment.

GENERAL COMMENTS AND QUESTIONS

1. The primary result of the DEIS analyses is hidden. It would be better to state in the Executive Summary and the Introduction that a Letter of Authorization for Incidental Take for marine animals is being sought. It is not clear that a confirmation of a FONSI is not being requested until well into the volume. Q1

2. The DEIS reflects a substantial amount of work by a number of persons. Should not the many contributors be cited together in Section 12? Q2

3. Results of the risk analysis are inconsistent with those of previous tests involving explosives. If the conventions used in recent approved assessments were applied to the SEAWOLF tests, the "unsafe" area for certain marine mammals would expand by factors of 15 or more (e.g. the radius of concern would be expanded from six miles to over 24 miles). Q3

4. Certain information needed to reconstruct the risk results for marine animals is absent. This is in spite of a specific written request from NMFS(SE) for the data. Q4

5. The prohibition of harassment of marine mammals by the MMPA is dealt with by the introduction of new terminology, viz. "acoustic discomfort." How "acoustic discomfort" relates to "harassment" is not at all clear. Whether or not the "discomfort" approach is technically sound, the departure from precedent may well raise doubts and may be difficult to defend (in the legal sense). Q5

6. Similar comments apply to the introduction of a new threshold function for marine mammal "discomfort." Can it be defended in light of precedent and technical scrutiny? Q6

More specific comments and questions, organized by topic, follow.

1

TOPIC ONE: ESTIMATES OF RISK

* COMMENTS: This is by far the most important part of the DEIS; its purpose is to provide best estimates of the risks of significant adverse impact of the shock trials to the marine environment.

The driving factor for this DEIS (and for most tests involving explosives under water) is the effect of the explosive pressure wave on marine mammals. "Safe" ranges, mitigation schemes, and incidental take estimates are driven by the laws protecting mammals.

There are four key elements in the construction of the risk estimates for marine mammals: (a) the characterization of the source, (b) the prediction of the wave properties at range, (c) the determination of thresholds for injury and harassment, and (d) the estimation of the number of each species of mammal that will experience effects of the explosion above threshold.

Our questions and comments regarding the final element (d) are given under TOPIC THREE below. They are related to the other elements in determining the risk areas and the proper survey of them.

* QUESTIONS: What is the authors' best estimate of the source properties? Besides the fact that the detonation is of 10,000 pound explosives planned for a depth of 100 feet in 500 feet of water, there is no other information provided. How was the detonation depth of 100 feet selected? What does the waveform look like at a nominal short range (e.g., 100 m)? Q7

* QUESTIONS: Using the four and six mile estimates of the spectrum shown in Appendix E, we determine that the transmission loss is more than would be suffered by a single path under spherical spreading. And yet the bottom conditions ("sand") and waveguide setting would in many cases yield something closer to cylindrical spreading. Have the models used been validated for shallow sources in shallow water? Have the predictions been compared to data? Was not an analysis done of this critical estimate for sensitivity to bottom description, source depth, and sound speed? Q8

* QUESTIONS: How does the new term "acoustic discomfort" relate to the legal definition of harassment? How does it relate to interpretations of previous Environmental Assessments and Impact Statements? A marine mammal may well significantly change its behavior (including feeding, calving, etc) without feeling any "discomfort." Why introduce an unproven replacement for harassment in this DEIS? Q9

* COMMENT: Regarding the thresholds for hearing damage and harassment of marine mammals, this is the second appearance of the Q10

arguments of Appendix E (by Goertner and Lehto) for "hearing-safe" ranges for marine mammals. The earlier documentation [Lehto(1995)] had even higher thresholds (by 30 dB) than are found in the DEIS. That memo was written to prove that the "safe" range for a 10,000 pound explosive in deep or shallow water is one nautical mile.

* QUESTIONS: Regarding the threshold for "acoustic discomfort" of Appendix E, why introduce an untested and rather arbitrary threshold in this high-visibility DEIS? With precedents set by the SSQ-110 Environmental Assessment (Ref 3), the DDG-53 Ship Shock Trials (Ref 1) (advertised threshold is in agreement with previous tests; application is in error), the Standard EIGER Assessment (Ref 4), and others, why take the chance of having to break from previous experience and defend an entirely different threshold? Q11

* QUESTION: The only mention of baleen whales in Appendix E is on page E-10. Of the little that is said, one statement is quite puzzling and concerns the fact that baleen whales are known to make sounds at levels above the proposed "discomfort" level without deafening themselves. What is the reference for this? Does harassment equate to deafening in the MMPA? Do terrestrial mammals ever make deafening-level sounds? Since the low-frequency part of the spectrum dominates the harassment problem for explosives, would not precedent be safer? Q12

* QUESTIONS: For the mammals with hearing most sensitive below 1000 Hz, is there an argument for the new threshold? In particular, is not the threshold for total energy over the band from 10 to 1000 Hz about 195 dB? The threshold used for the total band energy for the same band in the SSQ-110 assessment is 170 dB for a single event. The DDG 53 assessment argued in the range from 160 to 180 dB. The effect of raising the threshold by 25 dB means a decrease in the range of influence by a factor of four to eight, say from 25 nautical miles or more to six. In other words, if the 170 dB threshold had been used in the SEAWOLF DEIS, the "safe" range would approach 25 miles (not six miles). Q13

* QUESTIONS: The average "safe range" (for several different types of explosives) for baleen whales in the Standard EIGER test was estimated at 4 nmi, based on a threshold of 170 dB total energy in the band. The corresponding range for "avoidance" for the ACT II (Reference 2) experiment was estimated at 24 nmi and energy level of 156 dB; the range for the 170 dB threshold was about four miles. Both were in water depths comparable to those for the SEAWOLF test and both ended up with an "harassment" range for baleen whales of about four nautical miles. However, neither ACT II nor EIGER used shots of weights exceeding six pounds of TNT. Is there not a discrepancy here with previous approved assessments when small shots in shallow water require mitigation to four miles, while a 10,000 pound explosive in similar waters is pronounced safe beyond six miles? Q14

* COMMENT: From still another point of view, consider the step in the derivation of the "discomfort" threshold in which the "interim safety limit for a single pure brief tone" is derived (Figure 4 on page E-8). Values are presumed to be intensity values (or short-term averaged pressure squared values), since they are subsequently converted to energy for a 0.1 second integration time. The intensity threshold, then, of Figure 4 has values of about 188 dB at 50 Hz and 177 dB at 300 Hz. These are to be compared with the nominal 160 dB level used for LFA and other Navy active sonar applications. NOAA/NMFS has stated a preference for 120 dB for tones. To be consistent, acceptance of the threshold of Appendix E for explosives implies acceptance of the thresholds for tones listed above. It follows, for example, that no Environmental Assessment at all would be needed for the CORY CHOUEST LFA sonar in deep water, since the "safe" range for mammals would be under 1000 yards. Likewise, the ATOC source could hardly be as serious a threat to mammals as it is portrayed to be when its "safe" range is a few hundred yards. (Q15)

TOPIC TWO: RECONSTRUCTION OF ZONES

* QUESTION: For each "zone" (mortality, injury, "discomfort"), what are the source properties, propagation properties, and threshold definitions used in the DEIS? (Q16)

* COMMENT: From page C-8 of Appendix C, a letter from the NOAA\NMFS Southeast Regional Office in June 1995 states, in connection with an official consultation under the Endangered Species Act that: (Q17)

> "... the DEIS should address...the characteristics of the sounds (e.g., intensity, frequency, duration, properties of spreading, etc) that will be produced by the explosions and other noises associated with the ship shock tests, the level of received sounds from these sources at various distances from the source, 'zones of influence' upon .... including at what distances could these sounds be considered a disturbance to these animals (e.g., interfering with normal communications, prey detection, etc)."

This is a standard request that allows NMFS and others to understand how the zones were constructed and what might be the weak points in the determination of zone boundaries.

The properties of the source emissions requested above are nowhere to be found in the DEIS. Even if the source properties are to be found in books and papers, interested parties will want to see what was used in constructing the zones.

* QUESTIONS: Propagation properties of the explosive sound (shock and acoustic) to ranges and bearings of interest are not provided in the DEIS. The note on page E-11 gives a rough description of (Q18)

the rate of loss of energy for a nominal one-third-octave band (5 to 10 dB per doubling of distance from one nmi to 8 nmi). How does the peak pressure propagate? What is the arrival structure in time? Is the transmission the same in all directions? What are the losses in the first mile, and beyond eight nautical miles? What sound speed profile was used? Was it from the Navy standard data base? Was MOODS interrogated? What bottom geo-acoustic description was used (beyond the use of "sand")? Navy standard? There are three provinces for the low-frequency bottom properties in the vicinity of the Mayport site. Is the changing bathymetry in each direction from the source site taken into account? What bathymetry data base? What is the sensitivity in results to source depth? Could less damage be done at range, while maintaining required shock energy at the submarine, with a shallower source depth?

* QUESTIONS: Model-derived one-third-octave band spectra at four and six nmi are given in Appendix E for a 100-foot source depth and various gauge depths (pages E-14 to E-24). Spectra are also given on page E-9 for ranges of one, four and 16 nmi. The four-mile spectrum on page E-9 is not inconsistent with those that follow. Are the spectra on page E-9 calculated for one of the DEIS cases? Are they one-third-octave band spectra? (Q19)

* QUESTION: What does the model predict for peak pressure and positive impulse at various ranges and bearings? These are needed to calculate injury and mortality zones for each site. (Q20)

* QUESTIONS: What measurements of sound transmission, bottom interaction and sound speed profiles are available for the Mayport and Norfolk sites? Were they used to verify the model predictions? (Q21)

* QUESTIONS: What is the prevailing ambient noise in the vicinity of each site? How will it be affected by removal of nearby shipping? How does the noise field impact acoustic mitigation and possible interference with animal communications and hearing? (Q22)

* QUESTION: What exactly are the thresholds for mortality, injury, and acoustic "discomfort" for marine mammals? Sea turtles? How were the ranges determined in each case? Which were specific to the Mayport or Norfolk areas? (Q23)

* COMMENT: Consider, for example, Figure 5 on page D-27. It shows the curve that determines the mortality range for marine mammals (5000 feet). It is repeated as Figure 4-3 on page 4-21 of the main text. Exactly the same curve can be found in other assessment reports (e.g., on page 64 of Reference 7) for different environments and different explosives. It seems then that the range at which the threshold is exceeded does not depend on the environment (water depth, sound speed profile, bottom properties, etc). With ranges as great as 5000 feet, it seems unreasonable that the propagation does not depend on the local conditions. The use of (Q24)

the term "slant range" in the figure suggests that the curve is intended for deep water and deep explosives. The term has no meaning for waveguides of length ten times water depth as we have for the SEAWOLF case.

TOPIC THREE: ESTIMATES OF DENSITIES OF MARINE ANIMALS

* QUESTION: The 1995 aerial surveys (cf. pages B-12 ff of the SEAWOLF DEIS) of the Mayport and Norfolk sites covered the region extending perpendicularly from the 500-foot bathymetry contour to about six nmi (in both directions). Is this coverage sufficient to obtain a representative sample of the populations at risk? (Q25)

* RELATED QUESTIONS: The bathymetry in the Mayport area is such that the aerial survey covers the water depth regime from 400 feet to 1000 feet. According to Appendix B, certain of the animals at risk have preference for certain water depths. Does this limit to six miles from the 500-foot contour not bias the results? If the acoustic harassment regimes were to extend beyond six miles in certain directions (e.g., into very shallow water), would we expect the survey information to be relevant? (Q26)

TOPIC FOUR: SITE SELECTION

* QUESTION: How defendable are the three dominant criteria for site selection (east coast, 500 feet of water, and 100 miles to repair facility)? Only three sites received any serious consideration, and one was then immediately eliminated. Will this satisfy NEPA requirements? What about the Gulf of Mexico or the west coast? (Q27)

TOPIC FIVE: COMPARISONS TO OTHER TESTS

* QUESTIONS: The three zones (page 4-14) defining "mortality," "injury," and "acoustic discomfort" seem to be inconsistent with those of previous tests involving explosives. In particular, consider DDG 53 Ship Shock Trials (Ref 1), the SSQ-110 Environmental Assessment (Ref 3), the ACT II Test (Ref 2), and Standard EIGER (Ref 4). Can the inconsistencies be explained (using measured data or standard models)? (Q28)

* COMMENTS: As many acoustic analysts have discovered, the DDG 53 Assessment document has a major error (about 25 dB) in the definition of its threshold for acoustic harassment (mix up of units). (Q29)

The other Assessments estimate safety ranges from harassment on the same order as that of the SEAWOLF DEIS, but have much smaller explosives and are in regions with poorer propagation than that of the prime site (Mayport).

6

TOPIC SIX: MITIGATION EFFECTIVENESS

* QUESTIONS: Are estimates of MMATS effectiveness during the SEAWOLF shock tests realistic? Are they consistent with previous experience? (Q30)

* COMMENT: Although MMATS was a prime reason for the Navy obtaining permission to allow the DDG 53 ship shock tests (Ref 1) to occur, and although it has expanded bandwidth capability since then, it remains an experimental system. There is no question in the minds of the scientific community that acoustic surveillance of marine animals has great promise and may well eventually have capabilities equal to or beyond visual surveillance. However, at this time, capabilities of such systems as MMATS must not be exaggerated. A review of MMATS performance during the DDG 53 and Standard EIGER tests shows only a few detections (compared to hundreds of visual contacts), and then mostly beyond the range of interest. A projection that MMATS will supplement visual observations with 25% more contacts (for any species) is not consistent with the documentation of past experience. (Q31)

* QUESTIONS: Given the known effectiveness of visual surveillance, why limit the surveillance to the small area containing the zones for injury and mortality? Why not use several aircraft to monitor the entire acoustic "discomfort" zone? Given the costs and complexities of the tests, would not such enhanced surveillance be a relatively minor increase? Could such costs not be traded off against a reduction in MMATS and against the possible adverse effects of harming marine life? (Q32)

* QUESTIONS: Are there no plans to measure the field generated by the 10,000 pound explosives? In particular, would not measurements of the sound field (shock and acoustic) at locations to ten miles or so in four directions (using special sonobuoys or other sensors) be highly important in verifying predicted effects? Would not the measurements from the first explosive in the series be invaluable in "calibrating" the zones for subsequent tests? (Q33)

TOPIC SEVEN: AUTHORSHIP AND ATTRIBUTION

* QUESTIONS: Who were the principal authors and contributors to the DEIS? Is not the list of contributors and qualifications required by NEPA? Who were the primary authors for the sections that discuss site selection criteria, the explosive source, shock wave effects, propagation, acoustic mitigation, and the acoustic environment? What are their credentials? Is there not a member of the SEAWOLF office in NAVSEA who contributed to the DEIS? Are the authors credible? Would their expertise be sufficient for litigation? (Q34)

7

* COMMENTS: In Section 12 (page 12-1), the DEIS states that the DEIS was "prepared" by a contractor (Continental Shelf Associates, Inc. of Jupiter, FL). It then lists Mr. Sloger of NAVFACENGCOM as "responsible for preparing" the document. Finally it provides names and backgrounds for six senior (15-25 years of experience) scientists with specialties in oceanography, biology, and zoology. It is unclear whether or not these persons are employed by the contractor or the Government. None of the persons in the list claims expertise in explosives, shock waves, propagation, acoustics, signal processing, or acoustic mitigation. (Q35)

Appendices D and E are key to the conclusions of the DEIS; they ar the basis for estimates of ranges at which mortality, injury, and "acoustic discomfort" occur. Attribution is given to James Craig and Christian Hearn of CDNSWC for Appendix D and to Jean Goertner and Dr. Delbert Lehto of NSWC/White Oak for Appendix E. Were they not principal contributors? What are their technical credentials in the subject areas they write about?

NOTE ON UNITS

Unless otherwise stated, decibel values used above have references as follows:

For intensity, dB re 1 micropascal
For energy (flux density), dB re 1 [(micropascal)^2]-second
Spectrum levels are per Hz.

REFERENCES

(1) "Environmental Assessment of the Use of the Outer Sea Test Range for the Shock Trial of the DDG 53," Naval Sea Systems Command, April 1994.

(2) "Assessment of the Potential Impact of Experimental Acoustic Sources on Marine Animals and Fisheries in the New York Bight," Bolt Bèranek and Newman, Inc, Tech Memo W1182, August 1993

(3) "Environmental Assessment for the Use of the AN/SSQ-110 Sonobuoys in Deep Ocean Waters," Enclosure to Navy letter PEO ASW PMA-264/ ser 060 of 17 March 1995 (Confidential Nofom)

(4) "Environmental Assessment of the Use of Underwater Acoustic and Explosive Sources during Exercise Standard EIGER," prepared for the Submarine Security Program Office (CNO, N875) by SAIC, July 1995 (Secret)

(5) Lehto, D.L., "Proposed Hearing-Safe Range for Sea Mammals in the Vicinity of a Large Underwater Explosion," Technical Note DLL-1995-6, Sponsored by NSWC/Carderock Division (Code 622) under contract to Epoch Engineering of Gaithersburg MD, 5 June 1995

(6) Department of the Navy, "Draft Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," June 1996

(7) "Request for Letter of Authorization for the Incidental Take of Marine Mammals Associated with Navy Projects Involving Underwater Detonations in the Florida Straits," Naval Air Warfare Center, Key West, FL, April 1994

Raymond C. Cavanagh and Ernest T. Young

Written Comment, July 31, 1996

Navy Response:

General Response: A central issue in this set of comments is the Navy's use of an "acoustic discomfort" criterion developed in Appendix E of the DEIS. This represented a change from the 160 dB re 1 μPa criterion used in some previous environmental assessments. The Navy considered, but rejected, using the 160 dB criterion because it was based on a behavioral reaction (avoidance of repeated seismic pulses by migrating gray whales) that is of questionable biological significance in the context of the SEAWOLF shock test because the test has been scheduled to avoid migrating whales and there would be only a single pulse each week.

The subject of acoustic harassment of marine mammals is a complex one from both scientific and regulatory perspectives. There are no universally accepted criteria. Recognizing that the 160 dB criterion was inappropriate for SEAWOLF, the Navy developed an "acoustic discomfort" criterion in the DEIS based on the best available data at the time. This was an improvement over precedent because it treated impulsive noise in a manner that accounted for the way the ear responds and was tied to a specific, minor adverse effect from a single pulse.

Since the DEIS was released, the Navy has developed a harassment criterion based on temporary threshold shift (TTS), a standard measure in the auditory safety field. It incorporates new data on TTS in bottlenose dolphins, the first such data for any marine mammal (Ridgway et al., 1997). Appendix E has been completely rewritten and provides much more discussion of auditory effects. Further discussion of acoustic harassment has also been added to Section 4.0. Many of the specific comments no longer apply because of these changes. However, where appropriate, specific responses below address the issue of why a new criterion was developed.

Q1. In the FEIS, mention of the incidental take request has been added to the Executive Summary and Introduction. However, the primary purpose of the EIS is the identification, evaluation, and comparison of alternatives. An EIS does not lead to "confirmation of a FONSI." An EIS leads to a Record of Decision which (1) states what the decision was; (2) identifies and discusses alternatives considered by the agency; and (3) states whether all practicable means to avoid or minimize environmental harm have been adopted.

Q2. All contributors have been added to the List of Preparers, Section 12.

Q3. Calculations in Appendix D to develop mortality and injury criteria generally used the same models and methods used to prepare the incidental take request for the JOHN PAUL JONES (DDG 53) shock trial, which is the most appropriate for comparison because it involved 4,536 kg (10,000 lb) detonations. The table below compares the two tests.

Comparison of DDG 53 and (proposed) SEAWOLF shock tests.

Test Characteristic	Comparison		Notes
	SEAWOLF	DDG 53	
Charge weight	4,536 kg (10,000 lb)	4,536 kg (10,000 lb)	Identical
Charge depth	30 m (100 ft) ± 3 m (10 ft)	61 m (200 ft)	Shallower charge depth for SEAWOLF affects ranges for various criteria
Safety range	3.7 km (2 nmi)	3.7 km (2 nmi)	Identical
Buffer zone	1.85 km (1 nmi)	None	Total buffered safety range for SEAWOLF is 5.6 km (3 nmi)
Mortality range	1.1 km (0.6 nmi)	0.7 km (0.4 nmi)	DDG 53 used cavitation range; SEAWOLF uses onset of extensive lung injury
Injury	1.85 km (1.0 nmi)	2.9 km (1.6 nmi)	DDG 53 used "eardrum rupture unlikely;" SEAWOLF uses 50% eardrum rupture
Acoustic harassment (odontocetes)	15.7 km (8.5 nmi) [a]	None calculated	DDG 53 assumed odontocetes would not hear the low-frequency pulse; SEAWOLF assumed they could hear it and used TTS criterion
Acoustic harassment (mysticetes) [b]	23.5 km (12.7 nmi) [a]	37.0 km (20.0 nmi) [c]	DDG 53 used 160 dB criterion; SEAWOLF used TTS criterion

[a] These are the ranges predicted for the Mayport area.

[b] Mysticetes are not expected to occur at the Mayport area, so both SEAWOLF and DDG 53 methodologies would predict zero mysticete harassments

[c] The 160 dB range was calculated incorrectly in the DDG 53 report. The correct range is estimated to be about 4,630 km (2,500 nmi).

Maximum ranges differ somewhat because the charge depth was greater for DDG 53. Also, the DDG 53 report used a cavitation criterion to define the mortality radius, whereas the SEAWOLF FEIS uses a more conservative criterion, "onset of extensive lung hemorrhage," which was not estimated in the DDG 53 report. The SEAWOLF FEIS uses 50% probability of eardrum rupture rather than "eardrum rupture unlikely" for the injury criterion (see Appendix D for explanation). Although there are some differences in calculated mortality and injury ranges, the two tests use the same safety range (3.7 km or 2 nmi), and SEAWOLF adds a 1.85 km (1 nmi) buffer zone for a total radius of 5.6 km (3 nmi).

The main difference is that the DDG 53 analysis used an "acoustic harassment" criterion of 160 dB re 1 μPa. In the SEAWOLF DEIS, the Navy developed an "acoustic discomfort" criterion which has been replaced in the FEIS by temporary threshold shift (TTS). The 160 dB range used in DDG 53 did not define an "unsafe" area. Rather, it was an attempt to estimate the maximum range at which animals might react to the sound. The DDG 53 analysis included significant calculation errors and assumed that odontocetes would not hear the signal (due to high hearing threshold at low frequencies) and therefore estimated zero acoustic harassment for them. The Navy believes that the TTS criterion developed in the FEIS is a technically sound improvement which provides a measurable basis for estimating quantifiable acoustic harassment for SEAWOLF shock testing. It incorporates new data on TTS in bottlenose dolphins, the first such data for any marine mammal (Ridgway et al., 1997). TTS meets the definition of both Level A and Level B harassment. On a cellular level, TTS could be considered a very slight "injury" in the sense of damage to hair cells in the ear (see Appendix E). And because TTS is temporary hearing loss, it could lead to temporary "disruption of behavioral patterns" as specified in the statutory definition of Level B harassment. And in a further improvement over previous approaches, the FEIS calculates separate harassment ranges for odontocetes and mysticetes based on their differing sensitivity to low frequencies.

Q4. See response Q17.

Q5. The "acoustic discomfort" criterion has been replaced by TTS; however, the issue of changing the harassment criterion is still relevant. This comment implies that the relationship between harassment and previously used criteria (such as the 160 dB threshold) is clear and well established, which is not the case. The Navy believes the TTS criterion is a technically sound improvement. The relationship between TTS and harassment is addressed by further discussion in the FEIS.

Q6. See response Q5.

Topic One: Estimates of Risk

Q7. Information including examples of a waveform and a pressure-time history have been added to Appendix E of the FEIS.

The detonation depth and other aspects of test geometry (e.g., charge weight and standoff) for the SEAWOLF shock test are based on those used for the USS JACKSONVILLE shock test conducted in 1988. The intent is to create the same shock input so that the data of the two test series can be compared. Generally, charge weights of 4,536 kg (10,000 lb) and depths between 30 and 38 m (100 and 125 ft) are used for submarine shock tests to simulate mines and depth charges that would excite the athwartship response of the hull. A charge weight of 4,536 kg (10,000 lb) and a detonation depth of 61 m (200 ft) are commonly used for surface ship shock tests to excite a vertical response of the hull.

Q8. The Navy REFMS model has been used extensively to compute waveforms for underwater explosions in many different test geometries. A list of references for validation studies has been added to Appendix E of the FEIS. A comparison of measured and calculated pressure pulses is shown in Goertner and Lehto (1996, page A-10) for a range of 334 m (1,097 ft). No measured data are available at larger ranges.

A sensitivity study is not warranted for this type of application. The purpose was to make predictions in order to bound the problem. The velocity structure of the water column may vary from day to day and hour to hour. Past experience indicates that it would be unlikely to match archival data very closely.

Q9. The "acoustic discomfort" criterion has been replaced by TTS. The relationship between TTS and harassment has been addressed by further discussion in the FEIS.

Q10. Because the "acoustic discomfort" criterion has been replaced by TTS, this comment no longer applies. The analysis of 5 June 1995 by D.L. Lehto was a memo report of work in progress. It has been superseded by later work.

Q11. The reason for developing a new interim harassment criterion has been explained above in our general response and in Section 4.0 of the FEIS. The TTS criterion used in the FEIS is not arbitrary; rather, it is based on sound scientific data. Moreover, none of the thresholds used previously has been "tested" insofar as measured effects on marine mammals are concerned.

Q12. Because Appendix E has been rewritten, this comment no longer applies. The frequency range of baleen whale hearing has been taken into account in calculating TTS ranges in the FEIS.

Q13. The analysis for the FEIS uses 1/3 octave band levels (the effective filter bandwith of the hearing system), not total energy in a broad band. The TTS criterion presented in the EIS defines energy levels (in 1/3 octave bands, as a function of frequency) at which temporary acoustic damage to mammal ears would not be expected. Concerning differences in the predicted "safe" range, see response Q3.

Q14. The referenced ACT II document does not define or discuss harassment. It does discuss several types of non-injurious effects including detection, avoidance, and auditory damage. The 44 km (24 nmi) range and 156 dB criterion cited in this comment refer to "avoidance," which the authors further qualified by stating that "[A]ny avoidance reactions that do occur will be short-term and of negligible consequence to marine mammal individuals or populations." Auditory damage criteria were also discussed, with the conclusion that "the actual threshold for hearing damage may be above 220 dB in both toothed and baleen whales." The same authors later calculated an even higher damage risk criterion of 224 dB (peak pressure) (Richardson et al., 1995, p. 376). For the SEAWOLF detonations, these levels would occur well within the estimated TTS range.

Also, although part or all of the harassment range may have been mitigated in some previous tests involving smaller explosive charges, only the mortality and injury ranges were mitigated for the DDG 53 shock trial. The safety range for the DDG 53 shock trial, which involved 4,536 kg (10,000 lb) detonations, was the same as proposed for SEAWOLF (3.7 km or 2 nmi). SEAWOLF adds a 1.85 km (1 nmi) buffer zone. Expanding the mitigation radius to encompass the harassment range (e.g., 23.5 km or 12.7 nmi at Mayport) is logistically infeasible. Expanding the safety range to attempt to prevent such minor impacts would severely reduce the effectiveness of near-field mitigation and increase the chance of killing or injuring a marine mammal or turtle.

Q15. Due to the rewrite of Appendix E, this specific comment no longer applies. However, generally the criterion applied in the EIS gives much higher levels than those for continuous wave sources. This results from using a methodology for transient sources based on integration time of the ear. Therefore, applying the SEAWOLF criterion to LFA and ATOC sources is not correct.

Topic Two: Reconstruction of Zones

Q16. This general comment is addressed in responses Q17-Q24.

Q17. Details concerning propagation properties (transmission loss, etc.) cannot be individually separated out from calculations using the REFMS code because they are an integral part of calculating the various paths through many layers of water and bottom, reflections from surface and bottom, etc. The result of the calculation is the waveform at the range and depth of interest, which includes all of these effects. One can calculate this waveform for any set of conditions (charge size and depth, bottom structure, sound velocity structure, etc.). This has been done for many geometries and sets of environmental conditions; inclusion of all these results would double the size of the EIS without serving any useful purpose. Example pressure-time plots for the Mayport area have been added to the FEIS.

Q18. Regarding propagation properties, see response Q17.

Sound speed profiles used for Mayport were archival; those for Norfolk were measured during the shock test of the USS JACKSONVILLE in 1988. *In situ* measurements made during the test showed that bottom descriptions found in archival databases were only partially applicable to the actuai site of the tests; sound-speed profiles in the water changed significantly not only weekly and daily, but also hourly. The same may also be true near Mayport depending on the proximity of the edge of the Gulf Stream at the time of the tests.

Changing bathymetry was not used. Additional detailed analyses such as are indicated by this question could be performed, but based on earlier analyses conducted prior to the DDG 53 shock trial, the results would not change significantly or be any more valid for this application.

Rationale for the detonation depth is explained in response Q7. Because the detonation depth is fixed, an analysis of sensitivity to differing source depths is not appropriate.

Q19. Due to the rewrite of Appendix E, this figure has been replaced and the comment no longer applies.

Q20. Appendix D of the FEIS has been revised to state the peak shockwave pressure at the maximum range for each mortality and injury criterion. A summary table has been added which lists each criterion (in pressure, impulse, or energy units as appropriate) and the corresponding range.

Q21. Specific information about bottom descriptions and sound-speed profiles is available. However, there are no measured data to compare with the results calculated by REFMS.

Q22. Determining "prevailing" ambient noise would require long-term measurements, and the Navy is not aware of such measurements near the Mayport or Norfolk areas. Ambient noise in any given area can vary tremendously, by as much as 10-20 dB at a given frequency from day to day (Richardson et al., 1995; Chapter 5). The variability in ambient noise is due to variability in noise sources, including wind speed, wave action, seismic noise, biological activity, amount of distant human activity, and rate of precipitation. Ambient noise can also change seasonally.

Regarding vessel noise and its impact on "prevailing" ambient noise, Richardson et al. (1995, p. 94) stated: "Noise from specific ships and other identifiable human activities is generally not considered part of the background ambient noise. However, the aggregate traffic noise, arising from the combined effects of all shipping at long ranges, is included. This traffic noise originates *more than 10 km away...*" Since ambient noise includes ship noise >10 km distant and since the vessel exclusion zone is 9.3 km, "prevailing" ambient noise would not be affected by the removal of shipping within the vessel exclusion area.

Obviously, the planned exclusion of non-test-related vessel traffic from the immediate vicinity of the test site will improve acoustic mitigation. As noted in Section 2.2.3.3 of the FEIS, the size of the vessel exclusion zone was determined in part by the need to minimize broad-band noise from ship engines, which could interfere with passive acoustic monitoring for marine mammals. Previous experience with MMATS shows that acoustic mitigation can be successful (see response Q31).

Q23. A summary table has been added to Section 4.0 of the FEIS which lists the specific numerical mortality, injury, and harassment criteria and the corresponding ranges. Thresholds for mortality and injury were developed based on calculations presented in Appendix D. Lung injury calculations in Appendix D are specific to the test conditions (size of explosive charge and depth of burst). Eardrum rupture calculations also included the first bottom reflection using the appropriate water depth and substrate for the Mayport and Norfolk areas. TTS ranges were calculated in Appendix E using the REFMS model and site-specific archival data as noted above.

Q24. The same figure appears elsewhere because it was developed to be conservative for any combination of charge and mammal depths. The actual range could be less (but not greater) under the specific conditions of the SEAWOLF shock tests. In the FEIS, the figure has been replaced with one showing results for the specific charge depth of the SEAWOLF test. Substrate and sound speed profile are not significant influences on the lung injury ranges.

Topic Three: Estimates of Densities of Marine Mammals

Q25. The transects actually extended 7.4 km (4 nmi) in both directions from the 152 m (500 ft) depth contour. The survey plan, including standard aerial transect methods, was developed in consultation with the National Marine Fisheries Service and is considered adequate to obtain a representative sample of the population at risk.

Q26. The coverage is not biased; it is centered directly on the isobath where shock testing is proposed to occur. The survey data were collected primarily to identify marine mammals and turtles that could be present within the mortality and injury ranges and provide a representative sample of the population at risk. Extending survey transects to cover the entire acoustic harassment range would have more than doubled the survey effort, but we would not expect the results to be significantly different.

Topic Four: Site Selection

Q27. The analysis considers alternative areas that meet the Navy's operational requirements as defined in Section 2.0. As explained in Section 2.2.2.1, scheduling the test on the west coast or in the Gulf of Mexico would not meet operational requirements; it would increase the time the ship is away from the homeport, complicate or prolong repairs, and further delay deployment.

Topic Five: Comparisons to Other Tests

Q28. The mortality and injury zones are generally consistent with those used for the DDG 53 shock trial (see response Q3). The safety ranges are identical, except that the Navy has added a buffer zone of 1.85 km (1 nmi) for SEAWOLF. The "harassment" zone differs because a different criterion was used (see response Q3).

Mortality and injury criteria for the ACT II Test (Ref 2) were developed from the same set of data and equations used in SEAWOLF Appendix D (Yelverton et al., etc.). There is no obvious discrepancy. A different threshold for acoustic harassment was used, so it is not surprising that the results differ from the SEAWOLF EIS.

Regarding the differences among acoustic harassment criteria, there are no data or standard models to prove that one approach is superior to another. The thresholds used in any analysis are based on very limited data because the entire subject of the effects of explosions on marine mammal hearing is in its infancy. The current approach is technically sound because it is based on a standard, measurable auditory effect (TTS); it treats impulsive noise in a manner that accounts for the way the ear responds; and it is based on an effect (temporary hearing loss) which could be biologically significant in the context of exposure to a single pulse.

Q29. The Navy is aware of the error in the DDG 53 calculations. It has no effect on the SEAWOLF calculations. Regarding the differences in the harassment range, see response Q3.

Topic Six: Mitigation Effectiveness

Q30. See response Q31.

Q31. MMATS has repeatedly demonstrated its effectiveness at sea during Navy tests. MMATS frequently has detected cetaceans, including blue, humpback, sperm, and Bryde's whales, that had not been seen at the surface. On several of these occasions, visual confirmation was obtained after the initial MMATS detection.

The reference to MMATS as an experimental system is misleading. While not a production system, MMATS is a prototype which has been extensively tested during numerous sea tests over the course of the past three years. MMATS incorporates state of the art commercial off-the-shelf software and hardware. It implements algorithms that have evolved from seven years of experience processing acoustic transient signals on Navy programs.

During the DDG 53 shock trials, MMATS detected and localized a blue whale 17 km (9 nmi) away from and on-line with the intended detonation location. This occurred in an area which had been searched by two aerial surveillance aircraft with no detections. Subsequent aerial visual surveillance confirmed two blue whales at the location determined by MMATS. On a survey flight during the DDG 53 trials, a submerged sperm whale was detected and localized by MMATS. One hour and 20 minutes later the animal surfaced, and its identity was confirmed by the two onboard NMFS marine mammal observers. Other cetaceans have been detected acoustically by MMATS with subsequent visual confirmation during exercises in the Gulf of Mexico and offshore of Washington state and Hawaii.

Acoustic and visual detection methods are complementary. When animals are sighted visually, they are at the surface and usually not detectable acoustically. When they are submerged, they are usually not visible but may be audible if they are calling. Some species of marine mammals spend most of their time submerged, making them difficult to visually detect. The extent to which acoustic surveillance will supplement visual observation is a function of the relative local abundance of various species, each with different diving patterns.

The number of sighting events needs to be distinguished from the number of animals sighted. In comparing acoustic and visual methods, for purposes of environmental mitigation during Navy sea tests, the number of mammals sighted is a less useful statistic than the number of sighting events. Pods of dolphins can be very large, and are unlikely to go unobserved. Individual animals are much harder to detect visually. During the DDG 53 trials, there were substantially more visual than acoustic detections. These were, however, almost all of dolphins and pinnipeds, which (at the time) MMATS was not configured to detect. Regardless of how many animals are detected by either method, ANY detections within a danger zone are extremely important. As previously mentioned, MMATS detected a blue whale 17 km (9 nmi) away from and on-line with the intended detonation location for the DDG 53. This was an area covered twice by visual aerial surveillance with no detections. Subsequent aerial visual surveillance confirmed two blue whales at this location. As a result, the detonation location was altered to move away from the whales. All whale detections during the DDG 53 shock trial were by MMATS.

Other tests have confirmed that visual sightings are good for dolphins but MMATS is superior for detecting many whales. There are a number of reasons why, during past mitigation efforts, MMATS had fewer odontocete detection events than did visual surveillance. During the DDG 53 test, MMATS did not have the bandwidth necessary to detect dolphins or most other odontocetes.

Therefore, no attempt was made to acoustically detect these animals. During a later test, MMATS did have a rudimentary capability of detecting dolphins, but only through monitoring the lower third of the bandwidth of their calls, and only on a few channels. From time to time, sensor failure due to physical damage by high seas and radio interference degraded overall acoustic detection performance. (MMATS signal processing equipment was fully operational 100% of the time). For the SEAWOLF shock test, a much more closely spaced field of sensors would be deployed, and much more of the bandwidth of dolphin calls would be monitored. Sensor damage due to high seas would not be an issue, nor would radio interference.

Some previous tests involved use of MMATS on moving platforms where dolphins were either riding the bow wave or following. The high noise level of these moving platforms usually precluded detection of dolphin whistles. This would not be the case for the SEAWOLF tests.

Mooring the sensors for lengthy periods of time and in sometimes heavy seas can result in damage and loss. However, the SEAWOLF shock test would be conducted only in calm seas (no greater than Beaufort 4), and sensors would be deployed just before each shot. For the SEAWOLF shock test, sensors are also being built with the ability to remotely change channels to compensate for any radio interference.

Conservative detection factors with MMATS are based on whether various species are likely to be producing detectable sounds. Sperm whales would almost certainly be producing calls and should be acoustically detectable. Detection estimates used were 75% for sperm whales and *Stenella*, 50% for other odontocetes except Cuvier's beaked whale, and 25% for baleen whales and Cuvier's (see Appendix B).

Q32. Flight safety is the primary concern determining the number of mitigation aircraft for SEAWOLF. Moreover, replacing MMATS capabilities to add more aircraft would reduce mitigation effectiveness as MMATS has proven to be valuable in detecting submerged animals not visible from aircraft or ships.

The SEAWOLF shock test would use two shipboard monitoring teams, the MMATS acoustic detection team, and one aircraft to monitor an 11.1 km x 11.1 km (6 nmi x 6 nmi) area around the detonation point. Beginning at 2.5 hours prior to detonation, the aircraft would monitor this entire area for 1-1.5 hours. Then, during the last hour the aircraft would focus on the safety range and buffer zone, but the total complement of mitigation team assets would be capable of monitoring the larger area. This level of effort was proven reliable during the DDG 53 shock trial in June 1994 off the coast of southern California. In the test, one shipboard team, the MMATS team and three aircraft were used to monitor two adjacent 14.8 km x 18.5 km (8 nmi x 10 nmi) areas. The DDG 53 and the charge handling boat were making way at 5-8 knots which required that two large test areas be kept clear of marine animals. This required two aircraft flying in close proximity of each other and a third aircraft to relieve them as fuel became low. Aircraft were controlled by the DDG 53's AEGIS radar system which is the most advanced at-sea radar in the world. Even with this capability, controlling aircraft with the precision necessary to ensure safety of flight proved to be difficult and as a result caused a great deal of discomfort with the pilots and observers onboard the mitigation aircraft. The mitigation aircraft is required to make numerous unpredicted maneuvers including quick descents or changes in direction to maintain contact with an animal until its location, species, and swim direction can be noted. Lessons learned are documented in the Navy's post trial report submitted to NMFS in September 94 [Marine Mammal Protection/Mitigation and Results Summary for the Shock Trial of USS JOHN PAUL JONES (DDG 53)].

For SEAWOLF, the test site to be monitored is smaller (11.1 km x 11.1 km, or 6 nmi x 6 nmi) and it is stationary. One aircraft, complemented by MMATS and two shipboard observation teams would be able to monitor the area effectively in order to protect marine life. In total, 11-14 experienced observers would monitor the test site during each detonation. With one aircraft, the Navy can ensure flight safety by minimizing the potential of air accidents and injury to pilots and observers. The minimal value added by having additional aircraft flying over a relatively small area is not sufficient to offset the reduction in safety or the concentration of the observers who may otherwise be distracted by close encounters with the other aircraft.

Q33. The Navy is considering plans to measure Sound Pressure Levels (SPL) generated by the explosive charges to support future Navy efforts and programs.

Topic Seven: Authorship and Attribution

Q34. All contributors and their credentials are included in the revised List of Preparers.

Q35. All contributors and their credentials are included in the revised List of Preparers.

R

To - L.M. Pitts
From - Rev. René Robert
Date - July 30, 1996
Re - DEIS

I see no reason to justify the Seawolf Ship Shock Test. The cost and harm of marine life and possibly human life is uncalled for. Sure you need to protect the Seawolf crew but how were previous submarines tested. (R1)

With all our technological advances there should be another option that would be of no harm to marine life and humans. (R2) What do other nations do to test their submarines? (R3)

My hope and prayer is that this test will never occur. (R4)

Pastor - Let's build instruments of peace and not war.

RR

The Cathedral-Basilica of St. Augustine
35 TREASURY STREET
ST. AUGUSTINE, FLORIDA 32084

L.M. Pitts
Head, Environmental Planning
Dept. of the Navy
P.O. Box 190010

Rev. René Robert

Written Comment, July 30, 1996

Navy Response:

R1. The SEAWOLF is the first submarine to require realistic survivability testing in accordance with 10 USC 2366. However, prior to enactment of 10 USC 2366, several submarines have been shock tested to demonstrate their survivability (SSN699 in 1988, SSN692 in 1983, SSN593 in 1962, SSN585 in 1962, and SSN578 in 1960).

R2. As explained in Section 1.0, shock testing is necessary because computer modeling and component and surrogate testing do not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366. The entire manned submarine must be shock tested at sea.

R3. Other nations have conducted submarine shock tests or are planning to conduct them in the future. For example, the Australians are planning a submarine shock test in 1999 (their first). However, the U.S. has the most structured and consistent submarine shock testing program. Because shock testing is required by U.S. law (10 USC 2366), the practices of other nations are not relevant in determining whether the SEAWOLF shock test is necessary.

R4. Comment noted.

S

S1

Aug. 8, 1996

Sir:
We are unalterably opposed to the shock testing the navy proposes for offshore Norfolk, Va., Mayport, Fl. or any other site. It will prove harmful to sea life!

Thank you
Mr. & Mrs. Carl V. Steinhauser

JACKSONVILLE, FL 322
PM
09 AUG
1996

Old Glory
USA G

Mr. Will Sloger
Code 064 WS So. Div.
Naval Facilities
Engineering Command
P.O. Box 190010,
No. Charleston,
S.C. 29419-9010

Carl V & Patricia Steinhauser
2020 Indian Springs Dr
Jacksonville FL 32246-1058

Carl V. and Patricia Steinhauser

Written Comment, August 8, 1996

Navy Response:

S1. Comment noted.

T

Dear Sirs,

I am writing in regard to the DEIS. I am also writing in regard to the shock testing that will be Done on the Seawolf Submarine.

I Find that the information provided By the Deis. shows Nothing. I am absolutly sure that the Navy could Find more suitable testing for the seawolf Submarine (ie) large pool or some where absolutly guarenteed Not to harm the Environment. (T1)

I am a Navy vetern and have grown increasingly more conscious of the Disregard the Navy has for our environment. I am extremly upset with this testing and plan to write my congressman several time a week is support of my Disapproval. (T2)

Thank you For your time and God have mercy on your souls

Sincerly

Brian C. Merchant

Brian C. Merchant
811 E. City hall Ave
Norfolk Va. 23510
#2M-22

HAMPTON ROADS VA 233 PM 13 AUG 1996

[redacted]

MR Will Sloger Code 064WS
Southern Div. [illegible]
Engineering Command, P.O. Box 190[illegible]
North Charleston [illegible] 2[illegible]419-9010

Brian C. Merchant

Written Comment, August 13, 1996

Navy Response:

T1. The operational requirements for shock testing are explained in Section 1.0. There is no pond large enough to shock test the entire submarine.

T2. Comment noted.

U

The Virginia Beach Friends Meeting
of
The Religious Society of Friends

1537 Laskin Road
Virginia Beach, Virginia 23451

An Expression Of Concern

It has come to the attention of our Meeting that the Department of the Navy has proposed shock testing the SEAWOLF submarine at sites off shore near Norfolk, Virginia or Mayport, Florida. It is also our understanding that the Department of the Navy is soliciting suggestions and comments prior to making a final determination concerning this proposal. The Virginia Beach Society of Friends wishes to express its concerns regarding the possible negative impact of such testing on marine mammals, including the dolphin and whale populations. (U1)

Our Meeting respectively requests that the Department of the Navy cease or postpone these operations until an opportunity has been provided to fully study the potential negative impact of these tests on marine mammals within the designated testing areas. (U2) We ask that the Environmental Impact Statement for this project be carefully evaluated, and that the Department of the Navy engage in a formal consultation process with the National Marine Fisheries Service as prescribed under Section 7 of the Endangered Species Act. Further, we urge the Navy to comply with the mandates of the Marine Mammal Protection Act. (U3)

Please inform us of your decisions regarding our requests so that we may report them to our Meeting.

Respectfully Submitted

[signature] 8/13/96.

Louise Rothrock, Clerk

Virginia Beach Friends Meeting

The Religious Society of Friends
Written Comment, August 13, 1996

Navy Response:

U1. Comment noted.

U2. The EIS presents adequate information to evaluate potential impacts and to compare alternatives. Postponing the test would not significantly improve the information base for decisionmaking.

U3. The Navy has engaged in formal consultation with the National Marine Fisheries Service as prescribed under Section 7 of the Endangered Species Act. The Biological Opinion resulting from this consultation is presented in Appendix G. The Navy has also submitted an application to the NMFS for an "incidental take permit" as required under the Marine Mammal Protection Act.

V

8/20/96

— Written Comments —

Sea Wolf Submarine
Shock test

Please better define
"mitigation" in the
final EIS. (V1)
What exactly will
be done to handle
impacts. (V2)

Thank you

Traycie West
925 Sugar Tree Ct
Chesapeake VA
23320

This comment is as a
private citizen, not as an
employee of DEQ.

Traycie West

Written Comment, August 20, 1996

Navy Response:

V1. A brief definition of the term "mitigation" has been inserted where the topic first appears in the Executive Summary, Alternatives (Section 2.0), and Mitigation and Monitoring (Section 5.0). Detailed procedures to "handle impacts" (i.e., avoid and minimize impacts) are already described in detail in Section 5.0, Mitigation and Monitoring.

8/22

W

Dear Mr. Sloger,

I would like to protest the shock testing of the seawolf submarine. We can not afford the loss of both marine mammals or sea turtles in our oceans. It is unacceptable to continue degrading marine habitat for shock testing a new submarine. An outraged citizen –

Sincerely,

Dana L. Kuehn

(W1)

Ms. Dana L.L. Kuehn
2130 Jekyll Ct
Fernandina FL 32034-4403

PM
22 AUG
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Attn. Mr. Will Sloger
Dept. of the Navy
Southern Division
Naval Facilities Engineering Command
2155 Eagle Dr.
North Charleston SC
29406

Dana L. Kuehn

Written Comment, August 22, 1996

Navy Response:

W1. Comment noted.

X

Patrick McVicker
784 Windbrook Circle #304
Newport News, VA 23602-8892

August 24,1996

Mr. Will Sloger
Code 064WS
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
North Charleston, South Carolina 29419-9010

Dear Mr. Sloger:

Just as many cosmetic companies today still carry out useless animal tests in attempts to assure consumers of the safety of their products, the Navy now proposes similarly useless experiments, certain to sacrifice countless non-human animal lives, in a futile attempt to assure the American public that the Navy can build a strong and safe submarine.

(X1)

Many of the aforementioned cosmetic companies will openly claim that determining product safety is not even their main concern in conducting animal testing, but instead the animal tests (in *their* opinion) expunge them of blame when a consumer has a complaint about a product. In essence, these cosmetic companies are saying that their main priority is avoiding liability for the potentially faulty products that they produce instead of abolishing ineffective animal-testing models and replacing them with modern testing methods which are more accurate, cheaper and will likely preclude the possibility of the majority of liability cases from ever occurring. It would seem as though the Navy is modeling its product testing after animal-testing cosmetic companies.

I feel that determining product safety is not the Navy's primary concern in shock testing the SEAWOLF submarine (much as you would like us to believe) but in reality the shock tests are serving to exonerate the Navy if and when a problem arises with the SEAWOLF sometime in the future. You say the rules require a "Live Fire Test & Evaluation"? I say change the rules! These tests in no way assure me of the safety of the SEAWOLF but instead exemplify the type of waste and deceit the Navy, and indeed the entire defense community, has always been infamous for.

Taking into account the huge potential damage to the environment and the unacceptable loss of non-human animal life, in addition to what I have previously mentioned in this letter, I feel that the only option is the "no action" alternative. (X2)

Sincerely,

Patrick McVicker

Patrick McVicker

Written Comment, August 24, 1996

Navy Response:

X1. The Navy is testing a submarine, not animals. As stated in Section 1.0, the purpose of shock testing is to assess the survivability of the submarine. The ultimate goal is to assess the survivability of SEAWOLF class submarines and protect the lives of the sailors onboard, not to "avoid blame" in the event of a future loss.

X2. Comment noted.

Y

Mr. Will Sloger
Code 064WS
Southern Division
Naval Facilities Engineering Command
P.O. Box 190010
North Charleston, South Carolina 29419-9010

4 September, 1996

Dear Mr. Sloger,

We are writing to express several concerns we have about the DEIS *Shock Testing the Seawolf Submarine* (June 1996). We have read the DEIS and are impressed by the thoroughness with which the plan was compiled. We believe, however, that the mitigation measures do not adequately address our concerns about potential harm to marine mammals and sea turtles.

Below we've listed several areas that require consideration:

1. **The safety range is not large enough.** The size of the safety range was determined from calculations presented in Appendix D (Potential Impacts of Activities on Marine Mammals). Statements in Appendix D are contradicted in Appendix E (Criterion for Marine Mammal Acoustic Discomfort). In Appendix D, the assumption is made that since few air spaces are present in the marine mammal ear, these animals are less likely to incur ear trauma (page D-5). In Appendix E (page E-12) the following statement occurs: "*There are no existing data applicable to the definition of a meaningful criterion for potential auditory injury to marine mammals exposed to underwater explosions.*" We argue that since marine mammals rely heavily on their acoustic senses, they are more likely to be affected by acoustic disturbance. Even temporary auditory trauma may affect marine mammals. This type of disturbance can be seen in terrestrial mammals (i.e. headlights at night do not permanently damage the eyes of deer but the sudden bright light makes them vulnerable to being hit by vehicles that they could normally avoid.) Since we do not know and cannot prove the effect of these explosions on marine mammals (page E12), we should be as conservative as possible in developing mitigation measures. As such, it is suggested in Appendix E that a conservative safety limit is 4-6 nm. Since marine mammals are very acoustically oriented and even temporary hearing loss may have a negative effect, it makes sense to choose a conservative safety range, rather than one based on the terrestrial mammal data in Appendix D. We recommend a 5 nm safety range with an additional 2 nm buffer zone. (Y1)
2. **A postponement or delay period should be defined.** In Appendix G (page G-36 and G-45) the statement is made that "*Detection of even one marine mammal (or sea turtle) within the safety range would result in postponement of detonation...*" How long will detonation be postponed? Will aerial and shipboard surveys continue until no animals are within the safety range? Will detonation be canceled for the day? Please make this clear. The detection of one marine mammal indicates favorable conditions for the presence of others. In fact, corrections are used in Section 3 Table 3-1. Therefore if even one marine mammal or sea turtle is detected, several may be within the safety range. Additionally, it is stated that detection in the safety range will postpone detonation, what happens if animals are detected in the buffer zone? (Y2)
3. **Redefine the decision making process.** In Section 5: Mitigation and Monitoring, Figure 5-1 outlines the Go/No Go decision making process. Can the Officer in Command or the Test Director ignore the recommendation of the Lead Scientist and/or the survey team? If so, is this really going to work? One can visualize a situation where several postponements have occurred for various reasons. Under pressure to wrap up the test, an Officer in Command or a Test Director may override the recommendation of the science team, thus negating all of the survey work that has been conducted. If the Lead Scientist recommends No Go, the Officer in Command should be required to honor the recommendation. If the Lead Scientist recommends Go, then the Test Director can report Go/No Go based on environmental and operational range conditions. (Y3)
4. **The Mitigation Plan to capture sea turtles (page 5-6) is not feasible.** Healthy, large sea turtles will dive at the approach of a vessel. You cannot expect to capture them with a net. Some smaller turtles may be captured but there will most likely be many undetected turtles for each one that is captured. If you are planning to protect turtles, the detonation should be canceled if one is detected in the safety range. (Y4)

Thank you for considering our concerns. We understand the need to test the new Seawolf submarine in order to insure the safety of the men and women who serve on them. Since the country is not in a wartime situation or in a cold war, we should offer the same consideration to the protected species that may be affected by our testing activities.

Sincerely,

Susan G. Barco
Cetacean Ecologist
Virginia Beach, Virginia

W. Mark Swingle
Cetacean Ecologist
Virginia Beach, Virginia

cc: Chief, Marine Mammal Division, OPR, NMFS

Susan G. Barco and W. Mark Swingle

Written Comment, September 4, 1996

Navy Response:

Y1. Regarding the adequacy of the safety range and buffer zone, see response N2. The safety range was developed to prevent death and injury to marine mammals, and the buffer zone provides an additional margin of safety, especially for listed marine mammals. Marine mammals beyond the buffered safety range may experience reversible auditory effects, i.e., temporary threshold shift. However, expanding the safety range to attempt to prevent such minor impacts would severely reduce the effectiveness of near-field mitigation and increase the chance of killing or injuring a marine mammal or turtle.

Y2. Text has been added to Section 5.0 of the FEIS to better define the postponement period. See response NMFS-4a for further information.

Y3. The Lead Scientist has the authority to declare the range fouled and recommend a hold detonation until she is comfortable that the safety range is and will remain clear of animals prior to the detonation. There are a series of checks in the shot day event schedule including those at 3 minutes, and 1 minute prior to detonation in addition to periodic updates during the 2.5 hour mitigation period. The Lead Scientist also has the authority to declare a fouled range anytime between the 1 minute prior to detonation which would result in a "hold detonation" command by the Officer in Tactical Command (OTC), unless personal safety or an operational emergency dictates detonating the charge.

Y4. The main emphasis of the mitigation plan is detection of sea turtles (and marine mammals) and postponement of detonation if any of these animals are present within the safety range. However, if a turtle were seen in the safety range and showed no indication of moving from the area, MART would attempt to capture it. While capturing sea turtles may be difficult, MART would nonetheless be prepared to do so for their protection. Adult sea turtles have been captured by ships during research cruises.

The FEIS includes changes to the mitigation program (Section 5.0) designed to enhance detection and protection of sea turtles. These include tighter line spacing for aerial monitoring, addition of a third aerial observer, avoidance of sargassum-rich areas during test site selection (to the extent possible) and postponement of detonation if large sargassum rafts or jellyfish shoals are observed within the safety range.

Z

FACSIMILE COVER PAGE

To: Will Sloger - Naval Fac Eng Cmd **From:** Robert J Heid
Time: 14:09:26 **Date:** 9/10/9
Pages (including cover): 1

Mr Will Sloger
Code 064WS
Southern Division
Naval Facilities Engineering Command
PO Box 190010
North Charleston, SC 29419-9101

From: Susan Heider 719/573-9489 e-mail slheider@aol.com
PO Box 25524 Colorado Springs, CO 80936

I've recently learned of plans to explode five 10,000 pound bombs off the coast of Jacksonville. Having been in the military I'm sure they feel they have a good reason for doing this shock test on the Seawolf. I DON'T. (Z1)

Don't we already damage the sea life .the environment enough during war time? Must we contiue to do so during times of supposed "peace". I'm all for being prepared but.. The cosmetics companies have found ways to test products without harming animals .I'm sure the military is smart enough to find ways to test without harming the environment, to include sea life....If, note the IF, they would bother taking the time to search for alternatives. (Z2)

It may not matter to you but the damage done now will have a negative impact on your descendants as well as mine. It's time to stop the endless destruction. (Z3)

Susan Heider

Susan Heider

Written Comment, September 19, 1996

Navy Response:

Z1. Comment noted.

Z2. Data from previous shock tests have been incorporated into computer models which are used to help predict the survivability of SEAWOLF class submarines. However, this modeling is only one of three components of the SEAWOLF Live Fire Test & Evaluation program which together provide the data necessary to assess the SEAWOLF's survivability. The components are computer modeling and analysis, component and surrogate testing, and a shock test of the entire ship. As explained in Section 1.0, this project is needed because computer modeling and component testing on machines or in surrogates do not provide adequate information to assess the survivability of the submarine in accordance with 10 USC 2366.

Shock testing the manned submarine at sea is the only way to evaluate the response of the entire ship, including the interaction of its systems and components. Although computer models and component testing are helpful, combat experience has demonstrated that they cannot predict the broad range of complex failure mechanisms which could occur inside sophisticated electronic components or complex mechanical systems.

Z3. Comment noted.