Figure 1-1. Military Ranges and Operating Areas Supporting COMPTUEX/JTFEX

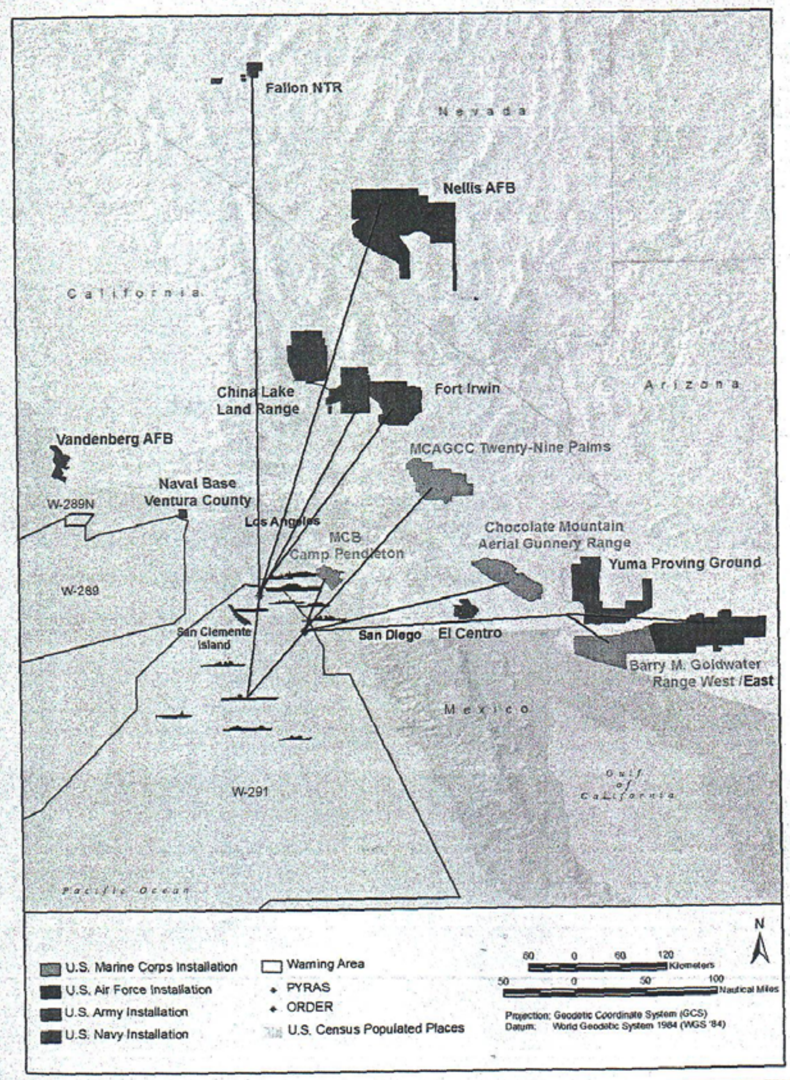

EXHIBIT NO. 1
APPLICATION NO.
CD-86-06

COMPOSITE TRAINING UNIT EXERCISES (COMPTUEX)

AND

JOINT TASK FORCE EXERCISES (JTFEX)

Information provided in this memorandum provide clarification to questions raised by CCD staff (Mark Delaplaine) during Oct 26, 2006 teleconference. Information can be used in conjunction with Coastal Consistency Determination (CCD) submitted to CCC on Oct 25.

COMPTUEX/JTFEX TRAINING OPERATION DESCRIPTIONS

Following information provides additional information on the five training activities detailed in the Consistency Determination.

I. Map showing location of activities.

San Clemente Island Range Complex (Figures 1-1 and 1-2)
Mining Operations occur offshore San Clemente Island in the Castle Rock Mining Range off the northwest coast of the Island; Eel Point Mining Range at the midpoint on the southwest side; China Point area, off the southwestern-most part of island; and Pyramid Head area, off the island's southeast tip (Figure 1-1.) These ranges are used for training of aircrews in mine - laying by delivery of inert mine shapes (no explosives) from aircraft.

Figure 1-1. Mining Areas off San Clemente Island

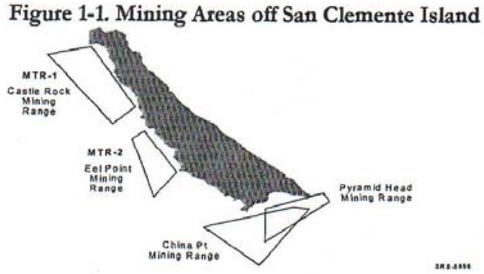

EXHIBIT NO. 2
APPLICATION NO.
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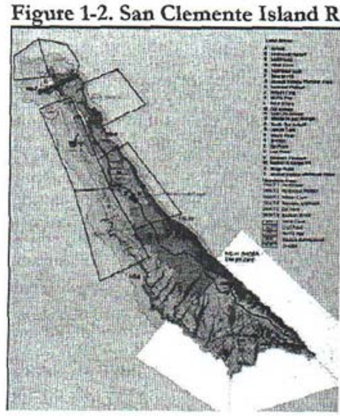
Naval Surface Fires Support operations are only conducted at the Shore Bombardment Area located on the southern tip of San Clemente Island. Offshore Navy vessels fire into either Impact I or Impact Area II (slightly to the west of Impact Area I). As depicted in Figure 1-2, the offshore ranges supporting firing activities into the Shore Bombardment Areas extend up to about 3 nm offshore, and are charted as Danger Zones (yellow area in Figure).

Demolition Operations occur in Pyramid Cove (offshore Impact Area I on the southern end of San Clemente Island); this area has been used for many years for underwater detonation activities.

Ship Mine Countermeasures rarely occur in Southern California, but when they do, they occur off the western side of San Clemente Island.

Amphibious landings occur at West Cove (northwestern side near the end of the runway) and Horse Beach Cove (southern end).

Figure 1-2. San Clemente Island Ranges



Silver Strand Training Complex (Figure 1-3)

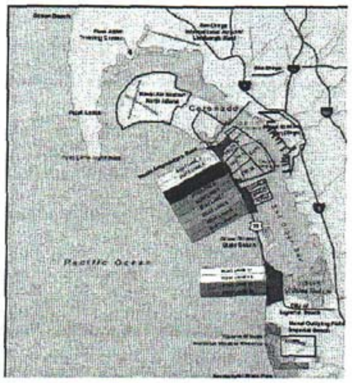
Mining Operations occur west of the boat lanes (greater than 2 nm offshore.) and involve dropping inert shapes into the water.

Demolition Operations occur in the offshore boat lanes and extend slightly west, beyond the end of the 2 nm boat lanes; this area has been used for many years for underwater detonation activities.

Ship Mine Countermeasures rarely occur in Southern California, but when they do, they occur in the boat lanes and slightly to the west.

Amphibious Operations have occurred at the Silver Strand Training Complex South

Figure 1-3. Silver Strand Training Complex



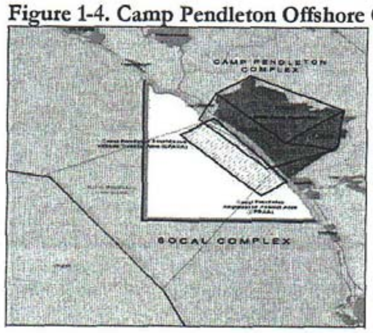
Marine Corps Base Camp Pendleton (Figure 1-4)
Mining Operations are conducted offshore Camp Pendleton in the Camp Pendleton Amphibious Assault Area, but not in the Camp Pendleton Amphibious Vehicle Training Area.

Demolition Operations occur in the offshore Camp Pendleton Amphibious Assault Area, but not in the Camp Pendleton Amphibious Vehicle Training Area; this area has been used for many years for underwater detonation activities.

Ship Mine Countermeasures rarely occur in Southern California, but when they do, they occur in the offshore Camp Pendleton Amphibious Assault Area, but not in the Camp Pendleton Amphibious Vehicle Training Area

Amphibious Operations occur in the Camp Pendleton Amphibious Assault Area and Camp Pendleton Amphibious Vehicle Training Area.

Figure 1-4. Camp Pendleton Offshore Operating Areas



In all cases, the Proposed Action:
(1) is consistent with ongoing activities, and does not occur at a new location, and
(2) occurs in offshore waters or on federally-owned property.

II. Number of ships/vehicles that will be used in each of the exercise
Because of the variability built into major range events, particularly JTFEX, only an estimated range can be provided.

Mining Operations
1 aircraft
2-5 small boats

Naval Surface Fires Support
4-6 ships

Demolition Operations
2-3 small boats
0-2 helicopters

Ship Mine Countermeasures
2 mine countermeasure boats
1 helicopter

Amphibious Operations
3 amphibious ships
Aircraft – rotary wing, fixed wing, and tilt-wing
Amphibious vehicles and vessels – Landing Craft Air Cushion, Amphibious Assault Vehicles, Combat Rubber Raiding Craft (small rubber boats), Rigid Hull Inflatable Boat (small, rigid hull boat), Landing Craft Utility (vessel used to carry personnel, equipment and land vehicles.)

MARINE MAMMAL MITIGATION MEASURES – UNDERWATER DETONATIONS AND MINING OPERATIONS

To ensure protection of marine mammals and sea turtles during underwater explosives training and Mining Operations, the operating area must be determined to be clear of marine mammals and sea turtles prior to detonation. Implementation of the following protective measures continue to ensure that marine mammals would not be exposed to TTS, PTS or injury from physical contact with training mine shapes during major range events.

These protective measures are the focus of consultation with NOAA NMFS SW Region.

Demolition and Ship Mine Countermeasures Operations

Safety Zones

All mine warfare and mine countermeasure operations involving the use of explosive charges must include safe zones for marine mammals and sea turtles to prevent physical and/or acoustic harm to those species. These safety zones shall extend in a 700-yard arc radius around the detonation site.

Pre-Exercise Surveys

For Demolition and Ship Mine Countermeasures Operations, pre-exercise survey shall be conducted within 30 minutes prior to the commencement of the scheduled explosive event. The survey may be conducted from the surface, by divers, and/or from the air, and personnel shall be alert to the presence of any marine mammal or sea turtle. Should such an animal be present within the survey area, the exercise shall be paused until the animal voluntarily leaves the area.

Post-Exercise Surveys

Surveys within the same radius shall also be conducted within 30 minutes after the completion of the explosive event.

Reporting

Pre- and post-exercise surveys shall be reported to the Commander Third Fleet Judge Advocate and the COMNAVREG Southwest Environmental Director at (619) 532-1428. Negative reports for post operations surveys are required. Any evidence of a marine mammal or sea turtle that may have been injured or killed by the action shall be reported immediately to Navy Region Southwest Environmental Director.

Mining Operations

As described in the COMPTUEX/JTFEX EA/OEA, Mining Operations involve aerial drops of inert training shapes on floating targets. Aircrews are scored for their ability to accurately hit the target. Although this operation does not involve live ordnance, marine mammals have the potential to be injured if they are in the immediate vicinity of a floating target; therefore, a safety zone shall be cleared around the target location. Pre- and post - surveys and reporting requirements outlined for underwater detonations shall be implemented during Mining Operations.

I. Endangered Species Consultation with NOAA.
Endangered Species Act (ESA) package was sent to NOAA HQ August 2006. NOAA HQ designated lead for the consultation to the local, NOAA National Marine Fisheries Service Southwest Regional Office in Long Beach. Navy met with SW Regional Office on Nov 16th and will continue ESA consultation until all issues are addressed.

II. What thresholds did we use to assess effects of SONAR?
Thresholds used to evaluate harassment considered the potential for behavioral effects at both 173 dB and 190 dB, with the 173 dB analysis conducted at the request of NMFS.

III. What mitigation measures are in place to minimize effects of SONAR on marine mammals?
Consultation with NMFS includes discussion on mitigations for MFA SONAR, and can be relayed in greater detail as they are developed in conjunction with ESA consultations with NOAA.

V. Does the Navy use trained observers to locate marine mammals?
Yes, the Navy has developed a Marine Species Awareness program that assists dedicated Navy watch standers in identifying marine mammals on the surface. To assist in this education process, the Navy has developed a Marine Species Awareness DVD, outlining watch standing techniques for locating and reporting presence of marine mammals during anti-submarine warfare training activities. Purpose of the Marine Species Awareness Program is to minimize and avoid interactions between marine mammals and anti-submarine warfare operations.

VI. What is the ZOI for each SONAR and underwater detonation?
Based on the results of marine mammal acoustic effects analysis modeling, SONAR will not affect resources in the coastal zone. While some anti-submarine operations occur on the instrumented, deep water range 5 nm west of San Clemente Island, the majority of anti-submarine warfare operations occur greater than 80 nm offshore – well outside the 3 nm coastal zone. Overlapping the outer periphery of sub-Temporary Threshold Shift (sub-TTS) zone of influence for the strongest SONAR system, the AN/SSQ 53, **active SONAR does not extend into the coastal zone;** therefore, mitigation measures for active SONAR do not fall within the Articles addressed in the Navy's Coastal Consistency Determination for COMPTUEX and JTFEX. The Navy is working with NMFS to ensure that the mitigations account for the potential sound exposures, including establishing the safety zone distances at which Navy will implement measures.

NAVY'S LONG-TERM STRATEGIC PLAN FOR ENVIRONMENTAL COMPLIANCE

The Navy has developed the COMPTUEX/JTFEX Environmental Assessment/Overseas Environmental Assessment, which addresses major range events in Southern California during a two year period of time. Concurrently, the Navy is developing the Southern California (SOCAL) Environmental Impact Statement (EIS)/Overseas EIS and Silver Strand Training Complex EIS, which address Navy training activities in Southern California from Unit Level Training to major range events to sustainment level training. Long-term, the SOCAL EIS, Silver Strand Training Complex EIS and supporting regulatory consultations will fulfill mandated, federal environmental compliance regulations for all phases of the Navy's pre-deployment readiness training conducted on the San Clemente Island Range Complex and offshore waters of Southern California.

Table 1-3. COMPTUEX/JTFEX Activities Outside the Coastal Zone

EVENT	RANGE/OPAREA
Anti-Aircraft Warfare Exercise	SCIRC
Surface-to-Surface Missile Exercise	SOCAL
Sink Exercise	SOCAL
Gunnery Exercise	SOCAL
Submarine Operations	SOCAL
Tracking Exercise	SOCAL
Psychological Operations	SOCAL
Aircraft Operations Support	SCIRC, SOCAL, MCBCP
Air-to-Air Missile Exercise	SOCAL
Air-to-Surface Missile Exercise	SOCAL
Haystack	Over San Diego
Urban Close Air Support	NTC Ft Irwin BSTRC
Long Range STRIKE	SCIRC
Deck Landing Qualification	SOCAL
War at Sea Exercise	SOCAL
GANGPLANK	SOCAL
Sea Surface Control	SOCAL
Maritime Interdiction	SOCAL
Maritime Patrol Aircraft	SOCAL
Anti-Submarine Warfare Exercise	SOCAL
Electronic Warfare Exercise	SOCAL
Command and Control	SOCAL
Air Defense Exercise	SOCAL
Counter Targeting	SOCAL
Final Battle Problem	SOCAL

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APPENDIX

COMPTUEX/JTFEX TRAINING ACTIVITIES OUTSIDE THE COASTAL ZONE

Anti-Submarine Warfare Exercise (ASWEX)

ASWEX provides crews of submarines, ships, aircraft, and helicopters with experience in locating, tracking, and attacking submarines or submarine-like mobile underwater targets.

Anti-Aircraft Warfare Exercise (AAWEX)

The AAWEX provides realistic training and evaluation of ships and their crews in defending against enemy aircraft and missiles.

Surface-to-Surface Missile Exercise (SSMEX)

SSMEX provides basic training for Fleet units in firing surface-to-surface HARPOON missiles.

Sinking Exercise (SINKEX)

In a SINKEX, a specially-prepared, deactivated vessel is deliberately sunk using multiple weapons systems.

Gunnery Exercise (GUNEX)

Surface ship gunnery exercises take place in the open ocean and involve a variety of stationary and moving surface and aerial targets to provide gunnery practice for ship crews in an offensive or defensive posture.

Submarine Operations (SUBOPS)

SUBOPS train submarine crews in using sonar systems to search for and track surface ships and submarines, responding to simulated attacks using evasive maneuvering and countermeasures in deep and shallow waters, and avoiding detection by anti-submarine warfare (ASW) systems.

Visit, Board, Search, and Seizure (VBSS) or Maritime Intercept Operations (MIO) or Helicopter Visit, Board, Search, and Seizure (HVBSS)

VBSS missions are the principal type of Maritime Intercept Operations. Highly trained teams of personnel are deployed by small Zodiac boats or helicopters to board and inspect ships and vessels suspected of carrying contraband.

Naval Cooperation and Guidance for Shipping (NCAGS)

NCAGS assists the operational Commander in managing risk by providing situational awareness, a real-time operational picture, and the coordinated and safe passage of friendly merchant shipping carrying military supplies into seaports for off-load during a crisis or contingency.

Maritime Security Operation/Oil Platform (MSO/OPLAT) Defense

MSO/OPLAT Defense operations train ship crews to defend stationary high value infrastructures at-sea from possible attack.

Table 3-3. Marine Mammal Species in Southern California Waters

Common Name Species Name	Abundance	Stock (SAR)	ESA & MMPA Status	Annual Population Trend	Southern California Operating Area
Blue whale *Balaenoptera musculus*	1,744 (0.28)	Eastern North Pacific	E, D, S	May be increasing	Uncommon
Bryde's whale *Balaenoptera edeni*	12 (2.0)	California		Unknown	Rare
Fin whale *Balaenoptera physalus*	3,279 (0.31)	California, Oregon, Washington	E, D, S	May be increasing	Uncommon
Gray whale *Eschrichtius robustus*	26,635 (0.1006)	Eastern North Pacific		Increasing – 2.5%	Common during migration
Humpback whale *Megaptera novaeangliae*	1,034 (0.11)	California, Oregon, Washington	E, D, S	Increasing 6-7%	Uncommon
Minke whale *Balaenoptera acutorostrata*	1,015 (0.73)	California, Oregon, Washington		Unknown	Uncommon
North Pacific right whale *Eubalaena japonica*	Unknown	Eastern North Pacific	E, D, S	Unknown	Rare
Sei whale *Balaenoptera borealis*	56 (0.61)	Eastern North Pacific	E, D, S	May be increasing	Rare
Baird's beaked whale *Berardius bairdii*	228 (0.51)	California, Oregon, Washington		Unknown	Rare
Bottlenose dolphin coastal *Tursiops truncatus*	206 (012)	California Coastal		Stable	Rare
Bottlenose dolphin offshore *Tursiops truncatus*	5,065 (0.66)	California Offshore		Unknown	Common
Cuvier's beaked whale *Ziphius cavirostris*	1,884 (0.68)	California, Oregon, Washington		Unknown	Uncommon
Dall's porpoise *Phocoenoides dalli*	99,517 (0.33)	California, Oregon, Washington		Unknown	Common
Dwarf sperm whale *Kogia sima*	Unknown	California, Oregon, Washington		Unknown	Possible visitor
False killer whale *Pseudorca crassidens*	Unknown Rare	Eastern Tropical Pacific		Unknown	Rare
Killer whale offshore *Orcinus orca*	1,340 (0.31)	Eastern North Pacific		Unknown	Uncommon
Harbor porpoise *Phocoena phocoena*	7,579 (0.38)	Central California North		Increasing but not	Very rare
Killer whale southern resident	83 (?)	British Columbia	D,S	Increased in 2002 & 2003	Uncommon
Killer whale transient *Orcinus orca*	346 (?)	Eastern North Pacific		Unknown	Uncommon
Long-beaked common dolphin	43,360 (0.72)	California		Unknown – seasonal	Uncommon
Mesoplodont beaked whales *Mesoplodon* spp.	1,247 (0.92)	California, Oregon, Washington		Unknown	Rare
Northern right whale dolphin *Lissodelphis borealis*	20,362 (0.26)	California, Oregon, Washington		No Trend	Cor

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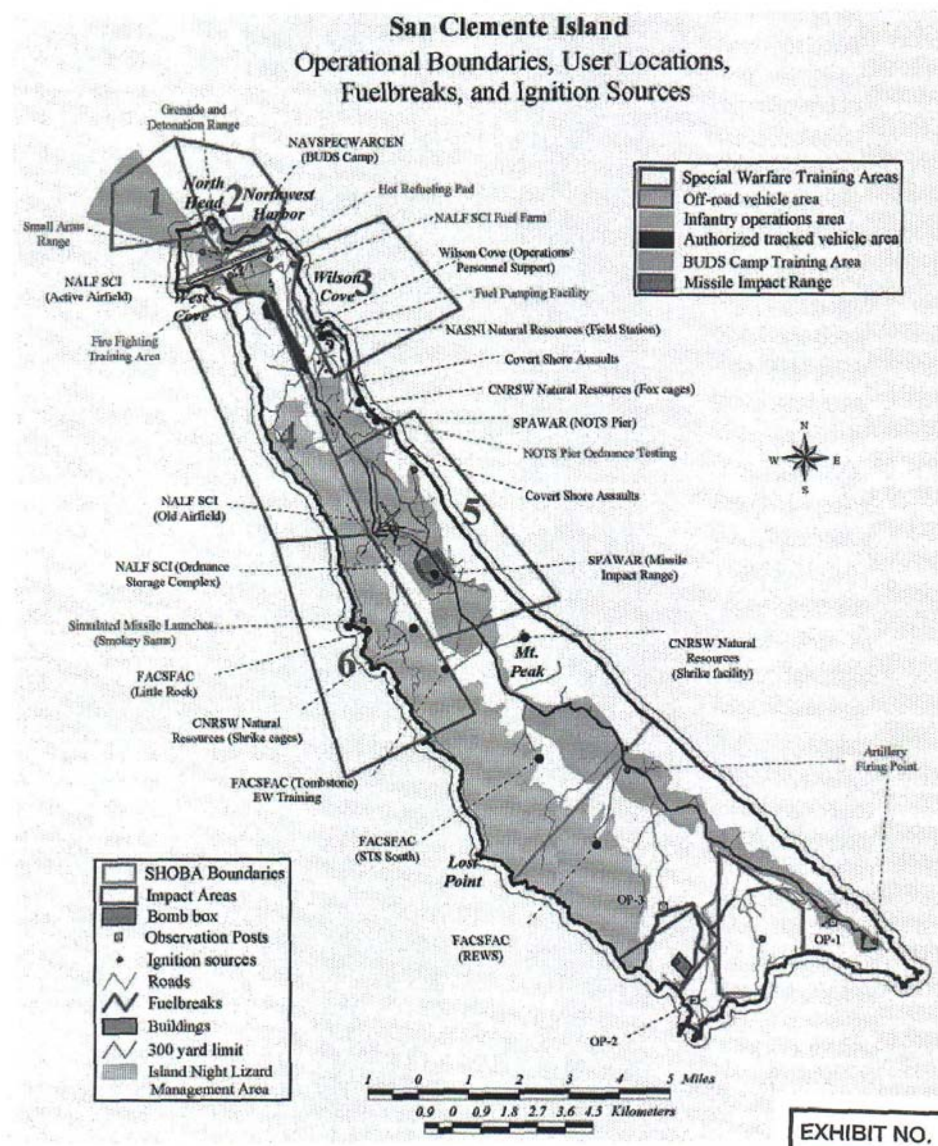
Common Name Species Name	Abundance	Stock (SAR)	ESA & MMPA Status	Annual Population Trend	Southern California Operating Area
Pantropical spotted dolphin *Stenella attenuate*	Unknown	Eastern Tropical Pacific		Unknown	Rare
Pygmy sperm whale *Kogia breviceps*	119 (?)	California, Oregon, Washington		Unknown	Rare
Risso's Dolphin *Grampus griseus*	16,066 (0.28)	California, Oregon, Washington		No Trend	Common
Pacific white-sided dolphin *Lagenorhynchus obliguidens*	59,724 (0.50)	California, Oregon, Washington		No Trend	Common
Rough-toothed dolphin *Steno bredanensis*	Unknown	Tropical and warm temperate		Unknown	Rare
Short-beaked common dolphin *Delphinus delphis*	449,846 (0.25)	California, Oregon, Wash		Unknown – seasonal differences	Common Seasonally abundant
Short-finned pilot whale *Globicephala macrorhynchus*	304 (1.02)	California, Oregon, Washington		Unknown	Uncommon; common before 1982
Sperm whale *Physeter macrocephalus*	1,233 (0.41)	California, Oregon, Washington	E, D, S	Unknown	Uncommon
Spinner dolphin *Stenella longirostris*	2,805 (0.66)	Tropical and warm temperate		Unknown	Rare
Striped dolphin *Stenella coeruleoalba*	13,934 (0.53)	California, Oregon, Washington		No Trend	Occasional visitor
Harbor seal *Phoca vitulina*	27,863 (0.17)	California		Stable	Common
Northern elephant seal *Mirounga angustirostris*	101,000	California		Increasing	Common
California sea lion *Zalophus californianus*	237,000	U.S. Stock		Increasing 6.1%	Abundant in summer
Guadalupe fur seal *Arctocephalus townsendi*	6,443	Mexico	T, D, S	Increasing 13.7%	Rare
Northern fur seal *Callorhinus ursinus*	7,784	San Miguel Island		Increasing 8.3%	Common
Stellar sea lion *Eumetopias jubatus*	6,555	California, Oregon, Washington	T, D	Decreasing	Rare
Southern Sea Otter *Enhydra lutris*	2,359	California	T, D	Increasing	Rare

Stock or population abundance estimates and the associated correlation of variance (CV) from NMFS Stock Assessment Reports (SAR), their status under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), the population trend, and relative abundance in each range area. E=Endangered under the ESA; D = Depleted under the MMPA; and S=Strategic Stock under the MMPA. Due to lack of information, several of the Mesoplodont beaked whales have been grouped together.

Effects of the Proposed Action

Overview

JTFEX/COMPTUEX activities would have negligible effects on marine mammals. Minor acoustic effects to marine mammals could occur from underwater detonations and possibly include: temporary changes in behavior, movement away from an area of activity, temporary



Map2-1. On-shore operational boundaries and user locations on San Clemente Island. (Do not reproduce or di[...] permission [see Document Disclaimer].)

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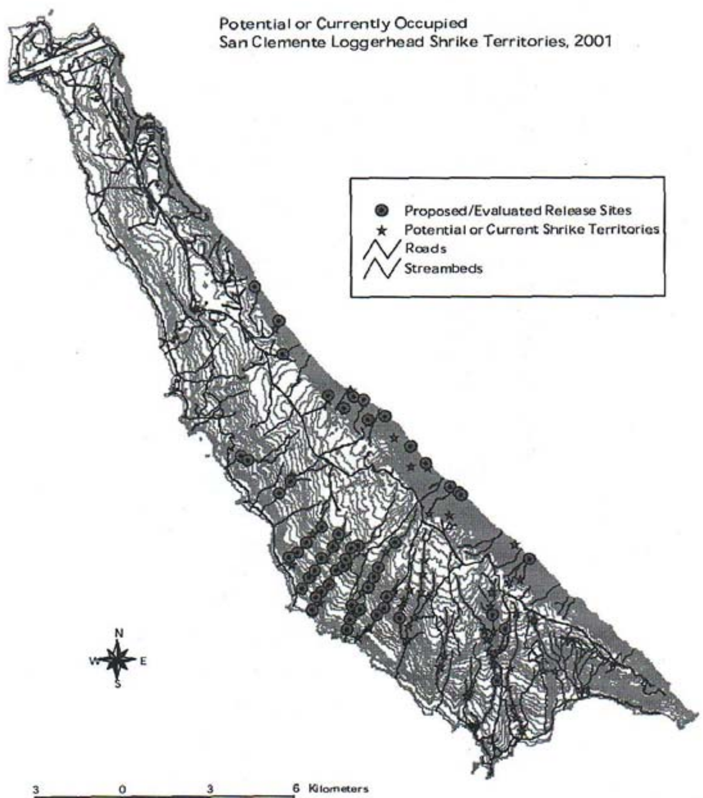
APPLICATION NO.	
CD-86-06	

Applicable INRMP Management Units: Units immediately important as nesting locations or future release sites are units numbered 9-18: Lemon Tank, Seal Cove, Mt. Thirst, Lost Point, Cave Canyon, Eagle Canyon, Upper China Canyon, China Cove, Pyramid Cove, and Mosquito Cove.

Current Military Values of the INRMP Management Units: **Highest**: China Cove (16) and Pyramid Cove (17), **High**: Seal Cove (10), **Medium**: Cave Canyon (13) and Mt. Thirst (11), **Low**: Lemon Tank (9), **Lowest**: Lost Point (12), Mosquito Cove (18), Eagle Canyon (14), and Upper China Canyon (15).



MapD-16. Recent and historical nest locations of the San Clemente loggerhead shrike. (Do not reproduce or di: permission [see Document Disclaimer]).

EXHIBIT NO. 6
APPLICATION NO.
CD-86-06

UNITED STATES DEPARTMENT OF COM[MERCE]
National Oceanic and Atmospheric Administ[ration]
NATIONAL OCEAN SERVICE
OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMEN[T]
Silver Spring, Maryland 20910

MAR 10 1995

Peter M. Douglas
Executive Director
California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219

Dear Mr. Douglas:

This letter responds to the California Coastal Commission's ("Commission") request to review, as an unlisted activity, the Scripps Institute of Oceanography's ("Scripps") application for a Monterey Bay National Marine Sanctuary ("MBNMS") permit renewal for activities associated with the Acoustic Thermometry of Ocean Climate ("ATOC") project. The Office of Ocean and Coastal Resource Management ("OCRM") has determined that the ATOC project can be reasonably expected to affect coastal uses or resources of California's coastal zone. Therefore, Scripps must comply with the federal consistency requirements of the Coastal Zone Management Act of 1972 ("CZMA") section 307(c)(3)(A) and 15 C.F.R. Part 930, Subpart D, and the Commission may review Scripps' application for a MBNMS permit renewal for the ATOC project. OCRM, through its Sanctuaries and Reserves Division and the MBNMS, will not approve Scripps' application until the Commission has concurred with Scripps' consistency certification, or, if the Commission objects, if Scripps appeals the objection to the Secretary of Commerce and the Secretary overrides the Commission's objection.

OCRM's determination that sounds emanating from the ATOC sound source can be reasonably expected to affect marine animals that are resources of both the outer continental shelf ("OCS") and the coastal zone is based on information provided by Scripps and the Commission. Scripps also raised procedural concerns with the Commission's request. OCRM has previously determined that there are no procedural defects in the Commission's request. Letter from Jeffrey R. Benoit, Director, OCRM, to Andrew Forbes, Scripps (Jan. 27, 1995).

The Commission received Scripps' consistency certification on December 1, 1994, but did not receive the MBNMS application until January 24, 1995. OCRM previously determined that, for this particular case, the Commission's receipt of the application constitutes federal agency notice for purposes of 15 C.F.R. § 930.54(a). Id. Therefore, in accordance with 15 C.F.R. § 930.54(e), the Commission must complete its review within six months from the receipt of the MBNMS application: by July 24, 1995. This assumes that the certification, draft environmental impact statement for the ATOC project ("DEIS"), and the MBNMS application contain all the necessary information.

EXHIBIT NO. 7
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OCRM has determined that the marine animals at issue that ply the waters of the coastal zone and the OCS are coastal resources. The CZMA and its legislative history indicate that the effects test is to be construed broadly. In addition, Secretary of Commerce consistency appeal decisions have held that coastal resources are not bound by jurisdictional limits, and they may be affected when outside of the coastal zone. The California coastal management program requires that:

> Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

Cal. Pub. Res. Code § 30230. The Commission considers marine mammals that migrate through or are found in California waters as coastal resources. Letter from Peter M. Douglas, Executive Director, Commission, to Jeffrey Benoit, Director, OCRM (Dec. 30, 1994), letter from Mark Delaplaine, Commission, to Andrew Forbes, Scripps (Dec. 29, 1994). (Thus, an activity that affects or is reasonably likely to affect these coastal resources that migrate through or use California waters, whether they may be affected while in or outside the coastal zone, is subject to federal consistency in accordance with the CZMA and 15 C.F.R. Part 930.)

In this case, the Commission asserts that the ATOC project can be reasonably expected to affect marine mammals of the coastal zone, including the humpback and blue whales that are sensitive to low frequency noise and which swim at depths where the noise would be audible. Further, the zone of influence of the noise source includes portions of California waters and the program may affect commercial fishing and coastal recreation. Letter from Peter M. Douglas, Executive Director, Commission, to David W. Hyde, Scripps, and Terry Jackson, MBNMS, at 2 (July 14, 1994). The State is concerned with the health of populations of marine resources that spend all or portions of their lives within the coastal zone.

Scripps asserts that effects will be temporary and localized at the sound source. Letter from Andrew Forbes, Scripps, to Jeffrey Benoit, Director, OCRM, at 5 (Jan. 13, 1995). However, Scripps states that there will be "minor or uncertain impacts" and derivative effects on commercial fisheries. While Scripps and the DEIS assert minimal effects on all marine resources, they make it clear that there will be some effects, and that there is a substantial amount of uncertainty regarding these effects. Id.; DEIS at 4-12, 15. While stating that effects are minimal, ATOC project proponents recognize this uncertainty and the potential to affect marine resources. The DEIS states that, "very little is known about effects of low frequency sound on marine animals, particularly marine mammals and sea turtles," DEIS at 1-4, and "[t]he lack of information is particularly acute" for large whales. DEIS at 4-12. Hence the proposal to conduct a pilot research study to accompany

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the ATOC project. Further, there could be direct impacts from the installation of cables needed for the sound source. DEIS at 4-9. These impacts are expected to be minimal, but there is the potential for effects to coastal resources. Id.

Therefore, OCRM approves the Commission's request to review Scripps' application for a MBNMS permit renewal. As such, the Commission's review includes a review of all associated facilities in accordance with 15 C.F.R. § 930.21. An associated facility is subject to consistency if it is covered by 15 C.F.R. § 930.21(a) and (b). This is further clarified by 15 C.F.R. § 930.21 which states, "the proponent [(federal agency or entity seeking federal approval or funding)] of a Federal action must consider whether the Federal action and its associated facilities affect the coastal zone . . . ." (emphasis added). Thus, an applicant for federal approval must include a discussion of individual and cumulative effects from associated facilities in making its consistency certification. The associated facilities for the ATOC project are those project components that are designed, operated or otherwise used, in full or in major part, to meet the needs of the project, and without which the project could not be conducted. See 15 C.F.R. § 930.21.

Please call David Kaiser, OCRM's Federal Consistency Coordinator, at (301) 713-3098, x 144, or John King, Assistant Regional Manager, Pacific Region, Coastal Programs Division, OCRM, at (301) 713-3121, x 188, if you have any questions.

Sincerely,

Jeffrey R. Benoit
Director

cc: Tami Grove
Andrew Forbes
Dr. Ralph W. Alewine, III
Ann Terbush
CDR Terry Jackson
Dr. Charlie Wahle

EX 20 p 3

WOODS HOLE OCEANOGRAPHIC INSTITUTION

Dr. Mark P. Johnson

Mr. Keith Jenkins, Code EV21KJ
Naval Facilities Engineering Command, Atlantic
6506 Hampton Boulevard
Norfolk, VA 23508-1278

27 January, 2006

Regarding: USWTR DEIS

Dear Mr. Jenkins,

I submit the following comments with regard to the draft environmental impact statement for the proposed Atlantic Undersea Warfare Training Range. I hold a doctorate in engineering from the University of Auckland, New Zealand and have worked at the Woods Hole Oceanographic Institution since 1993. For the last 6 years, I have been researching the behavior and effects of noise on wild cetaceans using advanced tag devices. Focus species have been the North Atlantic right whale, sperm whale and beaked whales (Cuvier's and Blainville's). This work has been published in 14 scientific papers and has been presented at numerous international conferences. Section (§) and page numbers in the following comments refer to the October 2005 EIS.

Beaked whale occurrence

The preferred habitat for beaked whales is not currently known. Stomach contents of stranded whales include crustacea, deep sea fish and squid indicating deep foraging but do not suggest any single habitat preference. Foraging sounds have been recorded by tags on Cuvier's and Blainville's beaked whales at depths ranging from 200m to more than 1500m although the majority occur below 500m. Beaked whales are notoriously difficult to spot at sea but the few reports indicate their occurrence in a wide variety of environments as variously reported in the EIS: submarine canyons, shelf edge, steep bathymetry offshore of oceanic islands, and hydrothermal processes such as fronts and gyres although one could also well add abyssal plains and sea mounts. Two problems plague any attempt to extrapolate beaked whale habitat

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EXHIBIT NO. 8
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preference from current observations: first, observational studies have not invested equal effort in different potential habitats, for example, whereas there are several on-going studies centered on coastal resident populations (e.g., Aguilar Soto et al 2004, Aparicio 2005, Biassoni 2003, Claridge 2005), off-shore observations have mostly come from infrequent transect surveys for which the sighting rates are acknowledged to be extremely low (Barlow 1999). The second problem in predicting beaked whale habitat is a fundamental lack of knowledge about what constitutes suitable habitat for beaked whales.

Given the above, the contrary statements about habitat preference in the EIS are understandable. With reference to Site A, beaked whales are said to prefer submarine canyons and hydrothermal features which are not present in the proposed USWTR (pg. 3.2-29). With reference to Site B, beaked whales 'do not appear to demonstrate as strong a preference for canyons as they do in other areas of the North Atlantic' (pg. 3.2-40). Clearly the uncertain habitat preferences of beaked whales combined with the low probability of visual observation make the occurrence of Ziphiidae very difficult to predict in any of the study areas. Although the author agrees that beaked whales are observed most frequently in waters deeper than 500m, observational studies on these species are still in their infancy and too little is currently known about their habits and needs to be able to extrapolate occurrence rates from one location to another.

Potential for strandings

The DEIS correctly points out that mass strandings of beaked whales have been associated with the use of high-power mid frequency sonar (e.g., Greece 1996, Bahamas 2000, Canary Islands 2002 and 2004, Madeira 2000 etc.). Some, but not all, of these incidents involved multiple surface vessels: the stranding of 14 Cuvier's beaked whales in Greece in particular involved a single vessel (the NATO ship Alliance). Moreover, the strandings have occurred over a wide range of bathymetric and sound propagation conditions. There is no support for the notion of there being a silver bullet scenario that gives rise to beaked whale strandings as suggested in §4.3.5.2. At this point it is unknown what conditions give rise to the acute physiological problems (Jepson, 2003; Fernandez 2005) and strandings connected with sonar.

The statement (e.g., pg. 3.2.31) that beaked whale strandings on-shore of the proposed sites are unlikely is an extremely limited view of the acoustic impact problem. The problem to face is clearly not the presence of beaked whales on a beach but the potential for harm or mortality due to sound exposure. It is currently unknown whether all beaked whales effected during sonar exercises such as those in the Bahamas and the Canary Islands, end up stranding. Dead beaked whales found floating after naval exercises have been reported by Martin et al. (2004).

A secondary point is that vessels from the U.S. Navy were not only involved in the Bahamas stranding, as stated in the first paragraph of §4.3.5.2 (pg. 4.3-30). A U.S. Navy destroyer (the Mahan DDG-72) was present during the NEOTAPON (Spanish Navy/NATO) activity connected with the 2002 Canary Island stranding (The Sydney Morning Herald, Australia, Oct. 2, 2002; El Pais, Madrid,16 Oct. 2002; NATO-SHAPE News Summary and Analysis Oct. 2, 2002).

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Exposure criteria and assessment

The exposure thresholds predicted for level A and B harassment in §4.3.3 and §4.3.4 are based on a very limited assessment of the literature. The observations used to determine the 190dB onset of behavioral disturbance were recorded from trained captive dolphins and belugas participating in TTS experiments. The basic cooperation of these study animals was assured by the use of food rewards. Given the limited behavioral options for captive animals, very little can be deduced from these studies with applicability to wild animals. The adoption of levels from these studies as opposed to the considerable literature on reactions of animals in the wild to sound (e.g., Richardson, 1995) is a fundamental flaw in the EIS.

The claim in §4.3.4 (pg 4.3-22) that '...there are few observations and no controlled measurements of behavioral disruption of cetaceans caused by sound sources with frequencies, waveforms, durations, and repetition rates comparable to those employed by the tactical sonars to be used on the proposed USWTR' is incorrect. Nowacek et al. (2003) reported controlled exposures of a sonar-like mid-frequency alarm sound to North Atlantic right whales. In that study, significant behavioral responses (cessation of foraging and re-location) were reported at ELs of about 154 dB re μPa-s (based on an RL of 135 dB re μPa RMS and a 2-minute response time to the 60% duty cycle exposure).

Many cetacean species considered to occur in the proposed USWTR sites have not been, nor could be, tested for response to sound in captivity. While the response of wild cetaceans to sound will clearly be context, sound and species dependent, all indications are that significant behavioral responses in the wild are likely at levels considerably lower than those found for the few species of animals held captive.

The concept that exposures to individual animals will be limited due to the continued movement of the sonar-carrying vessels (§4.3.4.3) is appealing but is not born out by the facts. The beaked whale strandings in the Bahamas occurred despite continued movement of the source vessels. The multiple sonar sources (surface vessel, helicopter, active sonobuoy, torpedo and submarine) that would be used in USWTR training exercises replicate in many respects the conditions of the Bahamanian event.

There are two additional peculiarities of the EIS with regard to the EL thresholds. The first is that the exposure level corresponding to a 50% disturbance level for captive animals (§4.3.4.2, pg. 4.3-25) was taken as the figure for the onset of behavioral effects. There is no precedence for selecting the 50% impact level in determining risk: in environmental law, the LD-50 for arsenic is not considered the acceptable environmental dose! The idea that the lowest exposure level that will give rise to significant behavioral impacts is just 5dB below the level that will cause TTS is completely unsupported by any human noise exposure regulation.

The second peculiarity is that, having developed the idea of exposure level, EL, as the touchstone for impact assessment, it is claimed (§4.3.7, pg. 4.3-33) that some sound sources will have no impact because their source level, SL, is below a certain level. For example, the DICASS source

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with SL of 201 dB re µPa at 1m need only be used for 13 minutes to exceed the 190 dB re µPa-s behavioral threshold at 100 m. If a lower threshold for behavioral response was adopted, as indicated by studies on wild cetaceans, the sources currently considered non-problematic would have to be re-evaluated.

Impact and Mitigation

The conclusion on pg. 4.3-57 that 29 Level A harassments annually to beaked whales in Site A would 'not affect annual rates of recruitment or survival' is not supported by any current scientific literature. Almost nothing is known about the population size of beaked whales either on the Atlantic coast in general or in the areas adjacent to the proposed sites. It is therefore not possible to predict the impact of 29 potential mortalities per year. However, if beaked whales occur in the areas around the proposed sites in the way reported elsewhere (i.e., small resident populations of perhaps 50-100 individuals) then this level of impact would be clearly unsustainable. Given that the exposure thresholds for impact adopted by the EIS are extremely high, the number of animals actually impacted may be considerably greater than predicted here.

It should also be born in mind that the proposed range will see frequent and year-round usage of sonar and other active sources. An alternative way in which frequent sound production in an area can effect marine mammals, not given due consideration in the EIS, is by habitat degradation. In effect, animals are displaced because of the high probability of disturbance. Without knowing the quality of the excluded habitat it is impossible to assess the importance of this kind of displacement. Considerably more detailed observational studies of the proposed sites are required to establish the patterns of usage of the areas by marine mammals and the likely impact of such displacement.

It is asserted in 6-5 that, 'Based on the status of acoustic monitoring science, effectiveness of use of the system nodes as a mitigation measure for detecting and localizing marine mammals is not yet known'. The primary form of mitigation proposed in the EIS is visual observations from the bridge of the sonar-carrying vessel and from aircraft. For deep diving species, visual observations from a moving vessel tend to have a very low probability of success (Barlow,1999). In comparison, the acoustic detection of sperm whales has been viable for many years and remote detection of beaked whales is currently a topic of research with promising results already obtained by U.S. Navy researcher Moretti of the NUWC Newport facility and others (Tregenza, 2001).

In conclusion, I find that the methodology adopted in the EIS to predict the impact of the sonar and other active sound sources on marine mammals in, and adjacent to, the proposed USWTR sites is flawed. The exposure level at which significant behavioral responses are anticipated, taken from studies on captive animals, is at least 30 dB higher than those reported in relevant studies on wild cetaceans. Moreover, insufficient is known about the distribution and effects of sound on the beaked whale species likely to be found near the proposed sites to predict the overall impact of the proposed range on these species. The finding of no significant effect on

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beaked whales cannot be interpreted from the available scientific literature and is not supported by the historical evidence of mass strandings associated with sonar use.

Sincerely,

Mark Johnson, PhD

References

Aguilar N., Johnson M., Aparicio C., Domínguez I., Díaz F., Hernández, A., Guerra, M., Bocconcelli, A., Brito, A., Tyack, P., "High concentrations of beaked whales observed close to the shore of El Hierro (Canary Islands)", European Research on Cetaceans 18th, Sweden, 2004.

Aparicio C., Guerra M., Hernández A., Padrón A., Díaz F., Domínguez I., Brito A., Johnson M., Aguilar de Soto N., "Resident and reproductive populations of beaked whales in El Hierro, Canary Islands", European Research on Cetaceans 19th, France, April 2005.

Barlow J., "Trackline detection probability for long-diving whales," in ***Marine mammal survey and assessment methods***, edited by G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson (A.A. Balkema Rotterdam), 209-224, 1999.

Biassoni, N., P.J.O. Miller, M. Podesta, M. Johnson, A. Sturlese, and P. Tyack, "Behavioral observations and non-invasive tagging of Cuvier's beaked whales, ***Ziphius cavirostris***, in the Ligurian Sea", European Research on Cetaceans 17th, Grand Canaria, 2003.

Claridge D., "Age class segregation of Blainville's bealed whale (***Mesoplodon densirostris***) groups in the Bahamas", 16th Biennial Conference of the Society of Marine Mammalogy, San Diego, 2005.

Fernandez A., *et al.*, "Gas and Fat Embolic Syndrome Involving a Mass Stranding of Beaked Whales (Family *Ziphiidae*) Exposed to Anthropogenic Sonar Signals", Vet Pathol 42: 446–457 2005.

Jepson P. D. *et al.*, "Gas-bubble lesions in stranded cetaceans," Nature 425, 575-576, 2003.

Johnson M., Madsen P.T., Zimmer W. M. X., Aguilar de Soto N., Tyack P.L., "Beaked whales echolocate on prey", Proc. R. Soc. Lond. B 271, pp. S383-386, 2004.

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Madsen P.T., Johnson M., Aguilar de Soto N. , Zimmer W. M. X., Tyack P.L., "Biosonar performance of foraging beaked whales (*Mesoplodon densirostris*)", J. Exp. Biology 208, 181-194, Jan. 2005.

Martin V., Servidio A., Garcia S., 'Mass strandings of beaked whales in the Canary Islands', Proceedings of the Workshop on Active Sonar and Cetaceans, eds. Evans P. and Miller L., European Cetacean Society, Gran Canaria 2003.

Nowacek D., Johnson M., Tyack P.L., "North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm stimuli", Proc. R. Soc. Lond. B 271, pp. 227-231, 2003. http://hdl.handle.net/1912/248.

Richardson, W. J., Greene, C. R., Malme, C. I. & Thomson, D. H. *Marine mammals and noise*. San Diego, CA: Academic, 1995.

Tregenza N.J.C., Johnson M., Aguilar de Soto N., "Automated detection of beaked whale sonar", European Research on Cetaceans 18th, Sweden, 2004.

Zimmer W. M. X., Johnson M., Madsen P.T.M., Tyack P.L., "Echolocation clicks of free-ranging Cuvier's beaked whales (Ziphius cavirostris)", J. Ac. Soc. Am., 117, pp. 3919-3927, June 2005. http://hdl.handle.net/1912/141

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Tyack comments on USWTR DEIS

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Comments on overseas environmental impact statement/environmental impact statement (OEIS/EIS) pursuant to NEPA and CEQ regulations to assess the potential environmental effects of installing and operating an undersea warfare training range (USWTR) offshore of the east coast of the United States (US)

Peter L. Tyack

I am a behavioral ecologist and have spent most of my career studying how marine mammals use sound, and how their behavior may be disrupted by manmade sounds. I appreciate the need for a shallow water test range, and believe that concentrating training on an appropriately instrumented range can help reduce impacts on marine mammals, and improve monitoring for potential short- and long-term impacts.

However, I question some of chapter 4.3 regarding acoustic effects on marine mammals involving behavioral disruption. Before I go into detail, I would like to point out that a detailed paper describing the NMFS Acoustic Criteria should become available this spring. If the Navy were to follow this new approach, that would resolve most of my concerns.

Significant effort has been devoted over the past decade to refining a distinction of what behavioral disruption may be biologically significant. Section 4.3.1 and 4.3.2 of the DEIS ignore this effort, and simply define behavioral disruption as "a change in behavior as a result of the action." 4.3-6 considers a temporary hearing impairment (TTS) level B harassment if it has been caused by exposure to manmade sound, even if a momentary modulation of hearing sensitivity causes no change in behavior. While such changes in sensitivity require relatively intense exposures, this section sets a standard for harassment that is radically lower than most applied in the past. A more carefully thought through criterion for what level of disruption would be considered a level B take would have been useful.

Section 4.3.3.4 and the bottom of p 4.3-9 establish the sound exposure leading to onset of TTS as the threshold for behavioral disruption. This is bizarre. Temporary threshold shifts have only been studied in the lab with highly trained animals. TTS experiments are extremely useful for establishing thresholds for risk of injury without injuring the subject, but they have nothing to do with behavioral disruption. These experiments stem from experimental sensory physiology – nothing in their theory or implementation is relevant for the behavioral ecological issues relating to behavioral disturbance or level E harassment.

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Furthermore, while the actual effect of a temporary reduction in hearing sensitivity sets a very low bar for behavioral disruption, the actual exposures required to induce TTS are very high compared to the dozens of well executed studies of behavioral disruption in marine mammals.

The DEIS restricts its analysis of acoustic criteria for behavioral disruption to 2 studies of hearing in which 2 beluga whales and 5 bottlenose dolphins were trained and rewarded for allowing exposures to intense sounds. P 4.3-22 states "These data are the most applicable to this OEIS/EIS because they are based on controlled tonal sound exposures within the tactical sonar frequency range, …". These studies were TTS experiments conducted by experts in hearing. The experimental design involved testing the subject's hearing, exposing it to 1 intense 1-sec tone from a sound source 1-2 m from the subject and then testing hearing again. While this work is carefully designed for a controlled hearing experiment, these parameters are poor for studying behavioral disruption from a naval ASW exercise. The behavioral observations were not part of a controlled or systematic behavioral protocol, nor were experts in behavioral ecology involved in the design, execution, or analysis. Behavior is often context dependent, and using a context in which animals are actually rewarded to allow exposures to a stationary sound source may not be appropriate for ASW exercises. This setting is similar to that when people use acoustic harassment devices to prevent a marine mammal from feeding in an aquaculture facility, but it is very different from the setting associated with animals near an exercise.

The DEIS ignores a massive peer reviewed scientific literature on behavioral disruption of wild marine mammals. In my opinion, it is incorrect in stating that "there are few observations and no controlled measurements of behavioral disruption of cetaceans caused by sound sources with frequencies, waveforms, durations, and repetition rates comparable to those employed by the tactical sonars to be used on the proposes USWTR" (p. 4.3-22), and that the TTS experiments are the most applicable to the EIS. For example, Nowacek et al. (2004) published a peer reviewed scientific paper in which an acoustic and behavior recording tag was attached to right whales, which were then exposed to a carefully controlled experimental series of sounds including an alert sound, which was an 18 min exposure consisting of three 2 min signals played sequentially three times over. The three signals had a 60% duty cycle and consisted of: (i) alternating 1 s pure tones at 500 and 850 Hz; (ii) a 2 s logarithmic down-sweep from 4500 to 500 Hz; and (iii) a pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1 s long.

The alert signals were designed with three specific goals: (i) to pique the mammalian auditory system with disharmonic signals spanning the whale's estimated hearing range; (ii) to maximize signal to noise ratio, i.e. use signals that would be distinct from the background and resist masking; and (iii) to provide localization cues for the whales. While they were not designed to mimic tactical sonars, this study is more closely applicable to the EIS than Finneran and Schlundt (2004). Evans and England (2001) state the following about mid-frequency tactical sonars: "Tactical mid-frequency range sonar systems are capable of producing a variety of waveforms, each designed for specific tasks. For example, narrow band, constant frequency signals (CW) are good for detecting movement (Doppler effects) but are relatively ineffective where environmental reverberation (sound reflection) is prevalent. On the other hand, signals that sweep quickly up or down in frequency (Frequency Modulated or FM signals) work well in reverberant environments, but don't detect movement as well. As a consequence, tactical mid-range sonars often emit several different signals in rapid sequence before waiting some time to listen to the returning echoes of the different signals." The alert stimuli also included a sequence of FM sweeps and CW tonals. While the exact timing and duty cycle is not identical to tactical sonars, they are much more similar to an ASW exercise than the single 1 sec CW tone played in Finneran and Schlundt (2004).

Source	Nowacek et al. (2004)	Tactical Sonar (Evans and England 2001)	Finneran and Schlundt (2004)
Frequency	500-4500	2600-8200	3000-20,000
Timing	Multiple pulse 1-2 sec 60% duty cycle for 18 min	Multiple pulse 0.5-2 sec every 24 sec for many hours	Single pulse 1 sec
Range from Source	100s of m	100s to 1000s of m	1-2 m
Whale	Wild and Swimming	Wild and Swimming	Trained, captive and on bite plate
Source	Unfamiliar location and moving	Unfamiliar location and moving	Stationary at familiar location

Table 1. Comparison of source characteristics.

Nowacek et al. (2004) found that 4 of the 5 whales tested showed clear signs of behavioral disruption. Soon after the sound started, they stopped feeding, rapidly increased their fluking rate, and ran along the water surface until the sound stopped. While this is a much stronger response than the TTS onset considered in the DEIS, it occurred at received levels of 133-148 dBrms re 1 μPa. The nominal RL at the start of alert playbacks was about 140 dBrms re 1 μPa and it took about 120 seconds for the whale to respond. With a duty cycle of 60%, this would correspond to .6 x 120 = 72 sec. The SEL at which the whale responded was thus about 140 + 10 log (.6 x120) = 159 dB re 1 μPa^2-s. This is far below the criterion proposed in the DEIS of 190 dB re 1 μPa^2-s. Over a dozen studies of porpoises exposed to pingers with CW or FM signals show strong avoidance responses at received levels well below those found for right whales. There are fewer controlled field studies involving delphinids, but at least one study raises questions about the 190 dB re 1 μPa^2-s criterion for responses of this taxon to naval sonar exercises. Rendell and Gordon (1999) observed pilot whales during a naval exercise involving mid-frequency sonar in the Ligurian Sea. They report a significant elevation in whistle rates during sonar exposure. Rendell and Gordon (1999) point out that they cannot prove that these responses had deleterious consequences, but the responses clearly rise above the threshold established in the DEIS. While these authors did not specify exposure level, they did not sight the naval vessel, suggesting that this behavioral change occurred at an exposure well below the 190 dB re 1 μPa^2-s threshold.

Therefore, I conclude that the DEIS uses an inappropriate measure for onset of harassment. TTS is useful for hearing studies, but is not appropriate as an indicator of behavioral disruption. While TTS would be considered a minor behavioral disruption (if one agrees it has anything to do with behavior), it occurs only after much higher exposure levels than more appropriate studies of disruption. The DEIS ignores a solid body of scientific literature that clearly demonstrates that the acoustic criteria used are inappropriate and not conservative.

The extrapolation from odontocetes to mysticetes (4.3.5.1) is particularly inappropriate and misleading. For estimating behavioral disturbance, it is irrelevant that we do not have audiograms or threshold shifts in these species. As illustrated with Nowacek et al. (2004), the data on acoustic exposures triggering behavioral disturbance from right whales are much more appropriate to ASW exercises with mid-frequency tactical sonars than are the TTS experiments on captive toothed whales.

While the DEIS is not specific about the expected frequency range of sonars to be used, I question the inclusion of data from 20 kHz when mid-frequency is typically considered 1-10 kHz. Finneran and Schlundt (2004) also incorrectly used each exposure as the unit of analysis, when the individual animal should be the unit. The DEIS also uses a 50% response criterion for the threshold of effect. If one is using the threshold to count takes, then this is appropriate as long as the number of animals that show behavioral disruption when exposed below the threshold is not greater than the number of animals that do not respond when exposed above. However it is clearly inappropriate to use the 50% criterion to predict the range at which the most sensitive animal will respond. I view the use of a single threshold as a step backwards from risk functions of the sort used in the SURTASS LFA EIS. Most dose response curves are not step functions, but are relatively well understood sigmoidal curves. The DEIS is correct that multiple pings of LFA were accounted for in a different way than EL. But both Finneran and Schlundt (2004) and the NMFS Noise Exposure Criteria Group present responses as a function of exposure in ways that allow development of risk functions. If a single number is to be used to predict whether there will be any takes, it must take into account the more sensitive elements of the population, not just the 50% point.

The exclusive use of Sound Exposure Level is problematic both for injury and behavioral disruption. While theory and TTS experiments show that EL is a good predictor for TTS, it is not the only measure needed. In terms of injury, it is well established that very short signals can damage hearing with sudden intense changes in pressure even if they have low SELs. Most acoustic criteria therefore include a dBpeak criterion as well as SEL. If no such explosive or impulse sources are to be used on the range, it still would be worth including the criterion and mentioning why it is not relevant. In terms of behavior, there is no theoretical or empirical justification for using sound exposure level alone. Signal detection theory has for decades provided a framework that biologists use to predict when an animal can detect and classify signals that may lead to a response. When an animal is listening for a signal and will respond as soon as it detects it, then signal-to-noise ratio or received level of the transient may be the most relevant measure, depending upon whether the animal is limited by hearing sensitivity or ambient noise. For animals listening to transients, the RL of each signal may or may not be more relevant for predicting a response than the long term energy received during a long sequence of signaling, depending upon how much the central nervous system integrates information of detected signals across the entire series. When animals are responding with annoyance to the loudness of a signal then either SEL or a transient RL may be useful. Until theoretical and empirical studies demonstrate which measure should be used in which context, I argue that the DEIS and similar criteria must use several criteria.

Luckily, the NMFS Acoustic Exposure Criteria Group has spent several years carefully evaluating how to develop the acoustic criteria for behavioral disruption that were erroneous in this DEIS. They divide marine mammals into hearing groups, and sources into different categories. For each hearing group and source type, they have analyzed the large body of scientific literature. A method has been developed to interpret signals in terms of the hearing capability of the animals. Every cell has had some data useful for establishing criteria for disturbance, reducing the need to extrapolate across cells. The group uses the RL measures that have dominated empirical studies to date, but urges inclusion of SEL measures in the future. I believe that the criteria used for behavioral disruption in this DEIS are fundamentally flawed, and I urge the Navy to use the criteria developed by NMFS Acoustic Exposure Criteria Group for this purpose.

Literature Cited

Evans, D. L. and England, G. R. (2001). Joint Interim Report, Bahamas Marine Mammal Stranding, Event of 15-16 March 2000, pp. 59: U.S. Department of Commerce and Secretary of the Navy.

Nowacek, D. P., Johnson, M. P. and Tyack, P. L. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London, B* **271**, 227-231.

Rendell, L. E. and Gordon, J. C. D. (1999). Vocal Response of Long-Finned Pilot Whales (*Globicephala melas*) to Military Sonar in the Ligurian Sea. *Marine Mammal Science* **15**, 198-204.

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North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli

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North Atlantic right whales were extensively hunted during the whaling era and have not recovered. One of the primary factors inhibiting their recovery is anthropogenic mortality caused by ship strikes. To assess risk factors involved in ship strikes, we used a multi-sensor acoustic recording tag to measure the responses of whales to passing ships and experimentally tested their responses to controlled sound exposures, which included recordings of ship noise, the social sounds of conspecifics and a signal designed to alert the whales. The whales reacted strongly to the alert signal, they reacted mildly to the social sounds of conspecifics, but they showed no such responses to the sounds of approaching vessels as well as actual vessels. Whales responded to the alert by swimming strongly to the surface, a response likely to increase rather than decrease the risk of collision.

Keywords: *Eubalaena glacialis*; ship-strike; controlled exposure experiment

1. INTRODUCTION

North Atlantic right whales (*Eubalaena glacialis*) were hunted for centuries (Reeves & Mitchell 1986), but despite protection from whaling since 1935 the population has not recovered and is in decline and at risk of extinction (Caswell *et al.* 1999; Clapham *et al.* 1999). Although other populations of right whales appear to be recovering from whaling (Best *et al.* 2001), a combination of factors is probably contributing to the failure of *E. glacialis* to recover. The North Atlantic species, for example, has a thinner blubber layer than their southern relatives (Miller *et al.* 2001; Moore *et al.* 2001), which may indicate some level of nutritional stress. Anthropogenic mortality in the form of ship strikes and entanglement in fishing gear, however, is directly and significantly hampering their recovery. Ship strikes are the largest single contributor to these deaths, and account for *ca.* 35% of all known mortalities (Knowlton & Kraus 2001; Laist *et al.* 2001). Right whales continue to die from vessel collisions, even though they can theoretically hear approaching ships (Richardson *et al.* 1995; Ketten 1998), and mitigation strategies have been developed to locate whales, to notify ships of whale locations, and even to redirect vessel traffic.

The question of why whales do not move out of the path of oncoming ships has been debated by biologists (Terhune & Verboom 1999; Laist *et al.* 2001). Some anecdotal observations suggest that right whales only respond when vessels approach to within a very close range. Right whales off the eastern coast of North America are frequently exposed to vessels, and they may have habituated to the sounds of approaching vessels at greater distances (Richardson *et al.* 1995; Terhune & Verboom 1999; Laist *et al.* 2001). Another problem is that the vessel noise received by whales at or near the surface may be complicated and/or attenuated due to the effects of the physical properties of the ocean on sound propagation, thus providing limited or confusing cues to the whales. Specifically, the propagation path from the source of vessel noise, primarily the propeller, to the whale's ear can be complicated. Variation in the temperature, salinity and pressure of sea water causes sound to refract. As a sound wave passes up or down through horizontal layers of sea water with different properties, it will tend to refract vertically. In the case of a whale at the surface in a deep water environment (more than 200 m) where sound at the surface is refracted downwards, a direct propagation path is unlikely, and the noise from the propeller will most likely be severely attenuated in the horizontal direction (Urick 1983). Sound energy from vessels can, however, propagate into surface waters in shallow water environments (less than 200 m) owing to interactions with the bottom, although this propagation depends on the type and depth of sediment present (Urick 1983). Although right whales inhabit primarily shallow water environments (Kraus *et al.* 1986), the overall effects of these phenomena on vessel noise propagation, and therefore the amount of acoustic energy reaching a whale, are difficult to predict and are best investigated experimentally (Urick 1983; Kinsler *et al.* 2000). Additionally, ships produce unique sound radiation patterns (Richardson *et al.* 1995), which further complicate the sound field. So, the lack of response to approaching ships by whales near the surface could be due to a variety of physical factors that compromise the cues a whale might otherwise use to detect and localize an oncoming ship.

Behavioural observations in the Bay of Fundy have documented the typical foraging dive patterns of right whales. These results indicate that individual whales in this summer foraging area display stereotyped dive patterns, with the depth and duration of dive varying by individual and presumably the depth of the food source (Murison & Gaskin 1989; Nowacek *et al.* 2001). During their summer feeding activity in the Bay of Fundy, these whales are also exposed to significant vessel traffic ranging from small fishing boats to oil super-tankers. The Bay of Fundy in the summer is then an ideal situation for this work because the behavioural patterns of the whales are

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well known and the vessel traffic is comparable to that in the rest of their range (Russell *et al.* 2001). We studied collision risk factors and the efficacy of different mitigation strategies by conducting controlled sound exposures with whales tagged with a multi-sensor acoustic recording tag.

2. METHODS

We tested the responses of whales in the Bay of Fundy summer foraging area to four stimuli: vessel noise as the test stimulus, right whale social sounds and an alert signal as alternative stimuli, and silence as an experimental control. We used an archival digital acoustic recording tag (DTAG) to record the acoustic and motor behaviour of the whales in the presence of these exposures. This tag has been non-invasively deployed on several species of marine mammal including right whales (Nowacek *et al.* 2001; Johnson & Tyack 2003). In addition to recording all sounds at a sampling rate of 32 kHz, a Nyquist rate of 16 kHz, well above the best known vocal and hearing ranges of the whales (Clark 1982; Ketten 1998), the DTAG simultaneously records the pitch, roll, heading and depth of the whale and temperature of the water at a sampling rate of 46 Hz (Johnson & Tyack 2003). After tagging a whale, we waited until it returned to normal behaviour, which, based on our earlier results, required two dive cycles. We then positioned the playback boat at the location where the whale dived. After 2 min, the approximate time required for the whales to reach foraging depths (Nowacek *et al.* 2001), we began the sound exposure with a Lubell underwater speaker (LL9162) in 2002 or J-13 underwater sound transducer (Naval Undersea Warfare Center) in 2001 suspended from the boat moving slowly along the whale's last known heading. The maximum source level (SL) of the playback was 173 dB re 1 μPa at 1 m, and no whale received the same stimulus twice nor more than three total exposures as stipulated by our research permit. We monitored the behaviour of the tagged whales throughout the experiments from the flying bridge of a 24 m research vessel.

For the silent stimulus, the amplifier and speaker were operated as normal, but with no input signal (figure 1*a*). The right whale social sound stimulus used recordings of socially active groups of right whales (Parks 2003). These vocalizations tend to last for 1–5 s and occur in the 500–4000 Hz frequency range (figure 1*b*). The vessel noise stimulus was recorded from a 120 m container ship as it passed within 100 m of a recording station. This was a 20 min continuous signal with most energy from 50 to 500 Hz (figure 1*c*), and the amplitude rose and fell to mimic an approaching and passing vessel. The alert sound was an 18 min exposure consisting of three 2 min signals played sequentially three times over. The three signals had a 60% duty cycle and consisted of: (i) alternating 1 s pure tones at 500 and 850 Hz; (ii) a 2 s logarithmic down-sweep from 4500 to 500 Hz; and (iii) a pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1 s long (figure 1*d*). The alert signals were designed with three specific goals: (i) to pique the mammalian auditory system with disharmonic signals spanning the whale's estimated hearing range (Edworthy & Meredith 1994; Ketten 1998); (ii) to maximize signal to noise ratio, i.e. use signals that would be distinct from the background and resist masking; and (iii) to provide localization cues for the whales. Finally, we measured the response of tagged whales to transiting vessels (i.e. research and whale watching vessels excluded) that passed within 1 nautical mile of the whale.

3. RESULTS

The swimming/diving response of whales exposed to the alert signal differed markedly from the hundreds of stereotyped dives recorded during current and previous experiments (Nowacek *et al.* 2001). The stereotypy of the normal dives extends to several aspects of an individual whale's behaviour including the angles and rates of ascent and descent, the fluke stroke rate (measured from the pitch record (Johnson & Tyack 2003)), and the amount of time spent in each part of the dive cycle. No significant deviations from these diving patterns occurred in the five whales exposed to the silent stimulus, the seven whales exposed to whale vocalizations or the five whales exposed to the vessel approach stimulus (table 1). Parks (2003) has documented strong approach responses of some whales to the playback of right whale social sounds, but while none of the tagged whales in this study showed significant diving responses, several did change heading to temporarily orient towards the source. Five out of six whales exposed to the alert signal, however, significantly altered their regular behaviour and did so in identical fashion. Each of these five whales: (i) abandoned their current foraging dive prematurely as evidenced by curtailing their 'bottom time'; (ii) executed a shallow-angled, high power (i.e. significantly increased fluke stroke rate) ascent; (iii) remained at or near the surface for the duration of the exposure, an abnormally long surface interval; and (iv) spent significantly more time at subsurface depths (1–10 m) compared with normal surfacing periods when whales normally stay within 1 m of the surface (see table 1 and figure 1 for all of these responses). The sixth animal ('Eg3103') showed no detectable response to the alert signal (table 1).

The strong response to the alert signal was an important experimental control demonstrating that the experimental design was capable of eliciting a strong response with an appropriate stimulus. The reaction observed in the five responding whales appears to be a response to the signal itself and not simply due to a variation in the received level (RL) of sound. There was no statistical difference in the maximum received levels, measured at the whale and analysed by octave bands, of the alert compared with the vessel noise exposures ($t = 2.01$, d.f. $= 5$, $p < 0.1$). The absence of a response to the vessel playback matches our observations of five opportunistic approaches of tagged whales. These whales were approached to within less than 1 nautical mile by passing vessels (table 1), and their lack of response suggests that whales are unlikely to respond to the sounds of oncoming vessels even when they can hear them.

4. DISCUSSION

Even though five out of the six whales exposed to the alert stimulus responded strongly, the response has several features that lead us to question whether the alert would be effective as a ship strike mitigation measure. By swimming to and remaining near the surface, instead of staying at depth, the whales most probably increased their risk of being struck. Under ideal conditions (e.g. favourable sighting weather and skilled lookouts), forcing the whales to the surface might assist collision mitigation, but by stay-

Table 1. Maximum RLs, ascent fluke stroke rates, surface intervals and subsurface time for tagged right whales under experimental conditions.
(Several of the tagged whales have been identified and matched to the catalogue (Hamilton & Martin 1999), and their 'Eg' number is given. Unidentified whales were given 'names', which consist of the two-digit year followed by the Julian day on which it was tagged (number) and the letters distinguish animals tagged on a given day. 'No playback' refers to dives taken when no stimulus was presented, and values shown for this category are means with the number of dives shown in parentheses after the fluke rate. For each whale, the max RL is in dB re 1 µPa and is the highest received sound level in the band of the exposure during the experiment, fluke stroke rates are in hertz and were measured as a whale swam to the surface during exposure, surfacing intervals (i.e. time spent at less than 10 m depth between dives) are in seconds, and subsurface times (i.e. time spent at 1–10 m depth during a surfacing interval) are in seconds. Ascent fluke rate and surface intervals during exposures were compared with the set of no playback results using a Student's *t*-test, and subsurface time as a portion of the total surface interval for each condition was tested using χ^2. A single asterisk indicates values significantly different from the no playback case at $p < 0.05$, and double asterisks indicate values significant at $p < 0.01$. In the 'vessel' column, results reported in bold indicate data collected during opportunistic vessel approaches. These data were collected only for approaches by transiting (i.e. research and whale watch excluded) motor vessels where the vessel passed within 1 nautical mile of the whale. Data for two whales '02_213g' and '02_232d' included two such approaches, and both are reported in the vessel column. While these approaches occurred at different points in the dive cycle, we have reported data for the same variables as in the playbacks.)

whale		no playback	alert	silent	whale sounds	vessel
02_213b	max RL					
	fluke rate	0.1435 (7)				
	surface interval	125				
	subsurface time					
02_213g	max RL		148	134	148	**135 | 142**
	fluke rate	0.1848 (15)	0.2259**	0.1843	0.1835	**0.1950 | 0.1788**
	surface interval	189	762**	203	177	**189 | 191**
	subsurface time	22	522**	13	11	**15 | 18**
02_220f	max RL		143			
	fluke rate	0.1925 (4)	0.2296*			
	surface interval	244	666**			
	subsurface time	0	474**			
Eg2350	max RL		137			
	fluke rate	0.1776 (15)	0.2041**			
	surface interval	314	442*			
	subsurface time	37	236**			
Eg3109	max RL		135	118		133
	fluke rate	0.1260 (21)	0.4139**	0.1833		0.0993
	surface interval	124	401**	72.5		128
	subsurface time	12	288**	10		15
02_232d	max RL		133	124		**136 | 132**
	fluke rate	0.1479 (14)	0.2064**	0.1608		**0.1342 | 0.1389**
	surface interval	222	896.9**	170		**211 | 225**
	subsurface time	41	610**	21		**38 | 45**
02_233a	max RL					**136**
	fluke rate	0.1771 (5)				**0.1593**
	surface interval	228.5				**214**
	subsurface time	54				**48**
Eg3103	max RL		134	120	148	129
	fluke rate	0.2126 (8)	0.2181	0.2066	0.2064	0.2299
	surface interval	140.6	163	124	222	149
	subsurface time	2.6	0	0	3	0
Eg2145	max RL				136	133
	fluke rate	0.1724 (15)			0.1861	0.1715
	surface interval	178			180	172
	subsurface time	12			8	5
Eg1142	max RL					139
	fluke rate	0.1726 (5)				0.1738
	surface interval	214				198
	subsurface time	6				4

ing just below the surface, the whales were vulnerable but seldom visible. Although some whales did swim on a heading that moved them out of the path of the playback boat, our experiment was not a good test of the 'horizontal' avoidance response because the playback vessel moved much more slowly than a ship under normal operation. Any future work evaluating the potential benefit of any such horizontal avoidance must be weighed against the cost of the increased time at the surface. Also, avoidance should be studied as a function of vessel speed for any evaluation of risk factors for collision. Additionally, even if the whales attempted to move out of the path of the

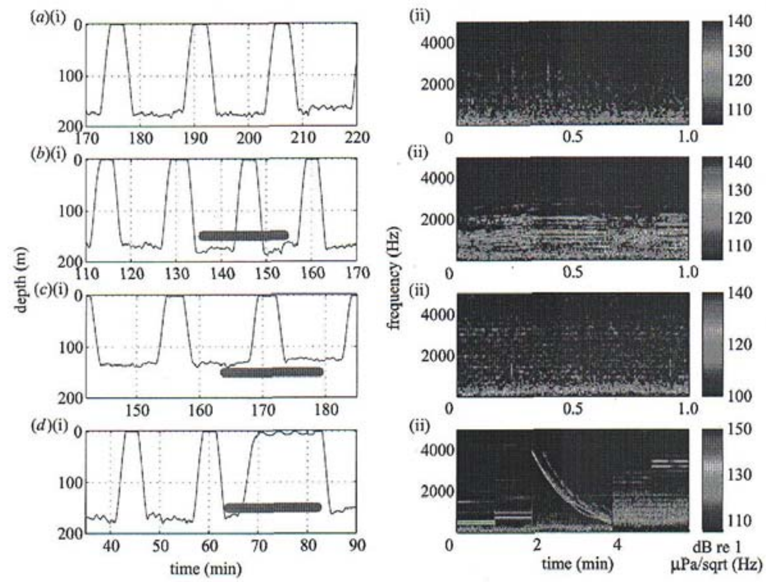

Figure 1. Swimming/diving behaviour and received sounds during control and sound exposure dives. (*a*–*d*)(i) show a time–depth profile for dives before, during and after exposures, and (*a*–*d*)(ii) show a representative spectrogram (time versus frequency) and RL of the sounds recorded on the tag: (*a*)(ii) no playback RL = 130 dB; (*b*)(ii) whale RL = 148 dB; (*c*)(ii) vessel RL = 140 dB; and (*d*)(ii) alarm RL = 148 dB. The times on the dive profiles are in minutes since the tag was attached to the whale. Red bars indicate the period of exposure to each stimulus. (*a*) Silent control; (*b*) whale social sound; (*c*) vessel noise exposure; and (*d*) the alert signal. Note the change in dive profile in response to the alert signal, including the time spent near, but not at, the surface during the exposure. The spectrogram in (*d*) shows an edited sequence of the alert signals so that each signal could be displayed. The first recording on the tag of each of the three types of alert signal is shown, although each signal occurred several times before the next type started (see text for description of signal order and duration). The increased noise for the last signal, after minute 4 in the spectrogram, resulted from increased flow noise over the tag caused by the whale's increased swim speed as it swam to the surface.

playback boat, right whales spend much of their time in areas of heavy vessel traffic (Kraus *et al.* 1986; Russell *et al.* 2001), so there is often more than one ship to which to respond. Finally, the sixth whale exposed to the alert signal showed no detectable response. In this case the alert signal would not decrease or increase the risk of collision relative to an encounter without the alert. All of these factors suggest that alerting stimuli would only be appropriate for mitigation after extensive study of the horizontal avoidance response as a function of vessel speed, and could only be one component of a comprehensive strategy to reduce the risk of collision.

Not only are there unresolved questions regarding the effect of the alert stimulus on the risk of a collision, but the behaviour of the responding whales has negative energetic consequences. The whales both lose foraging time and expend excess energy during their high-powered ascent and subsurface swimming. The actual metabolic cost of the rapid ascent is difficult to calculate. The power requirements for streamlined swimming vertebrates are proportional to the cube of the velocity (Webb 1975), and the whales' dramatically increased fluke stroke rates (table 1) suggest a strong and sustained increase in swimming speed. This manoeuvre could cost these whales significant energy, especially if repeated often. The energetic cost is especially alarming considering the reduced blubber thickness in this population (Miller *et al.* 2001). Any underwater sounds with an acoustic structure similar to our alert stimulus may also disrupt normal behaviour and evoke costly responses. This research suggests that signals like our alert are likely to disrupt feeding behaviour at received levels of only 133–148 dB re 1 µPa for the duration of the sound exposure, with return to normal behaviour within minutes of when the source is turned off.

None of the whales exposed to either approaches by transiting vessels or to our playbacks of ship noise displayed any of the responses seen to the alert stimulus (table 1). They did not respond even when we know they could hear the signals because the RLs of the playbacks as well as the opportunistic approaches were at least as strong as and contained frequencies similar to those that stimulated a strong response to the alert signal. Therefore, we must conclude that it is the alert signal itself, and not differences in RL between the different stimuli, that elicits the response. This lack of response to vessel noise at *ca.* 135 dB re 1 µPa could be very dangerous. For example, a vessel with an SL of 185 dB re 1 µPa would produce 135 dB re 1 µPa at ranges of only *ca.* 300 m based on simple spherical spreading, and, depending on the actual sound propagation, the level at this range would probably be less than 135 dB (Urick 1983). A large commercial vessel 300 m from a whale that is travelling at typical ocean speed of *ca*. 20 knots would pose a significant threat to the whale as it would travel this distance in *ca*. 30 s. Anecdotal observations of responses at less than 100 m are consistent with response at some higher exposure range, which perhaps could be the subject of future work.

A possible explanation for the difference in response to the alert versus vessel noise stimuli is that whales have habituated more to vessel noise, which is continuous and ubiquitous, than to the alert, which is intermittent and had not been introduced before these experiments. Habituation to the alert signal was not directly tested, although the one whale that showed no response was the last animal tested and was known to have been in the general area for four of the five other exposures before it was the experimental subject. Future efforts to stop collisions between ships and right whales will need to take into account the whales' lack of response to the sounds of oncoming vessels. The only obvious solution remains the difficult one of separating the vessels from the whales and/or slowing vessels to a safe speed to improve the possibility of detecting whales and/or reduce blunt trauma injuries, which are responsible for many whale mortalities (Knowlton & Kraus 2001).

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REFERENCES

Best, P. B., Brandao, A. & Butterworth, D. S. 2001 Demographic parameters of southern right whales off South Africa. *J. Cetacean Res. Mngmt* (Special Issue) **2**, 161–169.

Caswell, H., Fujiwara, M. & Brault, S. 1999 Declining survival probability threatens the North Atlantic right whale. *Proc. Natl Acad. Sci. USA* **96**, 3308–3313.

Clapham, P. J., Young, S. B. & Brownell, R. L. J. 1999 Baleen whales: conservation issues and the status of the most endangered populations. *Mammal Rev.* **29**, 35–60.

Clark, C. W. 1982 The acoustic repertoire of the southern right whale, a quantitative analysis. *Anim. Behav.* **30**, 1060–1071.

Edworthy, J. & Meredith, C. S. 1994 Cognitive psychology and the design of alarm sounds. *Med. Engng Physics* **16**, 445–449.

Hamilton, P. K. & Martin, S. K. (eds) 1999 *A catalog of identified right whales from the Western North Atlantic: 1935 to 1997*. Boston, MA: New England Aquarium.

Johnson, M. P. & Tyack, P. L. 2003 A digital acoustic recording tag for measuring the response of wild marine mammals to sound. *IEEE J. Oceanic Engng* **28**, 3–12.

Ketten, D. R. 1998 Marine mammal ears: an anatomical perspective on underwater hearing. In *Joint Meeting of the Acoustical Society of America and the International Acoustical Society*, Plenary Lecture. Seattle, WA.

Kinsler, L. E., Frey, A. R., Coppens, A. B. & Sanders, J. V. 2000 *Fundamentals of acoustics*. New York: Wiley.

Knowlton, A. R. & Kraus, S. D. 2001 Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *J. Cetacean Res. Mngmt* (Special Issue) **2**, 193–208.

Kraus, S. D., Prescott, J. H., Knowlton, A. R. & Stone, G. S. 1986 Migration and calving of right whales (*Eubalaena glacialis*) in the western North Atlantic. *Rep. Int. Whaling Commission* (Special Issue) **10**, 139–144.

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S. & Podesta, M. 2001 Collisions between ships and whales. *Mar. Mammal Sci.* **17**, 35–75.

Miller, C. A., Reeb, D., Best, P. B. & Moore, M. J. 2001 Blubber thickness and reproductive success in right whales. In *14th Biennial Conference on the Biology of Marine Mammals*. Vancouver, British Columbia.

Moore, M. J., Miller, C. A., Morss, M. S., Arthur, R., Lange, W., Prada, K. G., Marx, M. K. & Frey, E. A. 2001 Ultrasonic measurement of blubber thickness in right whales. *J. Cetacean Res. Mngmt* (Special Issue) **2**, 301–309.

Murison, L. D. & Gaskin, D. E. 1989 The distribution of right whales and zoolplankton in the Bay of Fundy, Canada. *Can. J. Zool.* **67**, 1411–1420.

Nowacek, D. P., Johnson, M. P., Tyack, P. L., Shorter, K. A., McLellan, W. A. & Pabst, D. A. 2001 Buoyant balaenids: the ups and downs of buoyancy in right whales. *Proc. R. Soc. Lond.* B **268**, 1811–1816. (DOI 10.1098/rspb.2001.1730.)

Parks, S. E. 2003 Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. *Mar. Mammal Sci.* **19**, 563–580.

Reeves, R. R. & Mitchell, E. 1986 American pelagic whaling for right whales in the North Atlantic. *Rep. Int. Whaling Commission* (Special Issue) **10**, 221–254.

Richardson, W. J., Greene, C. R., Malme, C. I. & Thomson, D. H. 1995 *Marine mammals and noise*. San Diego, CA: Academic.

Russell, B. A., Knowlton, A. R. & Zoodsma, B. 2001 *Recommended measures to reduce ship strikes of North Atlantic right whales*. Washington, DC: National Marine Fisheries Service.

Terhune, J. M. & Verboom, W. C. 1999 Right whales and ship noise. *Mar. Mammal Sci.* **15**, 256–258.

Urick, R. J. 1983 *Principles of underwater sound*. New York: McGraw-Hill.

Webb, P. W. 1975 Hydrodynamics and energetics of fish propulsion. *Bull. Fisheries Res. Board Can.* **190**, 1–158.

TECHNICAL REPORT 1913
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Effects of Intense Pure Tones on the Behavior of Trained Odontocetes

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ADMINISTRATIVE INFORMATION

This report was prepared for the Chief of Naval Operations, Code N45, by the Research and Animal Care Branch, Code 2351, of the Biosciences Division, Code 235, SSC San Diego.

Released by
P. Moore, Head
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EXECUTIVE SUMMARY

The U.S. Office of Naval Research (ONR) and Chief of Naval Operations (CNO) (N45) have sponsored research programs to investigate the auditory effects of high-intensity sounds on marine mammals. In addition to auditory effects, these studies reported behavioral reactions as the subjects were exposed to sounds of increasing intensity. The most common reactions were attempts by the subjects to avoid the site of previous noise exposures, or attempts to avoid an exposure in-progress.

Schlundt *et al.* (2000) gave a brief summary of the more significant behavioral changes they observed in dolphins and white whales exposed to intense pure tones. This report presents a more detailed summary of behavioral responses of dolphins and white whales exposed to 1-s tones.

Test sessions were grouped by species and exposure frequency. Within each group, the percentage of sessions in which subjects showed altered behavior was calculated as a function of exposure sound pressure level (SPL) and energy flux density level (EL). Altered behavior was defined as a change from a subject's "normal" behavior observed during baseline sessions without intense sound exposure. The percentage of sessions with altered behavior generally increased with increasing exposure levels. For pooled data at 3, 10, and 20 kHz, exposure ELs corresponding to sessions with 25, 50, and 75% altered behavior were 180, 190, and 199 dB re 1 μPa^2-s, respectively.

Behavioral effects were quantitatively assessed by comparing the time for the subjects to swim from one apparatus (the "S1 station") to another apparatus (the "S2 station"). Unlike behavioral reactions, which could only be assessed subjectively, S1–S2 travel times could be objectively measured. Unfortunately, there was no clear relationship between S1–S2 travel times and exposure SPL.

CONTENTS

1. INTRODUCTION

In response to concerns over the potential effects of underwater noise on marine mammals, the U.S. Office of Naval Research (ONR) and Chief of Naval Operations (CNO) (N45) have sponsored a number of research programs designed to investigate the auditory effects of high-intensity sounds on marine mammals (e.g., Kastak *et al.*, 1999; Schlundt *et al.*, 2000; Finneran *et al.*, 2000a; Finneran *et al.*, 2002; Nachtigall *et al.*, 2003).

The three groups actively researching marine mammal temporary threshold shift (TTS) are located at the Space and Naval Warfare Systems Center, San Diego (SSC San Diego), the University of California Santa Cruz, and the Hawaii Institute of Marine Biology. The groups' hearing test method, species studied, and exposure conditions differ, but the basic procedures are similar: hearing thresholds are measured in trained marine mammals before and after exposure to sounds with various sound pressure levels (SPLs), waveforms, frequencies, and durations to determine the amount of TTS produced. TTS is a temporary hearing loss that completely recovers after some period of time. The amount of TTS (in decibels) is calculated by subtracting the post-exposure hearing threshold from the pre-exposure threshold. A TTS indicates an increase in hearing threshold, which means a decrease in sensitivity (i.e., hearing loss). TTS data from these studies are used to estimate acoustic zones of impact for Navy activities (e.g., DoN, 2001).

The groups conducting TTS research have also noted certain behavioral alterations, or changes from the subjects' trained behaviors, that tend to occur as the subjects are exposed to sounds of increasing intensity. Behavioral alterations often consisted of attempts by the subjects to avoid the site of previous noise exposures (e.g., Schlundt *et al.*, 2000), or attempts to avoid an exposure in-progress (e.g., Kastak *et al.*, 1999). On some occasions, the subjects became aggressive or refused to further participate in the test (Schlundt *et al.*, 2000).

Schlundt *et al.* (2000) presented some of the more significant behavioral changes and exposure levels above which behavioral changes were observed, but they did not provide a detailed analysis or breakdown by exposure SPL. The objective of this study was to present a more detailed summary of the behavioral observations recorded during TTS tests conducted at SSC San Diego with 1-s tones. These experiments were originally reported in Schlundt *et al.* (2000) and Finneran *et al.* (2001, 2003). This report presents the methods used to analyze the behavioral data and the results.

2. BACKGROUND

The SSC San Diego TTS test methodology is described in detail in Schlundt *et al.* (2000) and Finneran *et al.* (2000a, 2002, 2003); however, because the interpretation of the behavioral data depends on the specific test procedures, a description of the TTS methodology is provided.

TTS testing requires three steps: (1) measurement of the subject's pre-exposure hearing threshold, (2) exposure of the subject to an intense underwater sound, called the "fatiguing stimulus," and (3) measurement of the subject's post-exposure hearing threshold. At SSC San Diego, hearing thresholds are measured by training subjects to perform specific actions when they hear certain sounds. Pure tones, or hearing test tones, are played to a subject at various levels and the subject's responses recorded. The hearing threshold is defined as the SPL at which the subject responds 50% of the time.

Figure 1 shows the TTS test setup. The test apparatus contains two underwater test platforms, called "stations." The two stations are referred to as the "S1 station" and the "S2 station." The intense sound exposure occurs at the S1 station. The hearing tests are conducted at the S2 station. Two stations are used to physically separate the hearing test location from the intense sound exposure location. Each station contains underwater sound projectors, hydrophones, a video camera, and a plastic "biteplate" on which the subject is trained to position itself. The biteplate ensures that the subject's head is in a known position with respect to the sound sources.

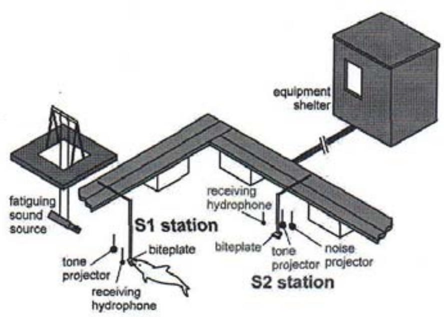

Figure 1. TTS test setup at SSC San Diego.

The test sequence begins with the trainer cueing the subject to dive underwater and position itself on the S1 biteplate. The subject remains at the S1 station until presented with a specific sound referred to as the "S1 release signal" or "S1 signal." When it hears the S1 signal, the subject swims to the S2 station and positions itself on the S2 biteplate. Once at the S2 station, the subject is presented with a number of hearing test tones. The subject is trained to produce an audible response if it detects a hearing test tone and to remain quiet otherwise. After a variable number of tones, the subject is recalled to the surface and given fish reward.

The sequence described above is repeated until the pre-exposure hearing threshold is obtained. The subject is then cued to the S1 station and exposed to the intense sound. Following the intense sound exposure, the post-exposure hearing threshold is measured (in a manner similar to the pre-exposure threshold). Pre- and post-exposure thresholds are compared to determine the amount of TTS.

2.1 SCHLUNDT *ET AL.* (2000)

Schlundt *et al.* (2000) reported eight individual TTS experiments. Table 1 lists the fatiguing sound frequencies, exposure levels, and species tested during each experiment (exp. 1 through 8 in Table 1). Fatiguing stimuli durations were 1 s. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. The S1 release signal was a 1-s, 141 dB re 1 μPa tone at the same frequency as the fatiguing stimulus. For the actual fatiguing stimulus, the S1 signal level was increased to the desired fatiguing sound level. Fatiguing sound levels generally increased from day to day during each experiment until a measurable TTS (i.e., greater than 6 dB) was observed. Experiments 1 through 8 differed in the exact test sequence. For example, some tests featured "recovery" thresholds measured tens of minutes or hours after the post-exposure threshold [see Schlundt *et al.* (2000) for more details].

Schlundt *et al.* (2000) reported that "behavioral alterations," or deviations from subjects' trained behaviors, occurred as the subjects were exposed to increasing fatiguing stimulus levels. Schlundt *et al.* also reported measurements of the amount of time taken for the subjects to travel from the S1 station to the S2 station after the fatiguing sound exposure. These data [Figure 8 in Schlundt *et al.* (2000)] suggested a relationship between the S1–S2 travel time, behavioral alterations, and the fatiguing stimulus level.

2.2 FINNERAN *ET AL.* (2001, 2003)

Finneran *et al.* (2001, 2003) conducted TTS experiments at SSC San Diego using 1-s duration tones at 3 kHz. The test method was similar to that of Schlundt *et al.* except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 $\mu Pa^2/Hz$), and no masking noise was used. The S1 signal was a sinusoidal amplitude modulated tone with a carrier frequency of 12 kHz, modulating frequency of 7 Hz, and SPL of approximately 100 dB re 1 μPa. An S1 signal distinct from the fatiguing sound allowed true control sessions. Two separate experiments were conducted. In the first (Table 1, exp. 9), fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment (Table 1, exp. 10), fatiguing sound levels between 180 and 200 dB re 1 μPa were randomly presented.

Table 1. Fatiguing sound frequencies, exposure levels, and number of subjects. The same two white whales were used for all tests at 3 and 20 kHz. Four different dolphins were used for the 3- and 20-kHz tests (some dolphins participated in more than one experiment).

Exp.	Frequency (kHz)	Levels (dB re 1 μPa)	Subjects (dolphin/w. whale)
1	20	160–197	2/0
2	75	160–194	2/0
3	3	160–202	2/2
4	10	180–197	2/2
5	20	180–201	2/2
6	20	178–202	2/2
7	3	180–201	2/2
8	0.4	179–193	2/2
9	3	160–201	2/0
10	3	180–200	2/0

3. METHODS

3.1 BEHAVIORAL ALTERATIONS

Behavioral observations recorded by the trainers or test coordinators during the Schlundt *et al.* (2000) and Finneran *et al.* (2001, 2003) experiments were examined. A total of 193 exposure sessions (fatiguing stimulus level > 141 dB re 1 μPa) were evaluated from Schlundt *et al.* (2000) and 21 exposure sessions from Finneran *et al.* (2001, 2003). Each exposure was put into one of the following nine exposure groups: 160±3, 170±3, 175±2, 180±2, 186±3, 192±2, 196±1, 199±1, and 201±1 dB re 1 μPa. The exposure groups and ± ranges were based on the distribution of the actual exposure SPLs. Exposures falling within the bounds outlined above were considered to have been at the center of the SPL range. For example, an exposure at 188 dB re 1 μPa would be put into the 186±3 group and from this point on considered to be at 186 dB re 1 μPa. All exposures had durations of 1 s.

The observations were used to subjectively assess a subject's behavior during the session. This assessment relied upon detailed knowledge of the subject's "normal" behaviors observed during baseline sessions conducted with no intense sound exposures. The main types of "altered behaviors" observed during the tests were:

- Committing more false alarms than normal during a hearing test
- Leaving the S2 station before signaled
- Not swimming to the S2 station after receiving the S1 release signal
- Returning to the S1 station after an S1 signal or fatiguing sound exposure (required an additional S1 release signal to go to S2)
- Tail slapping, "jaw popping" (see Finneran *et al.*, 2000b)
- Departing the S1 station in a direction away from the S2 station
- "Floating" to the S2 station, sluggish behavior
- Swimming erratically around test enclosure
- Ignoring the trainer, floating in test enclosure corner
- Vocalizing after the fatiguing stimulus exposure
- Positioning improperly on the S1 biteplate
- Requiring additional cues from trainer before going to S1 station
- Leaving the S1 station before the S1 signal
- Refusing to return to the S1 station
- Attacking the S1 station

The behavioral alterations are roughly arranged in order of least severe to most severe. The subjective assessment was used to categorize the subject's behavior in each session as "normal" or "altered." Altered behaviors were not restricted to the time period after the fatiguing sound exposure—in some cases behavioral changes (e.g., leaving the S1 station early) occurred before the fatiguing sound exposure. The subjective analysis in this report was, in general, more liberal than that performed by Schlundt *et al.* (2000), who reported mostly significant behavioral changes directly resulting from exposures; there may therefore be some differences between the results. The results presented here also include additional data not presented by Schlundt *et al.* (2000).

After categorizing each session as altered or normal behavior, sessions were grouped according to species and exposure frequency. For each species and frequency combination, the percentage of sessions with altered behavior was calculated for each exposure SPL group. The relatively small number of exposures for each subject prevented analyzing the data on a per subject basis. Data are reported for dolphins and white whales and for both species pooled. A probit analysis technique

(Finney, 1971) was used to fit smooth dosage-response curves to the percent altered behavior versus SPL data for the pooled dolphin/white whale data sets, except for the 0.4-kHz data, which could not be properly fit (see section 5.1).

3.2 S1–S2 TRAVEL TIMES

Exposures were categorized as outlined above and sessions were grouped according to species and fatiguing stimulus frequency. For each species group/exposure SPL combination, the mean S1–S2 travel time was calculated. Mean travel times from baseline test sessions reported by Schlundt *et al.* (2000) were also analyzed. The baseline travel times were from a random sample of 15 S1–S2 intervals over a minimum of 3 test days (Schlundt *et al.*, 2000).

4. RESULTS

4.1 BEHAVIORAL ALTERATIONS

Figures 2 through 8 show the results of the subjective behavior analysis. Each plot shows the percentage of sessions with altered behavior at each exposure SPL. Figures 2 through 6 show the data for 0.4, 3, 10, 20, and 75 kHz individually. Figures 7 and 8 pool the data at 3, 10, and 20 kHz and 0.4, 3, 10, 20, and 75 kHz, respectively. Each figure has three panels. The top panel shows the pooled results for both dolphins and white whales; the middle and bottom panels show the white whale and dolphin data separately. The exception to this is Figure 6, which has only two panels since white whales were not tested at 75 kHz. The solid lines show the curve-fits resulting from the probit analysis. The 0.4-kHz data suggested a decreasing percent altered behavior with increasing exposure SPL and thus could not be fit with the classic dosage response curves as seen in Figures 3 through 8.

The numbers above the bars in the lower panels indicate the number of (total) exposure sessions for each species/frequency group. The pooled data show the percentage of sessions with altered behavior after the data were pooled, not the average of the original (unpooled) data. For example, at 0.4 kHz, 180 dB re 1 µPa, altered behaviors were noted in 2 of 4 (50%) white whale sessions and 2 of 3 (66.6%) dolphin sessions. When the dolphin and white whale data were pooled, the percentage became 4 of 7 or 57%. The same method was used to pool data from multiple frequencies: percentages were re-calculated by dividing the total number of sessions with altered behavior by the total number of exposure sessions.

Exposure SPLs corresponding to specific percentages of sessions with altered behavior may be found by interpolating within Figures 3 through 8. Example results are displayed in Table 2 for percentages of 25, 50, and 75%.

Table 2. Exposure SPLs (dB re 1 µPa) corresponding to 25, 50, and 75% of sessions with altered behavior for the different frequency groups. Results are for the pooled white whale and dolphin data.

Frequency group (kHz)	25%	50%	75%
3	184	192	200
10	177	182	186
20	183	191	200
75	175	181	188
3, 10, 20	180	190	199
0.4, 3, 10, 20, 75	173	189	204

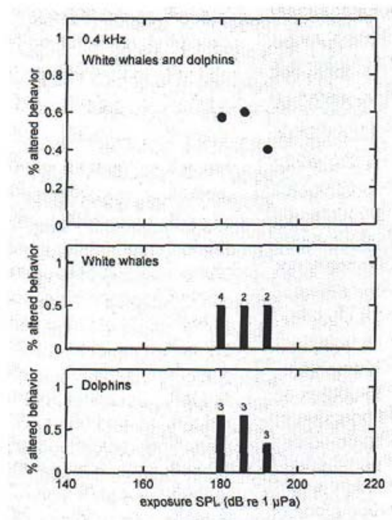

Figure 2. Altered behavior as a function of exposure SPL at 0.4 kHz.

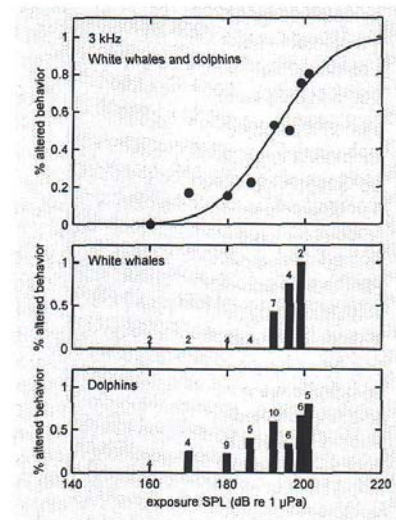

Figure 3. Altered behavior as a function of exposure SPL at 3 kHz.

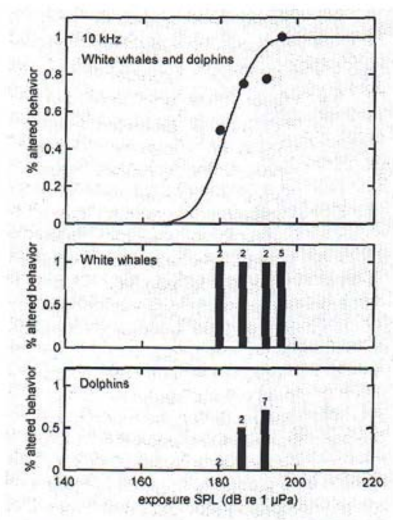

Figure 4. Altered behavior as a function of exposure SPL at 10 kHz.

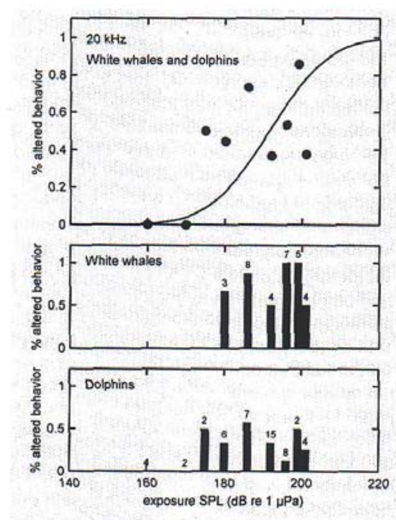

Figure 5. Altered behavior as a function of exposure SPL at 20 kHz.

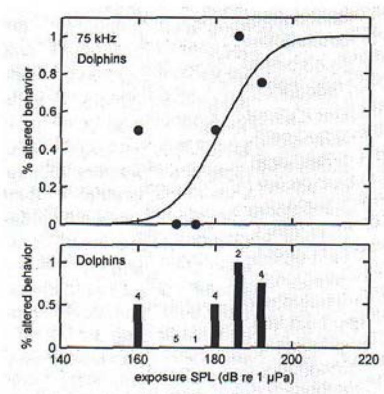

Figure 6. Altered behavior as a function of exposure SPL at 75 kHz.

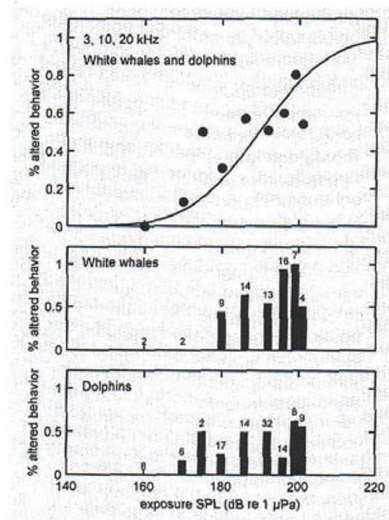

Figure 7. Altered behavior as a function of exposure SPL at 3, 10, and 20 kHz.

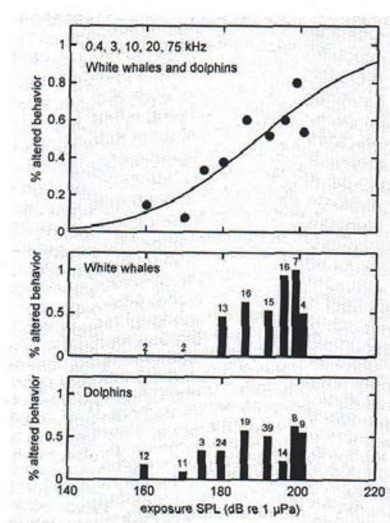

Figure 8. Altered behavior as a function of exposure SPL at 0.4, 3, 10, 20, and 75 kHz.

4.2 S1–S2 TRAVEL TIMES

Figures 9 through 15 show the mean S1–S2 travel times as functions of exposure SPL for different exposure frequencies. Figures 9 through 13 show the data for 0.4, 3, 10, 20, and 75 kHz individually. Figures 14 and 15 pool the data at 3, 10, and 20 kHz and 0.4, 3, 10, 20, and 75 kHz, respectively. Each figure has three panels. The top panel shows the pooled results for both dolphins and white whales; the middle and bottom panels show the white whale and dolphin data separately. The exception to this is Figure 13, which has only two panels since white whales were not tested at 75 kHz. The travel time data were pooled in a manner similar to the subjective behavioral data: means were re-calculated from the pooled data. The error bars indicate standard deviations. The "base" data point represents the mean and standard deviation from a random sample of 15 S1–S2 intervals over a minimum of three baseline test days (Schlundt *et al.*, 2000). Note that the ordinate limits are not uniform in all figures.

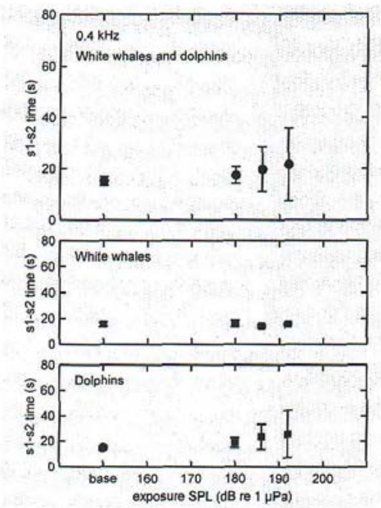

Figure 9. Mean S1–S2 travel times from baseline and exposure sessions at 0.4 kHz. Error bars indicate standard deviations.

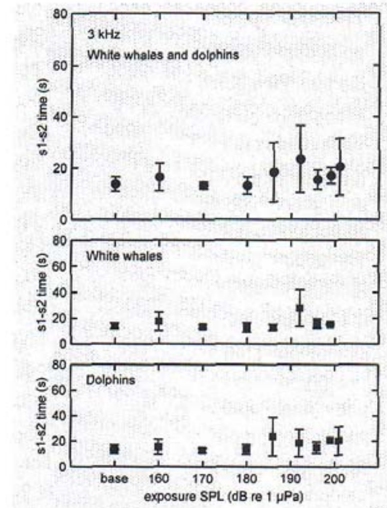

Figure 10. Mean S1–S2 travel times from baseline and exposure sessions at 3 kHz. Error bars indicate standard deviations.

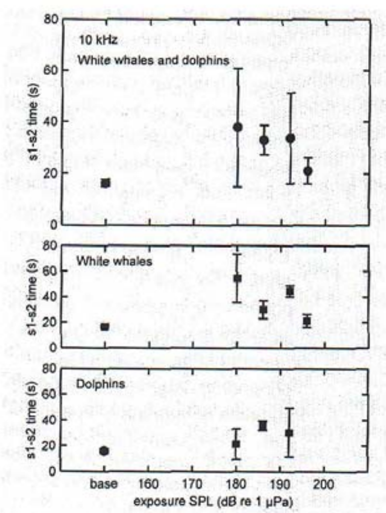

Figure 11. Mean S1–S2 travel times from baseline and exposure sessions at 10 kHz. Error bars indicate standard deviations.

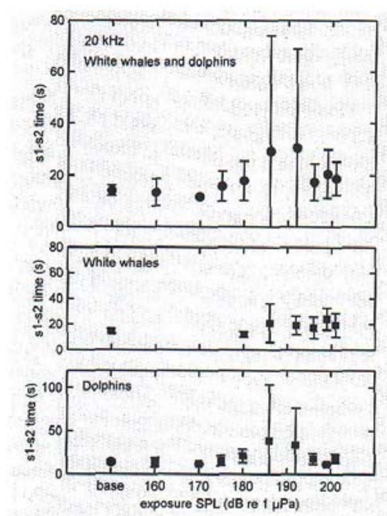

Figure 12. Mean S1–S2 travel times from baseline and exposure sessions at 20 kHz. Error bars indicate standard deviations.

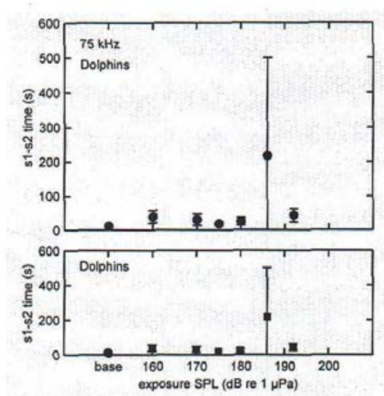

Figure 13. Mean S1–S2 travel times from baseline and exposure sessions at 75 kHz. Error bars indicate standard deviations.

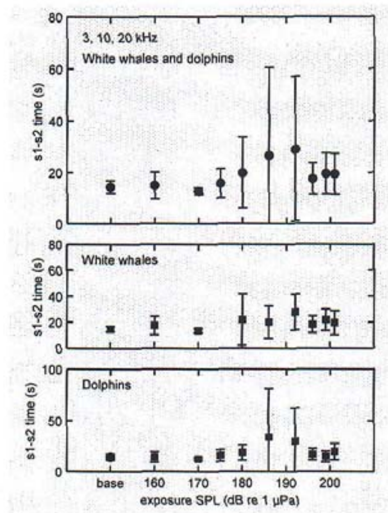

Figure 14. Mean S1–S2 travel times from baseline and exposure sessions at 3, 10, and 20 kHz. Error bars indicate standard deviations.

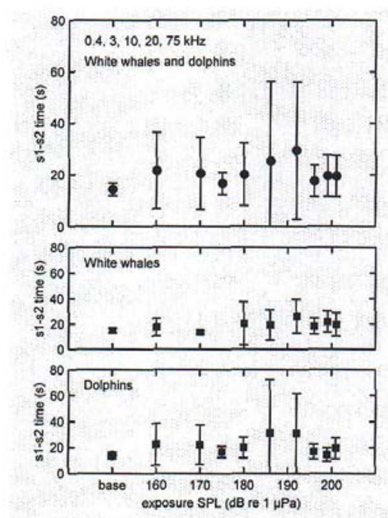

Figure 15. Mean S1–S2 travel times from baseline and exposure sessions at 0.4, 3, 10, 20, and 75 kHz. Error bars indicate standard deviations.

5. DISCUSSION

5.1 BEHAVIORAL ALTERATIONS

The behavior of a subject during intense sound exposure experiments was compared to the subject's normal behaviors to determine whether a subject exhibited altered behavior during a session. In this context, altered behavior means a deviation from a subject's normal trained behaviors. The subjective assessment was only possible because behavioral observations were made with the same subjects during many baseline hearing sessions with no intense sound exposures. This allowed comparisons to be made between how a subject normally acted and how it acted during test sessions with fatiguing sound exposures.

Subjectively categorizing each exposure session as normal or altered behavior allowed the percentage of sessions with altered behavior to be calculated as a function of the exposure SPL. Figures 2 through 8 show the percentage of sessions with altered behavior as a function of the exposure SPL for different species/frequency combinations. As reported by Schlundt *et al.* (2000), instances of altered behavior generally began at lower exposures than those causing TTS; however, there were many instances when subjects exhibited no altered behavior at levels above the onset-TTS levels. The 3-, 10-, and 20-kHz data generally show increasing percentages with increasing exposure SPL. The 0.4-kHz percentages do not increase with frequency; however, this is likely a reflection of the sparse data rather than a true relationship between increasing exposure and behavioral effects. The 75-kHz data tend to increase with exposure SPL but possess a great deal of variability.

Schlundt *et al.* (2000) reported minimum exposure levels required to produce behavioral alterations. The subjective analysis performed for this report was more liberal; changes from the subject's normal behaviors were considered to represent altered behavior regardless of whether that change could be explicitly tied to the fatiguing sound exposure. The more liberal approach was considered appropriate for this report because the data presentation method (percentage of sessions with altered behavior) helps to prevent misinterpreting the data. For example, presenting the minimum level at which any change was observed may be misleading if most occurrences of altered behavior were at much higher levels. Figures 2 through 8 keep the individual data values in perspective with respect to the effects at other exposure SPLs.

5.1.1 Limitations

Interpretation and extrapolation of the data shown in Figures 2 through 8 should be done with caution. These data represent behaviors of particular trained subjects in controlled circumstances. Behavioral reactions do not depend solely on the sound exposure, but also may vary with the subject's prior experience and motivational state. A great deal of variability may exist between subjects. Some subjects were more tolerant of the intense sound exposures than others. Some subjects were only used in one experiment while others were tested multiple times. Since all subjects were not tested at each exposure frequency, this may have skewed the data at some frequencies; one would expect more representative results from frequencies tested with more individuals.

Responses of trained, experienced subjects are not necessarily applicable to wild and/or naïve animals. Experienced and/or food-motivated subjects may tolerate higher sound levels than inexperienced or unmotivated animals. It is also possible that prior experiences may have made some subjects less tolerant of the sound exposures.

Because the TTS experiments were not designed to measure behavioral effects, certain aspects of the experimental design created confounds that affect the extrapolation of these data to other scenarios. For example, exposure levels generally started relatively low and increased over time until the subject exhibited a measurable TTS. This makes it difficult to attribute a particular behavioral reaction to a specific exposure, rather than to learning and the cumulative effect of increasing exposure levels over a period of days or weeks. Some behavioral reactions (e.g., refusing to station at the S1 biteplate) occurred before the fatiguing sound exposure (also reported in Finneran *et al.*, 2003). This shows that the subjects' prior experiences affected their responses during the tests. This also blurs potential cause-and-effect relationships between the intense sound exposure and the observed behavioral reactions.

During experiments 1 through 8, the fatiguing sound also acted as the S1 release signal (although at a higher SPL than normal). This test approach prevented control sessions where the test procedures are identical to the exposure sessions except there is no fatiguing sound exposure. This is a potential confound if subjects discriminated between the S1 release signal at 141 dB re 1 μPa and more intense fatiguing stimuli at higher levels. A subject may not have recognized the fatiguing sound as the cue to go to S2 (resulting in an increased S1–S2 time) simply because it was at a much higher level than normal, not because the received level was aversive or bothersome.

Another potential problem arises from the lack of data at lower levels in many experiments. The TTS experiments concentrated exposures near SPLs that were capable of inducing a TTS. In several experiments, there were no exposures below 180 dB re 1 μPa. In one case (white whales at 10 kHz), behavioral alterations were observed during both sessions at 180 dB re 1 μPa (the lowest exposure level) and all higher levels. It is unknown if behavioral alterations would have been observed at lower exposure levels if they had been tested.

5.2 S1–S2 TRAVEL TIMES

S1–S2 travel time measurements enable quantitative comparisons between baseline and exposure sessions at various SPLs. There was a large variation in the S1–S2 travel times for some exposure conditions. Some behavioral reactions, such as ignoring the trainer or requiring additional S1 release signals before going to S2, dramatically increased the measured travel time.

Schlundt *et al.* (2000) showed significant differences between mean S1–S2 travel times for baseline and exposure session *with altered behavior*. In this report, all exposure sessions are included, rather than just exposure sessions with altered behavior. Figures 9 through 15 do not indicate any obvious relations between exposure SPL and mean S1–S2 travel times. The difference between the Schlundt *et al.* (2000) results (significant differences between baseline and exposure sessions with altered behavior) and the current result (no difference between baseline and exposure sessions) arises because the S1–S2 travel time was one of the factors used to categorize a session as altered or normal behavior. Although the sessions judged by Schlundt *et al.* to exhibit altered behavior had larger mean S1–S2 times than the baseline sessions, the S1–S2 travel time cannot be used as a predictor of altered behavior.

6. REFERENCES

Department of the Navy (DoN) (2001). Environmental Impact Statement for the Shock Trial of the Winston S. Churchill (DDG-81).

Finneran, J. J., Carder, D. A., and Ridgway, S. H. (2001). "Temporary threshold shift (TTS) in bottlenose dolphins (*Tursiops truncatus*) exposed to tonal signals," *J. Acoust. Soc. Am.* 110(5), 2749(A), 142nd Meeting of the Acoustical Society of America, Fort Lauderdale, FL, December 2001.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A., and Ridgway, S. H. (2002). "Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun," *J. Acoust. Soc. Am.* 111, 2929–2940.

Finneran, J. J., Carder, D. A., and Ridgway, S. H. (2003). "Temporary threshold shift (TTS) measurements in bottlenose dolphins (*Tursiops truncatus*), belugas (*Delphinapterus leucas*), and California sea lions (*Zalophus californianus*)," Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, TX, 12–16 May 2003.

Finneran, J. J., Schlundt, C. E., Carder, D. A., Clark, J. A., Young, J. A. Gaspin, J. B., and Ridgway, S. H. (2000a). "Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and white whales (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions," J. Acoust. Soc. Am. 108, 417–431.

Finneran, J. J., Oliver, C. W., Schaefer, K. M., and Ridgway, S. H. (2000b). "Source levels and estimated yellowfin tuna (*Thunnus albacares*) detection ranges for dolphin jaw pops, breaches, and tail slaps," *J. Acoust. Soc. Am.* 107(1), 649–656.

Finney, D. J. (1971). *Probit Analysis*, third edition (Cambridge University Press, London).

Kastak, D., Schusterman, R. J., Southall, B. L., and Reichmuth, C. J. (1999). "Underwater temporary threshold shift induced by octave-band noise in three species of pinniped," *J. Acoust. Soc. Am.* 106(2), 1142–1148.

Nachtigall, P.E., Pawloski, J.L., and Au, W. W. L. (2003). "Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenosed dolphin (Tursiops truncatus)," *J. Acoust. Soc. Am.* 113, 3425–3429.

Schlundt, C. E., Finneran, J. J., Carder, D. A., and Ridgway, S. H. (2000). "Temporary shift in masked hearing thresholds (MTTS) of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones," *J. Acoust. Soc. Am.* 107(6), 3496–3508.

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Incidental Harassment Authorization

The Commander, U.S. Pacific Fleet, 250 Makalapa Dr.,Pearl Harbor, HI 96860-3131, and his designees, is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to the Rim of the Pacific (RIMPAC) Anti-submarine warfare (ASW) exercises conducted in the Hawaiian Islands Operation Area (OpArea), June 26 – August 15, 2006:

1 This Authorization is valid from June 26, 2006, through August 15, 2006.

2. This Authorization is valid only for the operation of mid-frequency tactical sonar during designated RIMPAC ASW exercises within the Hawaiian Islands OpArea.

3. (a) The incidental take of marine mammals under the activity identified in Condition 2, by Level B harassment only, is limited to the following species:

(i) Mysticete Whales - fin whale (*Balaenoptera physalus*), Bryde's whale (*Balaenoptera edeni*), sei whale (*Balaenoptera borealis*)

(ii) Odontocete Whales - sperm whale (*Physeter macrocephalus*), dwarf and pygmy sperm whales (*Kogia simus* and *K. breviceps*), short-finned pilot whale (*Globicephala macrorhynchus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), Fraser's dolphin (*Lagenodelphis hosei*), bottlenose dolphin (*Tursiops truncatus*), spinner dolphin (*Stenella longirostris*), pantropical spotted dolphin (*S. attenuata*), striped dophin (*S. coeruleoalba*), melon-headed whale (*Peponocephala spp.*), Blaineville's beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), Longman's beaked whale (*Indopacetus pacificus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), and pygmy killer whale (*Feresa attenuata*).

The taking by Level A harassment, serious injury or death of any of these species, or the taking of any species of marine mammal not listed in 3(a), is prohibited and may result in the modification, suspension or revocation of this Authorization.

(b) The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Pacific Islands Regional Office, National Marine Fisheries Service (NMFS), at (808) 944-2200, and the Division of Permits, Conservation, and Education, Office of Protected Resources (NMFS), at (301) 713-2289.

4. The holder of this Authorization is required to cooperate with NMFS and a
Federal, state or local agency monitoring the impacts of the activity on marine mamn

EXHIBIT NO. 13
APPLICATION NO.
CD-086-06

5. Mitigation and Monitoring

The holder of this Authorization is required to implement the following measures:

(a) All RIMPAC participants will receive the following marine mammal training/briefing during the port phase of RIMPAC:

(i) Exercise participants (CO/XO/Ops) will review the C3F Marine Mammal Brief, available OPNAV N45 video presentations, and a NOAA brief presented by C3F on marine mammal issues in the Hawaiian Islands.

(ii) Navy will train observers on marine mammal identification observation techniques.

(iii) Third Fleet will brief all participants on marine mammal mitigation requirements.

(iv) Participants will receive video training on marine mammal awareness.

(b) Navy watchstanders, the individuals responsible for detecting marine mammals in the Navy's standard operating procedures, will participate in marine mammal observer training by a NMFS-approved instructor. Training will focus on identification cues and behaviors that will assist in the detection of marine mammals and the recognition of behaviors potentially indicative of injury or stranding. Training will also include information aiding in the avoidance of marine mammals and the safe navigation of the vessel, as well as species identification review (with a focus on beaked whales and other species most susceptible to stranding). At least one individual who has received this training will be present, and on watch, at all times during operation of tactical mid-frequency sonar, on each vessel operating mid-frequency sonar.

(c) All ships and surfaced submarines participating in the RIMPAC ASW exercises will have personnel on lookout with binoculars at all times when the vessel is moving through the water (or operating sonar). These personnel will report the sighting of any marine species, disturbance to the water's surface, or object to the Officer in Command.

(d) All aircraft participating in RIMPAC ASW events will conduct and maintain, whenever possible, surveillance for marine species prior to and during the event. Marine mammal sightings will be immediately reported to ships in the vicinity of the event as appropriate.

(e) Submarine sonar operators will review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active mid-frequency sonar. Marine mammals detected by passive acoustic

(f) Safety Zones - When marine mammals are detected by any means (aircraft, lookout, or acoustically) within 1000 m of the sonar dome (the bow), the ship or submarine will limit active transmission levels to at least 6 dB below normal operating levels. Ships and submarines will continue to limit maximum ping levels by this 6-dB factor until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 2000 m beyond the location of the sighting.

Should a marine mammal be detected within or closing to inside 500 m of the sonar dome, active sonar transmissions will be limited to at least 10 dB below the equipment's normal operating level. Ships and submarines will continue to limit maximum ping levels by this 10-dB factor until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 1500 m beyond the location of the sighting.

Should the marine mammal be detected within or closing to inside 200 m of the sonar dome, active sonar transmissions will cease. Sonar will not resume until the animal has been seen to leave the area, has not been seen for 30 minutes, or the vessel has transited more than 1200 m beyond the location of the sighting.

If the Navy is operating sonar above 235 dB and any of the conditions necessitating a powerdown arise ((f), (g), or (h)), the Navy shall follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first powerdown will be to 229 dB, regardless of at what level above 235 sonar was being operated).

(g) In strong surface ducting conditions defined below), the Navy will enlarge the safety zones such that a 6-dB power down will occur if a marine mammal enters the zone within a 2000 m radius around the source, a 10-dB powerdown will occur if an animal enters the 1000 m zone, and shut down will occur when an animal closes within 500 m of the sound source.

A strong surface duct (half-channel at the surface) is defined as having the all the following factors: (1) A delta SVP between 0.6 to 2.0 m/s occurring within 20 fathoms of the surface with a positive gradient (upward refracting); (2) Sea conditions no greater than Sea State 3 (Beaufort Number 4); and (3) Daytime conditions with no more than 50% overcast (otherwise leading to diurnal warming). This applies only to surface ship mid-frequency active mainframe sonar.

(h) In low visibility conditions (i.e., whenever the entire safety zone cannot be effectively monitored due to nighttime, high sea state, or other factors), the Navy will use additional detection measures, such as infrared (IR) or enhanced passive acoustic detection. If detection of marine mammals is not possible out to the prescribed safety zone, the Navy will power down sonar (per the safety zone criteria above) as if marine mammals are present immediately beyond the extent of detection. (For example, if detection of marine mammals is only possible out to 700 m, the Navy must implement a 6 dB powerdown, as though an animal is present at 701 m, which is inside the 1000 m safety zone)

(i) Helicopters shall observe/survey the vicinity of an ASW exercise for 10 minutes before deploying active (dipping) sonar in the water. Helicopters shall not dip their sonar within 200 yards of a marine mammal and shall cease pinging if a marine mammal closes within 200 yards after pinging has begun.

(j) The Navy will operate sonar at the lowest practicable level, not to exceed 235 dB, except for occasional short periods of time to meet tactical training objectives.

(k) With the exception of three specific choke-point exercises (special measures outlined in item (m)), the Navy will not conduct sonar activities in constricted channels or canyon-like areas.

(l) With the exception of three specific "choke-point" exercises (special measures outlined in item (m)), and events occurring on range areas managed by PMRF, the Navy will not operate mid-frequency sonar within 25 km of the 200 m isobath.

(m) The Navy will conduct no more than three "choke-point" exercises. These exercises will occur in the Kaulakahi Channel (between Kauai and Niihau) and the Alenuihaha Channel (between Maui and Hawaii). These exercises fall outside of the requirements listed above in (k) and (l), i.e., to avoid canyon-like areas and to operate sonar farther than 25 km from the 200 m isobath. The additional measures required for these three choke-point exercises are as follows:

(i) The Navy will provide NMFS (Stranding Coordinator and Protected Resources, Headquarters) and the Hawaii marine patrol with information regarding the time and place for the choke-point exercises 24 hours in advance of the exercises.

(ii) The Navy will have at least one dedicated Navy marine mammal observer who has received the NMFS-approved training mentioned above in (b), on board each ship and conducting observations during the operation of mid-frequency tactical sonar during the choke-point exercises. The Navy has also authorized the presence of two experienced marine mammal observers (non-Navy personnel) to embark on Navy ships for observation during the exercise.

(iii) Prior to start up or restart of sonar, the Navy will ensure that a 2000 m radius around the sound source is clear of marine mammals.

(iv) The Navy will coordinate a focused monitoring effort around the choke-point exercises, to include pre-exercise monitoring (2 hours), during-exercise monitoring, and post-exercise monitoring (1-2 days). This monitoring effort will include at least one dedicated aircraft or one dedicated vessel for realtime monitoring from the pre- through post-monitoring time period, except at night. The vessel or airplane may be operated by either dedicated Navy personnel, or non-Navy scientists contracted by the Navy, who will be in regular communication with a Tactical Officer with the authority to shut-down, power-down, or delay the start-up of sonar operations. These monitors will communicate with this Officer to ensure the 2000 m safety zone is clear prior to sonar start-up, to recommend power-down and shut-down during the exercise, and to extensively search for potentially injured or stranding animals in the area and down-current of the area post-exercise.

(v) The Navy will further contract an experienced cetacean researcher to conduct systematic aerial reconnaissance surveys and observations before, during, and after the choke-point exercises with the intent of closely examining local populations of marine mammals during the RIMPAC exercise.

(vi) Along the Kaulakahi Channel (between Kauai and Niihau), shoreline reconnaissance and nearshore observations will be undertaken by a team of observers located at Kekaha (the approximate mid point of the Channel). Additional observations will be made on a daily basis by range vessels while enroute from Port Allen to the range at PMRF (a distance of approximately 16 nmi) and upon their return at the end of each day's activities. Finally, surveillance of the beach shoreline and nearshore waters bounding PMRF will occur randomly around the clock a minimum four times in each 24 hour period.

(vii) In the Alenuihaha Channel (between Maui and Hawaii), the Navy will conduct shoreline reconnaissance and nearshore observations by a team of observers rotating between Mahukona and Lapakahi before, during, and after the exercise.

(n) The Navy will conduct five exercises in the Pacific Missile Range Facilities that fall within 25 km of the 200 m isobath. The live sonar component of these 5 exercises will total approximately 6.5 hours. During these exercises, the Navy will conduct the monitoring described in (m)(i), (ii), and (iii).

(o) The Navy will continue to coordinate with NMFS on the "Communications and Response Protocol for Stranded Marine Mammal Events During Navy Operations in the Pacific Islands Region" that is currently under preparation by NMFS PIRO to facilitate communication during RIMPAC. The Navy will coordinate with the NMFS Stranding Coordinator for any unusual marine mammal behavior, including stranding, beached live or dead cetacean(s), floating marine mammals, or out-of-habitat/milling live cetaceans that may occur at any time during or shortly after RIMPAC activities. After RIMPAC, NMFS and the Navy (CPF) will prepare a coordinated report on the practicality and effectiveness of the protocol that will be provided to Navy/NMFS leadership.

6. Reporting

The holder of this authorization is required to:

(a) Submit a report to the Division of Permits, Conservation, and Education, Office of Protected Resources, NMFS, and the Pacific Islands Regional Office, NMFS, within 90 days of the completion of RIMPAC. This report must contain and summarize the following information:

(i) An estimate of the number of marine mammals affected by the RIMPAC ASW exercises and a discussion of the nature of the effects, if observed, based on both modeled results of real-time exercises and sightings of marine mammals.

(ii) An assessment of the effectiveness of the mitigation and monitoring measures with recommendations of how to improve them.

(iii) Results of all of the marine species monitoring (real-time Navy monitoring from all platforms, independent aerial monitoring, shore-based monitoring at chokepoints, etc.) before, during, and after the RIMPAC exercises.

(iv) As much information (unclassified and, to appropriately cleared recipients, classified "secret") as the Navy can provide including, but not limited to, where and when sonar was used (including sources not considered in take estimates, such as submarine and aircraft sonars) in relation to any measured received levels (such as at sonobuoys or on PMRF range), source levels, numbers of sources, and frequencies, so it can be coordinated with observed cetacean behaviors.

7. In the event that a stranding occurs during the RIMPAC ASW exercises, NMFS will implement the attached shutdown protocols.

8. A copy of this Authorization must be in the possession of all contractors and marine mammal monitors operating under the authority of this Incidental Harassment Authorization.

James H. Lecky
Director
Office of Protected Resources
National Marine Fisheries Service

JUN 27 2006
Date

Attachment

Pursuant to §101(a)(5)(D)(iv) of the MMPA, The Secretary shall modify, suspend, or revoke an authorization if the Secretary finds that the provisions of clauses (i) or (ii) of §101(a)(5)(D) are not being met. Marine mammal strandings are a common event in Hawaii and over the course of the 22 days of ASW exercises, NMFS expects that 1 or 2 single-animal strandings may occur that are not related to RIMPAC. To distinguish these strandings from a stranding that NMFS believes may occur as a result of exposure to the hull-mounted Mid-Frequency Active Sonar (MFAS) activities covered in this authorization, NMFS and the U.S. Navy have established this "shutdown criteria" to provide the necessary time for the Secretary to investigate the cause of uncommon marine mammal stranding events and determine whether the IHA should be modified, suspended, or revoked. The established protocols in place between NMFS Stranding Coordinator Pacific and COMPACFLT Environmental Coordinator are the basis for this document.

Definitions:

Shutdown area – An area within 50 km of the half of the island centered on the place where the animal was found.

Limited Chokepoint Shutdown – Temporary suspension of the hull-mounted MFAS during the choke point exercises.

Uncommon Stranding Event – An event involving any one of the following:

- Two or more individuals of a commonly stranded species found dead or live beached within a two day period (not including mother/calf pairs), or
- A single uncommonly stranded whale found dead or live beached, or
- A group of 10 or more animals milling out of habitat (e.g. such as occurred with melon headed whales in Hanalei Bay in 2004)

Commonly Stranded Odontocete Species - spinner dolphin, striped dolphin, *Kogia* sp, *Tursiops* sp, melon-headed whale, pilot whale, and sperm whales.

Investigation – consists of the following components and can be conducted within 3 days of notification of a stranding event

- NMFS will undertake a survey around stranding site to search for other stranded/out of habitat animals
- Physical Exam of animal (and blood work if live animals) to investigate and verify presence or absences
    - of impacts on the hearing of live stranded mammals. If feasible and if medical condition of the animal allows, Acoustic Brainstem Response (ABR) and Auditory Evoke Potential (AEP) will be conducted to rapidly assess whether the hearing of a live stranded animal has been affected.
    - of long term illness (based on body condition), life threatening infection, blunt force traumas or fishery interaction that would indicate the likely cause of death
    - of gross lesions or CT/MRI findings that have been documented in previous sonar related strandings (i.e., gas emboli or fat emboli, hemorrhages in organs,

hemorrhage in ears). Note: Care must be taken to control and document the conditions under which the carcass is handled. The investigation of microscopic histology can be compromised by the decomposition, freeze/thaw, transport conditions and subsequent necropsy of the mammal.

- Evaluation of environmental conditions (through remote sensing, modeling and direct observations) preceding and during the stranding or out of habitat event to determine if environmental factors that are known to contribute to such events were in place, such as fronts, swells, particular currents, Kona winds, prey abundance, seismic events, lunar phase, toxins or predators in area. Navy will assist in providing environmental data that is otherwise collected for tactical purposes.
  - Strong evidence of environmental factors that might contribute to stranding event were present
  - Weak to no evidence of environmental factors that might contribute to stranding were present
- Within 72 hours of notification of an Uncommon Stranding Event, Navy will provide information regarding where and what (or where not) the Navy was operating sonar leading up to the stranding.

Shutdown Protocol:

1. NMFS will respond to all reports of marine mammal strandings during the exercise. If a stranding is suspected to be an Uncommon Stranding Event, the NMFS Stranding Coordinator Pacific will immediately notify the COMPACFLT Environmental Coordinator. The Coordinators will utilize existing protocols as amplified by this document to verify whether or not an event constitutes an Uncommon Stranding Event.

2. If an Uncommon Stranding Event is verified, NMFS will inform the Navy and will identify the shutdown area. NMFS will also confirm with Navy the start time and duration of any recent choke-point exercises.

3. The Navy will cease hull-mounted MFAS activities in the shutdown area. Additionally, if the uncommon stranding event occurred during or within 48 hours of the end of a choke point exercise the Navy will invoke the limited choke point shutdown for up to 4 days.

4. NMFS will conduct its investigation and inform the Navy of its findings as soon as possible, but no later than 4 days from the date the Uncommon Stranding Event was verified.

5. If the results of the investigation indicate that the stranding resulted from causes other than activities covered by this authorization NMFS will inform the Navy that exercises authorized by this IHA may resume.

6. If NMFS determines that the Navy's activities authorized under the IHA may have contributed to the uncommon marine mammal stranding event NMFS will advise the Navy whether the IHA should be modified, suspended, or revoked.

Communication

Effective communication is critical to the successful implementation of this protocol.

- NMFS will provide Navy with a list of NMFS staff, empowered to inform the Navy to implement the appropriate shutdown protocol as described above. These individuals will be reachable 24 hours/day for 22 consecutive days (a pre-identified group will be on call in shifts to make these decisions and a phone tree will be available). Week-end on call will be designated for HQ staff by noon on Friday.
- Navy will provide NMFS a list of people empowered to implement the shut down protocol, at least one of whom will be reachable at any hour during the 22 days of ASW exercises prior to the initiation of the exercise

Re: Application for Consistency Determination for Navy Activities Including Mid-Frequency Sonar Training (CD-086-06)

At last Friday's hearing, the Commission directed Commissioner Wan and staff to outline minimum mitigation measures and information requirements for the next two years of Navy sonar training off southern California. To aid in that process, we are providing further detail on the proposals we laid out in our Dec. 13 letter, in which several of the Commissioners expressed interest.

Above all, we think it is critical that the Commission set conditions that are specific and concrete (*e.g.*, specifying the radius of the safety zone to be achieved), since otherwise it will be impossible to ensure that the Navy take any additional steps to protect the California coast.

These measures would apply, of course, only to Navy sonar training off California, not to any operational deployment.

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MITIGATION MEASURES

(1) Safety zones

The Navy shall establish a shut-down safety zone that protects marine mammals from exposure to sound above 154 decibels (EL); or, if that cannot be practicably achieved, the Navy shall cease sonar transmissions should a marine mammal be detected within 2 km of the sonar dome, as currently required by the Navy in its SURTASS LFA sonar operations.

Rationale: According to NMFS, the safety zone presently used in mid-frequency sonar training would allow exposure of marine mammals to 195 dB of sound (NMFS 2006). Clearly, this practice falls far short of preventing exposures to sound greater than 154 dB (EL), as the Commission has required in the past for high-frequency sonar, an apparently less hazardous technology (CD-037-06). Other navies have established a substantially wider safety zone for their mid-frequency sonar exercises. The Royal Australian Navy, for example, requires shut-down whenever a protected species comes within 4 km of the source – a mandate that the U.S. Navy follows while participating in Australian Navy exercises (RAN 2004). We recommend that the Navy employ at least a 2 km shut-down zone, which it uses in its SURTASS LFA sonar operations along the east coast of Asia.

(2) Geographic mitigation

(a) The Navy shall maintain a coastal exclusion zone of 100 nm from the mainland shore, except on the Navy's instrumented range off San Clemente Island.
(b) The Navy shall avoid known gray whale migration corridors during the migration season.
(c) The Navy shall avoid active sonar transmissions within the National Marine Sanctuaries off California's coast (Channel Islands, Monterey Bay, Gulf of the Farallones).
(d) The Navy shall avoid seamounts and coastal areas with complex, steep seabed topography, except on the Navy's instrumented range off San Clemente Island.

Rationale: The Coastal Commission has called avoidance of biologically important areas "the most effective [tool] in preventing harmful effects of noise on marine mammals" (Coastal Commission 2005). Exclusion of sensitive areas has also been endorsed by the IWC Scientific Committee (IWC 2004), other international bodies (*e.g.*, ACCOBAMS 2004), foreign navies (*e.g.*, Government of Spain 2004, RAN 2004), and expert commentators (Barlow and Gisiner 2006) as an essential mitigation measure, particularly due to the known difficulties of real-time monitoring for marine mammals.

The exclusions proposed above would reduce impacts on sensitive marine mammal habitat off California. For example, it appears from several years of NMFS surveys that a coastal exclusion of 100 nm would avoid both areas of high global densities of marine mammals and known feeding habitat of baleen whales, while allowing unmitigated use of the Navy's instrumented range, where more resources are available for monitoring. Avoidance of seamounts (again, with an exception for the Navy's instrumented range) would minimize harm to species such as beaked whales that tend to associate with steeply sloping areas (Baird 2006). **Alternatively, as a secondary option,** the Commission could require additional mitigation, such as reductions in power levels, for sonar use in sensitive areas.

(3) Reduced power levels in higher-risk conditions

(a) During strong surface ducting conditions, as defined by NMFS (2006), the Navy shall power down the sonar source by 6 dB. The Navy shall assess whether surface ducting conditions at least once hourly during periods when both NMFS conditions (b) (conditions no greater than Sea State 3 (Beaufort Number 4)) and (c) (daytime conditions with no more than 50% overcast) are met.

Rationale: Everyone, including the Navy and NMFS (*e.g.*, Commerce and Navy 2001; 71 Fed. Reg. 38720), has recognized that surface ducting conditions increase the risk of environmental damage, both by enlarging the impact zone and, potentially, by altering the sound field in a way that leads to disastrous behavior by beaked whales or other species. For example, during the 2000 mass stranding of whales in the Bahamas, a surface duct caused the Navy's sonar signals to reach above 160 dB (SPL) more than 20 nm away (Commerce and Navy 2001). The most direct way to mitigate harm under these circumstances, aside than avoiding operations entirely, is to reduce source levels to the lowest available power, which for hull-mounted sonar is 10 dB below normal operating levels. According to NMFS, even a 6 dB reduction in source level would reduce the size of the impact area *by 75 percent* (71 Fed. Reg. 20998).

(b) At night and in other low-visibility conditions (*e.g.*, high sea states, thick fog), the Navy shall power down the sonar source by 6 dB.

Rationale: As the Marine Mammal Commission has indicated (MMC 2006), the Navy's current plan (which requires power down if an operator determines that marine mammals cannot be observed within the safety zone) falls short of what is needed to protect marine mammals. Instead, the Commission has recommended that, "given the limitations of night vision devices (based on [NMFS'} assessment in its previous Federal Register notices) and passive acoustic monitoring," the Navy observe a mandatory power-down in low-visibility conditions, assuming it cannot simply avoid them. Again, even a 6 dB reduction in source level would significantly reduce the impact area. According to NMFS, "a 6-dB reduction in ping levels would reduce the range of potential acoustic effects to about half of its original distance… [which], in turn, would reduce to area of acoustic effects to about one quarter of its original size" (71 Fed. Reg. 20998).

(4) Monitoring

(a) The Navy shall post at least two dedicated marine mammal lookouts for choke point exercises, and for any other mid-frequency active sonar training taking place within 12nm of any coast, on all surface ships engaged in those activities.
(b) For all other training activities, the Navy shall post at least one dedicated marine mammal lookout on all surface ships operating mid-frequency active sonar.
(c) In addition to dedicated marine mammal lookouts, the Navy shall maintain three non-dedicated watchstanders on all surface ships operating mid-frequency sonar and shall notify ships that all such watchstanders are required to look out for marine mammals and that all sightings of marine mammals are to be reported to the appropriate watch stations for appropriate action.
(d) The Navy shall ensure that aircraft operating in the Navy's instrumented range off San Clemente will monitor the area for marine mammals during their assigned missions and will monitor the area throughout any mid-frequency sonar exercises on the instrumented range. All other aircraft flying low enough to reasonably spot a marine mammal will watch for marine mammals.

(e) The Navy shall require that all aerial sightings of marine mammals be reported to the appropriate watch stations for appropriate action. Appropriate action means taking mitigation measures and disseminating the information to other units and watchstanders for increased situational awareness.

(f) All personnel engaged in passive acoustic sonar operation during an exercise employing mid-frequency sonar shall monitor for marine mammals and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action.

Rationale: These provisions mirror the monitoring measures used during the Navy's 2006 RIMPAC exercises off Hawaii. *Note*: For further guidance on passive acoustic monitoring on the Navy's Southern California range, we recommend that the Commission confer with John Hildebrand, of Scripps Institution of Oceanography.

(5) Research

(a) The Navy shall conduct research into the feasibility of increasing passive acoustic monitoring for marine mammals within its instrumented range off San Clemente Island and by the use of commercial sonobuoys and other promising methods of passive acoustic detection, and shall report on the results to the Commission.

Rationale: This recommendation is consistent with research already conducted by the Navy at its AUTEC site, in the Bahamas (Jarvis and Moretti 2002), on the PMRF, off Kaua'i (Tiemann et al. 2006), and to some degree in the Southern California operations area (Tiemann et al. undated).

(b) The Navy shall provide the Commission a report on the extent to which simulation training has replaced, and has the potential to further replace, live active sonar training or has reduced, and has the potential to reduce, sonar training in channels and near-shore areas.

Rationale: This recommendation is consistent with the strong emphasis placed, in the Coastal Commission's statement to the Marine Mammal Commission (Coastal Commission 2005), on source reduction: "The agencies should work with the U.S. Navy [and other producers of undersea noise] to prioritize and ensure the development and use of quieter technologies, and other source reduction tools or methods" (p. 25, rec. no. 10; *see also* p. 24, rec. no. 1).

INFORMATION REQUIREMENTS

The Commission should require the Navy to furnish its application for an incidental harassment authorization, which, as of Friday's hearing, had been submitted to but not yet accepted by NMFS. It is clear, however, based on the Navy's prior applications, that its application for major exercises on the Southern California range will not include certain information necessary to the Commission's consistency review. We recommend that the Commission require the Navy to provide the following additional information prior to the January hearing.

(1) Most importantly, the Navy should undertake a supplemental analysis of impacts to marine mammals from its mid-frequency sonar training and provide the Commission with an estimate of the number of marine mammals that will be exposed to levels of 154 dB (EL) or greater, consistent with Commission precedent (CD-037-06).
(2) The Navy should provide the Commission the model or models it uses to estimate impacts to marine mammals from its sonar training exercises, except and only to the extent such models are classified.

References

ACCOBAMS. 2004. Res. 2.16. Adopted at the 2nd Meeting of Parties to the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area (ACCOBAMS), in Majorca, Spain.

Barlow, J., and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management* 7: 239-249.

Coastal Commission. 2005. Statement for the Report of the Advisory Committee on Acoustic Impacts on Marine Mammals, to the Marine Mammal Commission. 28 pp.

Commerce and Navy. 2001. Joint Interim Report: Bahamas Marine Mammal Stranding Event of 15-16 March 2000. Washington: U.S. Department of Commerce. 59 pp.

Government of Spain. 2004. Resolución 79/2004 and Statement of Bono Martinez. Boletín Oficial del Estado 102: 16643-16645.

IWC. 2004. 2004 Report of the Scientific Committee and Annex K.

Jarvis, S., and D. Moretti. 2002. Passive detection and localization of transient signals from marine mammals using widely-spaced bottom-mounted hydrophones in open ocean environments. Pages 109-121 in *Listening to Fish: Passive Acoustic Applications in Marine Fisheries*, Conference Proceedings, MIT, Apr. 8-10, 2002.

MMC. 2006. Comments from Tim Ragen, Acting Executive Director, Marine Mammal Commission, to P. Michael Payne, Chief of the Permits Division, NMFS, on the Navy's 2006 Rim of the Pacific (RIMPAC) Exercise.

NMFS. 2006. Incidental Harassment Authorization for Rim of the Pacific (RIMPAC) 2006 ASW Exercises.

RAN. 2004. Maritime Exercise Areas Environmental Management Plan: Procedure S1 for Operation of Spherion B, Spherion MFS, SQS-56 and Mulloka Hull-Mounted ASW Sonars (Active Mode Only). Adopted June 9, 2004 by Royal Australian Navy.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters, 1998-2000. JNCC Report 323. Joint Nature Conservation Committee: Aberdeen. 43 pp.

Tiemann, C.O., S.W. Martin, and J.R. Mobley, Jr. 2006. *IEEE Journal of Oceanographic Engineering* 31: 107-119.

Tiemann, C.O., M.B. Porter, and J.A. Hildebrand. Undated. Automated model-based localization of marine mammals near California. Available at cetus.uscd.edu/projects/pubs.