GULF of ALASKA

Navy Training Activities

FINAL ENVIRONMENTAL IMPACT STATEMENT/
OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

March 2011
Final EIS/OEIS
Volume Two

Gulf of Alaska Navy Training Activities
Preliminary Final Environmental Impact Statement/
Overseas Environmental Impact Statement

Commander, U.S. Pacific Fleet
Environmental - N01CE1
250 Makalapa Dr., Bldg 251
Pearl Harbor, HI 96860-3131

Appendices A-I
Volume 2

MARCH 2011

Appendix A

Federal Register Notices

TABLE OF CONTENTS

NOTICE OF INTENT TO PREPARE AN ENVIRONMENTAL IMPACT STATEMENT FOR NAVY TRAINING ACTIVITIES IN THE GULF OF ALASKA

ENVIRONMENTAL PROTECTION AGENCY-NOTICE OF AVAILABILITY

NOTICE OF PUBLIC HEARINGS FOR THE DRAFT ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR THE GULF OF ALASKA NAVY TRAINING ACTIVITIES

NOTICE OF PUBLIC HEARINGS FOR THE DRAFT ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR THE GULF OF ALASKA NAVY TRAINING ACTIVITIES; CORRECTION

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Inquiries regarding field Service Record Books/Officer Qualification Records of current members should be addressed to the Commanding Officer of the Marine Corps unit to which they are attached.

Official mailing addresses are published in the Standard Navy Distribution List that is available at *http://doni.daps.dla.mil/sndl.aspx*.

Requests should contain the member's full name, Social Security Number (SSN) (and/or enlisted or officer service number), rank/rate, approximate dates of service, address, and signature of the requester. Transfer or Discharge (DD Form 214), discharge certificate, driver's license, or other data sufficient to ensure that the member is the subject of the record.

Current members (active and reserve) and former members may visit any of the above activities for review of records. Proof of identification will be required and may consist of an individual's active, reserve, or retired identification card, Armed Forces Report of.

RECORD ACCESS PROCEDURES:

Individuals seeking access to records about themselves contained in this system of records should address written requests to the following officials:

Inquiries regarding permanent Official Military Personnel File records of all active duty and reserve members, former members discharged, deceased, or retired after 31 December 1997 should be addressed to the Commandant of the Marine Corps (Code MMSB), Headquarters, U.S. Marine Corps, 2008 Elliot Road, Quantico, VA 22134–5030.

Inquiries regarding field Service Record Books/Officer Qualification Records of reserve members serving in the Individual Ready Reserve should be addressed to the Commanding General, Marine Corps Mobilization Command, 15303 Andrews Road, Kansas City, MO 64147–1207.

Inquiries regarding Official Military Personnel File records of former members discharged, deceased, or retired before 1 January 1998 should be addressed to the Director, National Personnel Records Center, Military Personnel Records, 9700 Page Avenue, St. Louis, MO 63132–5100.

Veterans and relatives of deceased veterans may obtain information on how to obtain copies of records from the National Personnel Records Center Web site at *http://www.archives.gov/st-louis/military-personnel/index.html*.

Inquiries regarding field Service Record Books/Officer Qualification Records of current members should be addressed to the Commanding Officer of the Marine Corps unit to which they are attached.

Official mailing addresses are published in the Standard Navy Distribution List that is available at *http://doni.daps.dla.mil/sndl.aspx*.

Requests should contain the member's full name, Social Security Number (SSN) (and/or enlisted or officer service number), rank/rate, approximate dates of service, address, and signature of the requester.

Current members (active and reserve) and former members may visit any of the above activities for review of records. Proof of identification will be required and may consist of an individual's active, reserve, or retired identification card, Armed Forces Report of Transfer or Discharge (DD Form 214), discharge certificate, driver's license, or other data sufficient to ensure that the member is the subject of the record.

CONTESTING RECORD PROCEDURES:

The USMC rules for contesting contents and appealing initial agency determinations are published in Secretary of the Navy Instruction 5211.5; Marine Corps Order P5211.2; 32 CFR part 701; or may be obtained from the system manager.

RECORD SOURCE CATEGORIES:

Staff agencies and subdivisions of Headquarters, U.S. Marine Corps; Marine Corps commands and organizations; other agencies of federal, state, and local government; medical reports; correspondence from financial and other commercial enterprises; correspondence and records of educational institutions; correspondence of private citizens addressed directly to the Marine Corps or via the U.S. Congress and other agencies; investigations to determine suitability for enlistment, security clearances, and special assignments; investigations related to disciplinary proceedings; and the individual of the record.

EXEMPTIONS CLAIMED FOR THE SYSTEM:

None.

[FR Doc. E8–5349 Filed 3–14–08; 8:45 am]

BILLING CODE 5001–06–P

DEPARTMENT OF DEFENSE

Department of the Navy

Notice of Intent To Prepare an Environmental Impact Statement and Overseas Environmental Impact Statement for Navy Training Activities in the Gulf of Alaska

AGENCY: Department of the Navy, DoD.

ACTION: Notice.

SUMMARY: Pursuant to section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA) as implemented by the Council on Environmental Quality regulations (40 CFR Parts 1500–1508), and Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions), the Department of the Navy (Navy) announces its intent to prepare an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) to evaluate the potential environmental effects of conducting Navy training in and around the Gulf of Alaska (GOA), including participation in large-scale Joint exercises, to support Fleet training exercise requirements. The Navy will invite the U.S. Fish and Wildlife Service and National Marine Fisheries Service to be cooperating agencies in preparation of this EIS/OEIS.

DATES AND ADDRESSES: Three public scoping meetings will be held to receive oral and/or written comments on environmental concerns that should be addressed in the EIS/OEIS. Each of the three scoping meetings will consist of an informal, open house session with information stations staffed by Navy representatives. The public scoping meetings will be held at the following dates, times, and locations:

1. Tuesday, April 1, 2008, 6 p.m. to 9 p.m., at Kodiak Best Western, 236 W. Rezanof Drive, Kodiak, AK 99615,
2. Wednesday, April 2, 2008, 6 p.m. to 9 p.m., at Kincaid Outdoor Center, North Assembly Room, 9401 W. Raspberry Road, Anchorage, AK 99502,
3. Thursday, April 3, 2008, 6 p.m. to 9 p.m., at Mt. Eccles Elementary School, 200 Adams Street, Cordova, AK 99574.

Details of the meeting locations and times will be announced in local newspapers. Additional information concerning meeting times will be available on the EIS/OEIS Web page located at: *http://www.GulfofAlaskaNavyEIS.com*.

FOR FURTHER INFORMATION CONTACT: Mrs. Amy Burt, Naval Facilities Engineering Command, Northwest, 1101 Tautog Circle Suite 203, Silverdale, Washington 98315–1101, Attn: GOA Navy Training Activities EIS/OEIS Project Manager,

Code EV1.AB, telephone number: 360–396–0924.

SUPPLEMENTARY INFORMATION: The proposed EIS/OEIS analyzes potential environmental effects of Navy training activities that will take place in and around the Gulf of Alaska and those aircraft events that originate in the maritime exercise area (MEA) and extend over established inland Alaska military operating areas. Navy training activities primarily take place in, or originate from, the MEA. The MEA provides approximately 42,000 nm^2 (144,056 km^2) of air and surface/subsurface ocean operating area and overlying airspace.

The MEA is a polygon that is oriented from northwest to southeast, approximately 300 nm in length by 150 nm in width, situated south of Prince William Sound and east of Kodiak Island, Alaska. The EIS/OEIS study area includes Gulf of Alaska ocean area within approximately 200 km from the MEA and the waters within this boundary up to the coastline. Military operations also occur over established land-based Military Operating Areas maintained by the Air Force in Alaska.

These Alaska training areas are used to conduct Navy training, including participating in large-scale Joint training exercises such as the annual Northern Edge exercise, involving military hardware, personnel, tactics, munitions, explosives, and electronic combat. Alaska is an ideal location to support naval and joint operational readiness by providing the maritime component to a ''geographically realistic'' range for U.S. Pacific Command (PACOM) and U.S. Northern Command (NORTHCOM) scenario-based training.

The purpose of the Proposed Action is to: (1) Support PACOM and NORTHCOM training requirements; (2) achieve and maintain Fleet readiness using these Alaska training areas to support and conduct current, emerging, and future training activities; (3) accommodate new training requirements associated with the introduction of new weapons and systems to the Fleet; and (4) support civilian authorities in homeland defense training exercises.

The need for the Proposed Action is to: (1) Maintain current levels of military readiness; (2) accommodate future increases in training activities to support Fleet exercise requirements in the Alaska training areas; (3) support the acquisition and implementation into the Fleet of advanced military technology; and (4) maintain the long-term viability of the Alaska training areas as a Navy training area while protecting human health and the environment, and enhancing the quality and the capabilities of the training area, including safety.

The No Action Alternative is the continuation of current training levels, with one carrier strike group per exercise, to exclude the use of mid-frequency active sonar (MFAS). Alternative 1 consists of an increase in the number of training activities from baseline levels, to include the use of MFAS, plus training associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2 consists of all elements of Alternative 1, plus the addition of a second summertime carrier strike group exercise each year, to include the use of MFAS.

Environmental issues that will be addressed in the EIS/OEIS include but are not limited to the following: Air quality; airspace; biological resources, including threatened and endangered species; cultural resources; geology and soils; hazardous materials and waste; health and safety; noise; socioeconomics; transportation and water resources.

The Navy is initiating the scoping process to identify community concerns and local issues that will be addressed in the EIS/OEIS. Federal, state, and local agencies, Alaska Native Federally-Recognized Tribes, the public, and interested persons are encouraged to provide oral and/or written comments to the Navy to identify specific environmental issues or topics of environmental concern that the commenter believes the Navy should consider. All comments, written or provided orally at the scoping meetings, will receive the same consideration during EIS/OEIS preparation.

Written comments on the scope of the EIS/OEIS should be postmarked no later than April 30, 2008. Comments may be mailed to: Mrs. Amy Burt, Naval Facilities Engineering Command, Northwest, 1101 Tautog Circle, Suite 203, Silverdale, Washington 98315–1101, Attn: GOA Navy Training Activities EIS/OEIS Project Manager, Code EV1.AB. Comments can also be submitted via the EIS/OEIS Web page located at *http://www.GulfofAlaskaNavyEIS.com*.

Dated: March 11, 2008.

T.M. Cruz,

Lieutenant, Judge Advocate General's Corps, U.S. Navy, Federal Register Liaison Officer.

[FR Doc. E8–5316 Filed 3–14–08; 8:45 am]

BILLING CODE 3810–FF–P

DEPARTMENT OF ENERGY

Agency Information Collection Extension

AGENCY: U.S. Department of Energy.

ACTION: Notice and Request for Comments.

SUMMARY: The Department of Energy (DOE), pursuant to the Paperwork Reduction Act of 1995, intends to extend for three years, an information collection package with the Office of Management and Budget (OMB) concerning *Collection of Human Resource information from major DOE contractors for contract management, administration, and cost control.* Comments are invited on:

(a) Whether the extended collection of information is necessary for the proper performance of the functions of the agency, including whether the information shall have practical utility;

(b) The accuracy of the agency's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used;

(c) Ways to enhance the quality, utility, and clarity of the information to be collected; and

(d) Ways to minimize the burden of the collection of information on respondents, including through the use of automated collection techniques or other forms of information technology.

DATES: Comments regarding this proposed information collection must be received on or before May 16, 2008. If you anticipate difficulty in submitting comments within that period, contact the person listed below as soon as possible.

ADDRESSES: Written comments may be sent to: Robert M. Myers, U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585–1615, 202–287–1584, or by fax at 202–287–1656 or by e-mail at *robert.myers@hq.doe.gov.*

FOR FURTHER INFORMATION CONTACT: Requests for additional information or copies of the information collection instrument and instructions should be directed to Robert Myers at the address listed above.

SUPPLEMENTARY INFORMATION: This package contains:

(1) *OMB No.* 1910–0600;

(2) *Package Title:* Industrial Relations;

(3) *Type of Review:* Renewal;

(4) *Purpose:* This information is required for management oversight for the Department of Energy's Facilities Management Contractors and to ensure that the programmatic and

Approximately 400 Acres, Currently Operated by Los Angeles Harbor Department (LAHD), Located along the West Side of Los Angeles Harbor's Main Channel, from the Vincent Thomas Bridge to Cabrillo Beach, US Army Section 10 and 404 and Section 103 Marine Protection, Research, and Sanctuaries Act Permits, (MPRSA) City of Los Angeles, CA.

Summary: EPA continues to have concerns about the unavoidable air quality impacts to environmental justice communities.

EIS No. 20090335, ERP No. F–AFS–K65341–AZ, Black River Exchange Project, Proposal to Exchange Federal and Non-Federal Lands, Apache-Sitgreaves National Forests, Apache County, AZ.

Summary: EPA does not object to the proposed project.

EIS No. 20090347, ERP No. F–AFS–J65512–MT, Butte Lookout Project, Proposed Timber Harvest, Prescribed Burning, Road Work and Management Activities, Missoula Ranger District, Lola National Forest, Missoula County, MT.

Summary: EPA continues to have environmental concerns because significant portions of the proposed rehabilitative and restorative work are not currently funded. EPA encouraged timely funding of the remainder of the proposed rehabilitative and restorative work.

EIS No. 20090351, ERP No. F–AFS–J65503–WY, Thunder Basin National Grassland Prairie Dog Management Strategy, Land and Resource Management Plan Amendment #3, Proposes to Implement a Site-Specific Strategy to Manage Black Trailed Prairie Dog, Douglas Ranger District, Medicine Bow-Routt National Forests and Thunder Basin National Grassland, Campbell, Converse, Niobrara and Weston Counties, WY.

Summary: EPA continues to have environmental concerns About impacts to black-footed ferret habitat.

EIS No. 20090354, ERP No. F–USN–K11023–00, West Coast Basing of the MV–22 Determining Basing Location(s) and Providing Efficient Training Operations, CA, AZ.

Summary: EPA expressed environmental concerns about project-related noise impacts.

EIS No. 20090355, ERP No. F–AFS–K65361–CA, Thom-Seider Vegetation Management and Fuels Reduction Project, To Respond to the Increasing Density and Fuels Hazard Evident along the Klamath River between Hamburg and Happy Camp, Klamath National Forest, Siskiyou County, CA.

Summary: EPA does not object to the proposed project.

EIS No. 20090357, ERP No. F–NPS–H65028–MO, Jefferson National Expansion Memorial, General Management Plan, Implementation, St. Louis, MO.

Summary: EPA does not object to the proposed project.

EIS No. 20090359, ERP No. F–FHW–H40194–MO, MO–63 Corridor Improvement Project, To Correct Roadway Deficiencies, Reduce Congestion and Provide Continuity along the MO–63 Corridor on the Existing Roadway and on New Location, Osage, Maries and Phelps Counties, MO.

Summary: EPA continues to have environmental concerns about stream and wetland impacts, and requested additional mitigation.

EIS No. 20090361, ERP No. F–NOA–A91073–00, Programmatic—Toward an Ecosystem Approach for the Western Pacific Region: From Species-Based Fishery Management Plans to Place-Based Fishery Ecosystem Plans, Bottomfish and Seamount Groundfish, Coral Reef Ecosystems, Crustaceans, Precious Corals, Pelagics, Implementation, American Samoa, Commonwealth of the Northern Mariana Islands, Hawaii, U.S. Pacific Remote Island Area.

Summary: No formal comment letter sent to the preparing agency.

Dated: December 12, 2009.

Robert W. Hargrove,

Director, NEPA Compliance Division, Office of Federal Activities.

[FR Doc. E9–29561 Filed 12–10–09; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[ER–FRL–8986–4]

Environmental Impacts Statements; Notice of Availability

Responsible Agency: Office of Federal Activities, General Information (202) 564–1399 or *http://www.epa.gov/compliance/nepa/.*

Weekly receipt of Environmental Impact Statements.

Filed 11/30/2009 Through 12/04/2009.

Pursuant to 40 CFR 1506.9.

EIS No. 20090413, Final EIS, USFS, NV, Martin Basin Rangeland Project, Reauthorizing Grazing on Eight Existing Cattle and Horse Allotments: Bradshaw, Buffalo, Buttermilk, Granite Peak, Indian, Martin Basin, Rebel Creek, and West Side Flat Creek, Santa Rosa Ranger District, Humboldt-Toiyabe National Forest, NV, Wait Period Ends: 01/11/2010, Contact: Vernon Keller 775–355–5056.

EIS No. 20090414, Draft EIS, USFS, UT, Tropic to Hatch 138kV Transmission Line Project, Proposing Construction of a new 138 kV transmission Line that would replace some or all the existing 69 kV Transmission Line, Applications for Special-Use Permits and/or Right-of-Way Grants, Grand Staircase-Escalante National Monument Management Plan Amendment, Garfield County, UT, Comment Period Ends: 03/10/2010, Contact: Susan Baughman 435–865–3703.

EIS No. 20090415, Final EIS, FHWA, MI, Detroit Intermodal Freight Terminal (DIFT) Project, Proposes Improvement to Intermodal Freight Terminals in Wayne and Oakland Counties, MI, Wait Period Ends: 01/11/2010, Contact: David T. Williams 517–702–1820.

EIS No. 20090416, Final EIS, USMC, NC, U.S. Marine Corps Grow the Force at MCB Camp Lejeune, MCAS New River, and MCAS Cherry Point, To Provide the Infrastructure to Support the Permanent Increases at these three Installation, US Army Corps Section 404 and 10 Permits, City of Jacksonville, NC, Wait Period Ends: 01/11/2010, Contact: Michael H. Jones 757–322–4942.

EIS No. 20090417, Final EIS, NOAA, 00, Comprehensive Ecosystem-Base Amendment 1 (CE–BA 1) for the South Atlantic Region, Implementation, Wait Period Ends: 01/11/2010, Contact: Roy E. Crabtree, PhD 727–824–5305

EIS No. 20090418, Draft EIS, USACE, NC, The Town of Nags Head Beach Nourishment Project, Propose to Utilize a Self-Contained Hooper Dredge and Other Feasible Dredging Equipment during a Proposed Construction Window from April through September, Dare County, NC, Comment Period Ends: 01/25/2010, Contact: Raleigh Bland 910–251–4564.

EIS No. 20090419, Draft EIS, USACE, MN, U.S. Steel Keetac Taconite Mine Expansion Project, Propose to Restart an Idled Production Line and Expand Contiguous Sections of the Open Pit Iron Ore Mine, located near Keewatin, Itasca and St. Louis Counties, MN, Comment Period Ends: 01/27/2010, Contact: Ralph Augustin 651–290–5378.

EIS No. 20090420, Final EIS, FHWA, IN, I–69 Evansville to Indianapolis, Indiana Project, Section 3, Washington to Crane NSWC (US 50 to US 231), Daviess, Greene, Knox and Martin Counties, IN, Wait Period Ends: 01/11/2010, Contact: Janice Osadczuk 317–226–7486.

EIS No. 20090421, Draft Supplement, NRC, WY, Moore Ranch In-Situ Uranium Recovery (ISR) Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission an In-Situ Recovery (ISR) Facility, NUREG–1910, Campbell County, WY, Comment Period Ends: 02/01/2010, Contact: Behram Shroff 301–415–0666.

EIS No. 20090422, Final EIS, BR, KS, Equus Beds Aquifer Storage Recharge and Recovery Project, To Provide Municipal and Industrial (M&I) Water to City and Surrounding Region, Equus Beds Division, Wichita Project, Kansas, Harvey, Sedgwick, and Reno Counties, KS, Wait Period Ends: 01/11/2010, Contact: Charles F. Webster 405–470–4831.

EIS No. 20090423, Second Draft Supplement, NRC, WY, Nichols Ranch In-Situ Uranium Recovery (ISR) Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission and In-Situ Recovery Uranium Milling Facility, Campbell and Johnson Counties, WY, Comment Period Ends: 02/01/2010, Contact: Irene Yu 301–415–1951.

EIS No. 20090424, Draft EIS, USN, AK, Gulf of Alaska Navy Training Activities, Proposal to Support and Conduct Current, Emering, and Future Training Activities, Implementation, Gulf of Alaska, AK, Comment Period Ends: 01/25/2010, Contact: Amy Burt 360–396–9024.

EIS No. 20090425, Third Draft Supplement, NRC, WY, Lost Creek In-Situ Uranium Recovery (ISR) Project, Proposal to Construct, Operate, Conduit Aquifer Restoration, and Decommission an In-Situ Recovery (ISR) Uranium Milling Facility, Sweetwater County, WY, Comment Period Ends: 02/01/2010, Contact: Alan B. Bjornsen 301–415–1195.

EIS No. 20090426, Draft EIS, FRA, VA, Richmond and the Hampton Roads Passenger Rail Project, Proposed Higher Speed Intercity Passenger Rail, VA, Comment Period Ends: 01/25/2010, Contact: John Winkle 202–493–6067.

EIS No. 20090427, Final EIS, NPS, MN, Disposition of Bureau of Mines Property, Twin Cities Research Center Main Campus, Implementation, Hennepin County, MN, Wait Period Ends: 01/11/2010, Contact: Steven P. Johnson 651–290–3030 Ext. 223.

Amended Notices

EIS No. 20090312, Draft EIS, USACE, OH, Cleveland Harbor Dredged Material Management Plan, Operations and Maintenance, Cuyahoga County, OH, Comment Period Ends: 02/01/2010, Contact: Frank O'Connor 716–879–4131. Revision to FR Notice Published 09/11/2009: Extending Comment Period from 12/07/2009 to 02/01/2010.

EIS No. 20090394, Draft EIS, USN, GU, Guam and Commonwealth of the Northern Mariana Islands (CNMI) Military Relocation, Proposed Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force, Implementation, GU, Comment Period Ends: 02/17/2010, Contact: Kyle Fujimoto 808–472–1442. Revision to FR Notice Published 11/20/2009: Disregard the FR Notice of 11/28/2009: Correction to Comment Period from 01/04/2010 to 02/17/2010.

Dated: 12/08/2009.

Robert W. Hargrove,

Director, NEPA Compliance Division, Office of Federal Activities.

[FR Doc. E9–29562 Filed 12–10–09; 8:45 am]

BILLING CODE 6560–50–P

ENVIRONMENTAL PROTECTION AGENCY

[FRL–9090–1]

Issuance of a Final NPDES General Permit (GP) for Offshore Seafood Processors Discharging in Federal Waters Off the Alaska Shore (Permit Number AKG–524–000)

AGENCY: Environmental Protection Agency (EPA).

ACTION: Issuance of Final NPDES General Permit.

SUMMARY: On September 26, 2008, the Director, Office of Water and Watersheds, EPA Region 10, proposed to issue a general permit to cover offshore seafood processors discharging seafood processing waste off the shore of Alaska. During the 76-day comment period, EPA received comments from 11 people and has prepared a Response to Comments document to explain changes made in the permit and reasons for not making changes that were requested.

DATES: The permit will become effective March 1, 2010 and will expire February 28, 2015. The permit issuance date is December 28, 2009.

ADDRESSES: Copies of the General Permit and the Response to Comments may be requested from Audrey Washington, EPA Region 10, 1200 Sixth Avenue, Suite 900, OWW–130, Seattle, WA 98101–3140, by phone at (206) 553–0523, or by e-mail: *washington.audrey@epa.gov.*

FOR FURTHER INFORMATION CONTACT: Copies of the general permit and response to comments are available on the EPA Region 10 Web site at *http://yosemite.epa.gov/R10/WATER.NSF/NPDES+Permits/General+NPDES+Permits.*

SUPPLEMENTARY INFORMATION

A. Endangered Species Act

Section 7 of the Endangered Species Act requires EPA to consult with the U.S. Fish and Wildlife Service and National Marine Fisheries Service regarding the potential effects that an action may have on listed endangered or threatened species or their critical habitat. To address these ESA requirements, and in support of EPA's informal consultation with the Services, a Biological Evaluation (BE) was prepared to analyze these potential effects. The results of the BE concluded that discharges from Offshore Seafood Processing facilities will either have no effect or are not likely to adversely affect threatened or endangered species, their critical habitat, or essential fish habitat in the vicinity of the discharge. After reviewing the BE and permit the Services concurred with EPA's findings.

B. Executive Order 12866

The Office of Management and Budget has exempted this action from the review requirements of Executive Order 12866 pursuant to Section 6 of that order.

C. Paperwork Reduction Act

The information collection requirements of this permit were previously approved by the Office of Management and Budget (OMB) under the provisions of the Paperwork Reduction Act, 44 U.S.C. 3501 *et seq.* and assigned OMB control numbers 2040–0086 (NPDES permit application) and 2040–0004 (discharge monitoring reports).

D. Unfunded Mandates Reform Act

Section 201 of the Unfunded Mandates Reform Act (UMRA), Public Law 104–4, generally requires federal agencies to assess the effects of their ''regulatory actions'' (defined to be the same as ''rules'' subject to the RFA) on tribal, state, and local governments and the private sector. However, general

currently developed. The project proposes to develop approximately 1,870 acres, and set aside 1,274 acres of wetland preserve/open space. The proposed action includes approximately 584 acres of commercial uses associated with the adjacent Mather Airport, 201 acres of commercial, 84 acres of aggregate extraction, 598 acres of university village/residential, 102 acres of parks and recreation, 274 acres for a regional sports park, and 27.4 acres for utilities and infrastructure. Approximately 124 acres of waters of the United States have been identified in the proposed project area, including 69.8 acres of vernal wetlands (pools and swales), 27.3 acres of depressional seasonal wetlands, 1.9 acres of ditches, 5.7 acres of lake/pond and 19.1 acres of other waters of the United States. The applicant has applied for permits to fill 35.39 acres of these waters. The approximately 1,274 acre open space and wetland preserve would contain approximately 47.3 acres of waters not directly impacted by the project. In addition, approximately 4.9 acres of wetlands at the west end of the Mather Airport runway would be avoided and placed under some type of protective agreement, but not a conservation easement.

The EIS will include an evaluation of a reasonable range of alternatives. Currently, at least four alternatives are expected to be analyzed in detail: (1) The no action alternative (no permit issued), (2) the applicant's preferred project (proposed action), (3) an offsite alternative, and (4) a reduced development footprint alternative. The no action alternative assumes limited development would occur in the Mather Specific Plan area with all waters of the United States avoided. The off-site alternative assumes the proposed project would be developed at a different but suitably-sized site in the region. A reduced development footprint alternative will have a smaller development footprint than the applicant's preferred project with less direct impacts to waters of the United States.

The Corps' scoping process for the EIS includes a public involvement program with several opportunities to provide oral and written comments. In addition to public meetings and notifications in the **Federal Register**, the Corps will issue public notices when the draft and final EISs are available. Affected Federal, State, and local agencies, Native American tribes, and other interested organizations and parties are invited to participate.

Potentially significant issues to be analyzed in the EIS include, but are not limited to: Hydrology, water supply, water quality, cultural resources, biological resources, traffic and transportation, and air quality.

The Corps is the lead agency for preparation of the EIS under the requirements of the National Environmental Policy Act (NEPA). The Corps will coordinate with the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service and Central Valley Regional Water Quality Control Board.

Other environmental review and consultation requirements for the proposed action include the need for the applicant to obtain water quality certification under Section 401 of the Clean Water Act from the Central Valley Regional Water Quality Control Board. In addition, because the proposed project may affect federally-listed endangered species, the Corps will formally consult with the U.S. Fish and Wildlife Service in accordance with Section 7 of the federal Endangered Species Act. The Corps will also be consulting with the State Historic Preservation Officer under Section 106 of the National Historic Preservation Act concerning properties listed, or potentially eligible for listing, on the National Register of Historic Places.

One public scoping meeting for the EIS will be held on January 6, from 4 p.m. to 7 p.m. Conference Room 170 located at 10545 Armstrong Avenue, Mather CA, 95655. Interested parties can provide oral and written comments at the meeting. Interested parties may also submit written comments on this notice. Scoping comments should be submitted before January 31, 2010, but may be submitted at any time prior to publication of the Draft EIS.

Interested parties may register for the Corps' public notice email notification lists at: *http://www.spk.usace.army.mil/organizations/cespk-co/regulatory/pnlist.html.*

Dated: November 30, 2009.

Thomas C. Chapman,

Colonel, Corps of Engineers, District Engineer.

[FR Doc. E9–29603 Filed 12–10–09; 8:45 am]

BILLING CODE 3720–58–P

DEPARTMENT OF DEFENSE

Department of the Navy

Notice of Public Hearings for the Draft Environmental Impact Statement/ Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities

AGENCY: Department of the Navy, DoD.

ACTION: Notice.

SUMMARY: Pursuant to section 102(2)(c) of the National Environmental Policy Act (NEPA); the Council on Environmental Quality Regulations for implementing the procedural provisions of NEPA (Title 40 Code of Federal Regulations Parts 1500–1508); and Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, the Department of the Navy (Navy) has prepared and filed with the U.S. Environmental Protection Agency a Draft Environmental Impact Statement/ Overseas Environmental Impact Statement (EIS/OEIS) for public release on December 11, 2009. The National Marine Fisheries Service (NMFS) is a Cooperating Agency for the EIS/OEIS.

The Draft EIS/OEIS evaluates the potential environmental effects of the Proposed Action from Navy training activities conducted in the Gulf of Alaska and Alaska's inland training areas, collectively referred to as the Alaska Training Areas (ATA). The Draft EIS/OEIS addresses ongoing and proposed military training activities, as well as proposed force structure changes and the introduction of new weapons and systems to the Fleet. The Proposed Action serves to achieve and maintain Fleet readiness using the ATA to support and conduct current, emerging, and future training activities. A Notice of Intent for this Draft EIS/OEIS was published in the **Federal Register** on March 17, 2008 (73 FR 14237).

The Navy will conduct five public hearings to receive oral and written comments on the Draft EIS/OEIS. Federal, State, and local agencies, elected officials, and other interested individuals and organizations are invited to be present or represented at the public hearings. This notice announces the dates and locations of the public hearings for this Draft EIS/OEIS.

An open house session will precede the scheduled public hearing at each of the locations listed below, and will allow individuals to review the information presented in the Draft EIS/ OEIS. Navy representatives will be available during the open house sessions to clarify information related to the Draft EIS/OEIS.

Dates and Addresses: Five public hearings will be held in Alaska to receive oral and written comments on the Draft EIS/OEIS. All meetings will start with an open house session from 5 p.m. to 7 p.m., followed by a presentation and formal public comment period from 7 p.m. to 8:30 p.m. Public hearings will be held on the following dates and at the following locations:

1. Thursday, January 7, 2010, at Kodiak High School Cafeteria, 722 Mill Bay Road, Kodiak, Alaska;

2. Friday, January 8, 2010, at Fairview Recreation Center Main Gymnasium, 1121 E. 10th Avenue, Anchorage, Alaska;

3. Saturday, January 9, 2010, at West Homer Elementary School Gymnasium, 995 Soundview Avenue, Homer, Alaska;

4. Monday, January 11, 2010, at Juneau Arts and Culture Center Main Hall, 350 Whittier Street, Juneau, Alaska;

5. Tuesday, February 12, 2010, at Orca Adventure Lodge Meeting Room & Café, 2500 Orca Road, Cordova, Alaska.

FOR FURTHER INFORMATION CONTACT: Naval Facilities Engineering Command Northwest, Attention: Mrs. Amy Burt, Gulf of Alaska Navy Training Activities EIS/OEIS Project Manager, 1101 Tautog Circle, Suite 203, Silverdale, WA 98315–1101; or *http://www.GulfofAlaskaNavyEIS.com.*

SUPPLEMENTARY INFORMATION: Air and sea training activities are conducted within the Gulf of Alaska Temporary Maritime Activities Area (TMAA) which is part of the ATA. The land, air, and sea components of the ATA provide the space and resources needed to realistically train Navy Sailors to achieve and maintain Fleet readiness. Navy air and sea training activities originate from Navy ships located within the TMAA. The TMAA is situated south of Prince William Sound and east of Kodiak Island and includes 42,146 square nautical miles of airspace, sea space, and undersea space. The Navy also conducts activities in established U.S. Air Force and U.S. Army inland training areas, which include more than 65,000 square miles of airspace and land area. The ATA serve as the principal training venue for annual joint training exercises, which can involve forces from the U.S. Navy, Air Force, Army, Coast Guard, and local, state, and nongovernmental agencies. The ATA are used for training activities including operating aircraft, ships, and submarines; conducting training against moving ships and aircraft; practicing aerial surveillance; and detecting and locating submarines.

The purpose of the Navy's Proposed Action is to: Achieve and maintain Fleet readiness using the ATA to support and conduct current, emerging, and future training activities.

The need for the Proposed Action is to: (1) Maintain current levels of military readiness by training in the ATA; (2) accommodate future increases in levels of training activities in the ATA; (3) adequately support the training need for new aircraft, ships, submarines, and weapons systems; (4) identify shortfalls in training, particularly training instrumentation, and address through enhancements; (5) maintain the long-term viability of the ATA as a Navy training area while protecting human health and the environment, and enhancing the quality, capabilities, and safety of the training area; and (6) be able to bring U.S. Army, Navy, Air Force, and Coast Guard assets together into one geographic area for joint training.

Under the No Action Alternative, training activities within the ATA would continue at current levels over a maximum time frame of 14 days. This alternative includes one annual Carrier Strike Group training exercise and excludes the use of mid-frequency active sonar. Alternative 1 proposes an increase in the number of training activities from current levels as necessary to support Fleet exercise requirements over a maximum time frame of 21 days in the summer months (April—October), to include the use of active sonar; and accommodates training enhancement instrumentation, including the use of a Portable Undersea Tracking Range, and force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2, the Preferred Alternative, consists of all elements of Alternative 1. In addition, Alternative 2 includes an increase in the number of training activities over Alternative 1 levels by conducting a second annual Carrier Strike Group training exercise, which could also last up to 21 days in the summer months, and conducting a Sinking Exercise during each summertime exercise (a maximum of two).

The Draft EIS/OEIS addresses potential environmental impacts on multiple resources, including but not limited to: Air quality; water resources; biological resources; cultural resources; socioeconomics; and public health and safety.

No significant impacts are identified for most resources within the ATA that cannot be mitigated. The results of the analysis indicate, however, that while there is the possibility for physiological effects and altered behavior from sound in the water from active sonar and explosives, no mortality to marine mammals is anticipated. Furthermore, the estimation of sound exposures does not consider the Navy's use of protective measures, which would reduce the likelihood of exposures at the highest sound levels. The Navy has requested from NMFS a Letter of Authorization (LOA) in accordance with the Marine Mammal Protection Act to authorize the incidental take of marine mammals that may result from the implementation of the activities analyzed in the Gulf of Alaska Navy Training Activities Draft EIS/OEIS.

In accordance with Section 7 of the Endangered Species Act, the Navy is consulting with NMFS and U.S. Fish and Wildlife Service (USFWS) for potential impacts to federally listed species. Navy analysis has indicated that under the Clean Air Act requirements, while emissions over current levels may occur, these emissions would not exceed air quality standards, and under the Clean Water Act there would be no significant impacts to water quality. Analysis under the National Historic Preservation Act, in addition to other applicable laws and regulations, indicates that no significant impacts to cultural resources would occur if the Proposed Action or alternatives were implemented. Implementation of the Proposed Action or alternatives would not result in a significant adverse effect on the population of a migratory bird and fish species.

The decision to be made by the Navy is to determine which of the alternatives analyzed in the EIS/OEIS best meet the operational needs of the Navy given that all reasonably foreseeable environmental impacts have been considered.

The Draft EIS/OEIS was distributed to Federal, State, and local agencies, elected officials, and other interested individuals and organizations. The public comment period will end on January 25, 2010. Copies of the Draft EIS/OEIS are available for public review at the following libraries: Z.J. Loussac Library, Government Documents, 3600 Denali Street, Anchorage, AK; Alaska State Library, Government Documents, 333 Willoughby Avenue, 8th Floor, Juneau, AK; A. Holmes Johnson Memorial Library, 319 Lower Mill Bay Road, Kodiak, AK; University of Alaska Fairbanks, Rasmussen Library, Government Documents, 310 Tanana Loop, Fairbanks, AK; Cordova Public Library, 622 First Street, Cordova, AK; Copper Valley Community Library, Mile 186 Glenn Highway, Glennallen, AK; Seward Community Library, 238 5th Avenue, Seward, AK; Homer Public Library, 500 Hazel Avenue, Homer, AK.

The Gulf of Alaska Navy Training Activities Draft EIS/OEIS is also available for electronic public viewing at: *http://www.GulfofAlaskaNavyEIS.com.* A paper copy of the Executive Summary or a single CD with the Draft EIS/OEIS

will be made available upon written request by contacting Naval Facilities Engineering Command Northwest, Attention: Mrs. Amy Burt, Gulf of Alaska Navy Training Activities EIS/OEIS Project Manager, 1101 Tautog Circle, Suite 203, Silverdale, WA 98315–1101.

Federal, State, and local agencies, elected officials, and interested individuals and organizations are invited to be present or represented at the public hearing. Written comments can also be submitted during the open house sessions preceding the public hearings.

Oral statements will be heard and transcribed by a stenographer; however, to ensure the accuracy of the record, all statements should be submitted in writing. All statements, both oral and written, will become part of the public record on the Draft EIS/OEIS and will be responded to in the Final EIS/OEIS. Equal weight will be given to both oral and written statements. In the interest of available time, and to ensure all who wish to give an oral statement have the opportunity to do so, each speaker's comments will be limited to three (3) minutes. If you have prepared a written statement, you may read it out loud if you can do so within the three minute time limit, or you may turn it in at the public hearing or mail the statement to Naval Facilities Engineering Command Northwest, Attention: Mrs. Amy Burt, Gulf of Alaska Navy Training Activities EIS/OEIS Project Manager, 1101 Tautog Circle, Suite 203, Silverdale, WA 98315–1101. In addition, comments may be submitted online at *http://www.GulfofAlaskNavyEIS.com* during the comment period. All written comments must be postmarked by January 25, 2010, to ensure they become part of the official record. All comments will be addressed in the Final EIS/OEIS.

Dated: December 7, 2009.

A.M. Vallandingham,

Lieutenant Commander, Office of the Judge Advocate General, U.S. Navy, Federal Register Liaison Officer.

[FR Doc. E9–29565 Filed 12–10–09; 8:45 am]

BILLING CODE 3810–FF–P

DEPARTMENT OF DEFENSE

Defense Acquisition Regulations System

Waiver of 10 U.S.C. 2534 for Certain Defense Items Produced in the United Kingdom

AGENCY: Defense Acquisition Regulations System, Department of Defense (DoD).

ACTION: Notice of waiver of 10 U.S.C. 2534 for certain defense items produced in the United Kingdom.

SUMMARY: The Under Secretary of Defense (Acquisition, Technology, and Logistics) is waiving the limitation of 10 U.S.C. 2534 for certain defense items produced in the United Kingdom (UK). 10 U.S.C. 2534 limits DoD procurement of certain items to sources in the national technology and industrial base. The waiver will permit procurement of enumerated items from sources in the UK, unless otherwise restricted by statute.

DATES: *Effective Date:* This waiver is effective for one year, beginning December 28, 2009.

FOR FURTHER INFORMATION CONTACT: Ms. Patricia Foley, OUSD(AT&L), Office of the Director of Defense Procurement and Acquisition Policy, Contract Policy and International Contracting, Room 5E621, 3060 Defense Pentagon, Washington, DC 20301–3060, telephone (703) 693–1145.

SUPPLEMENTARY INFORMATION: Subsection (a) of 10 U.S.C. 2534 provides that the Secretary of Defense may procure the items listed in that subsection only if the manufacturer of the item is part of the national technology and industrial base. Subsection (i) of 10 U.S.C. 2534 authorizes the Secretary of Defense to exercise the waiver authority in subsection (d), on the basis of the applicability of paragraph (2) or (3) of that subsection, only if the waiver is made for a particular item listed in subsection (a) and for a particular foreign country. Subsection (d) authorizes a waiver if the Secretary determines that application of the limitation ''would impede the reciprocal procurement of defense items under a memorandum of understanding providing for reciprocal procurement of defense items'' and if he determines that ''that country does not discriminate against defense items produced in the United States to a greater degree than the United States discriminates against defense items produced in that country.'' The Secretary of Defense has delegated the waiver authority of 10 U.S.C. 2534(d) to the Under Secretary of Defense (Acquisition, Technology, and Logistics).

DoD has had a Reciprocal Defense Procurement Memorandum of Understanding (MOU) with the UK since 1975, most recently renewed on December 16, 2004.

The Under Secretary of Defense (Acquisition, Technology, and Logistics) finds that the UK does not discriminate against defense items produced in the United States to a greater degree than the United States discriminates against defense items produced in the UK, and also finds that application of the limitation in 10 U.S.C. 2534 against defense items produced in the UK would impede the reciprocal procurement of defense items under the MOU.

Under the authority of 10 U.S.C. 2534, the Under Secretary of Defense (Acquisition, Technology, and Logistics) has determined that application of the limitation of 10 U.S.C. 2534(a) to the procurement of any defense item produced in the UK that is listed below would impede the reciprocal procurement of defense items under the MOU with the UK.

On the basis of the foregoing, the Under Secretary of Defense (Acquisition, Technology, and Logistics) is waiving the limitation in 10 U.S.C. 2534(a) for procurements of any defense item listed below that is produced in the UK. This waiver applies only to the limitations in 10 U.S.C. 2534(a). It does not apply to any other limitation, including section 8018 of the DoD Appropriations Act for Fiscal Year 2009 (Pub. L. 110–329). This waiver applies to procurements under solicitations issued during the period from December 28, 2009, to December 27, 2010 Similar waivers have been granted since 1998, most recently in 2008 (73 FR 73257, December 2, 2008).

List of Items to Which This Waiver Applies

1. Air circuit breakers.
2. Welded shipboard anchor and mooring chain with a diameter of four inches or less.
3. Gyrocompasses.
4. Electronic navigation chart systems.
5. Steering controls.
6. Pumps.
7. Propulsion and machinery control systems.
8. Totally enclosed lifeboats.

Amy G. Williams,

Editor, Defense Acquisition Regulations System.

[FR Doc. E9–29568 Filed 12–10–09; 8:45 am]

BILLING CODE 5001–08–P

the northern section of the Bay where pinniped and cetacean species are more abundant. Based on these previous NEPA analyses and the analysis contained within this notice, NMFS has determined that issuance of a one-year IHA to Caltrans for the taking, by Level B harassment only, incidental to the Antioch Bridge Seismic Retrofit project does not have the potential to result in any significant changes to the human environment. Therefore, the issuance of an IHA to Caltrans for the specified activity falls under the category of those actions which can be categorically excluded from the need to prepare an Environmental Assessment or Environmental Impact Statement.

Dated: December 14, 2009.

Helen M. Golde,

Deputy Director, Office of Protected Resources, National Marine Fisheries Service.

[FR Doc. E9–30179 Filed 12–18–09; 8:45 am]

BILLING CODE 3510–22–S

DEPARTMENT OF DEFENSE

Department of the Navy

Notice of Public Hearings for the Draft Environmental Impact Statement/ Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities; Correction

AGENCY: Department of Navy, DoD.

ACTION: Notice; correction.

SUMMARY: The Department of the Navy published a document in the **Federal Register** (74 FR 65761) of December 11, 2009, concerning public hearings on a Draft Environmental Impact Statement/ Overseas Environmental Impact Statement for the Gulf of Alaska Navy Training Activities. The document contained an incorrect date.

FOR FURTHER INFORMATION CONTACT: Naval Facilities Engineering Command Northwest, Attention: Mrs. Amy Burt, Gulf of Alaska Navy Training Activities EIS/OEIS Project Manager, 1101 Tautog Circle, Suite 203, Silverdale, WA 98315–1101; or *http://www.GulfofAlaskaNavyEIS.com.*

Correction

In the **Federal Register** (74 FR 65761) of December 11, 2009, on page 65762, in the first column, correct the fifth paragraph to read:

5. Tuesday, January 12, 2010, at Orca Adventure Lodge Meeting Room & Café, 2500 Orca Road, Cordova, Alaska.

Dated: December 15, 2009.

T. M. Cruz,

Lieutenant Commander, Office of the Judge Advocate General, U.S. Navy, Alternate Federal Register Liaison Officer.

[FR Doc. E9–30318 Filed 12–18–09; 8:45 am]

BILLING CODE 3810–FF–P

DEPARTMENT OF EDUCATION

Notice of Proposed Information Collection Requests

AGENCY: Department of Education.

SUMMARY: The Acting Director, Information Collection Clearance Division, Regulatory Information Management Services, Office of Management, invites comments on the proposed information collection requests as required by the Paperwork Reduction Act of 1995.

DATES: Interested persons are invited to submit comments on or before February 19, 2010.

SUPPLEMENTARY INFORMATION: Section 3506 of the Paperwork Reduction Act of 1995 (44 U.S.C. Chapter 35) requires that the Office of Management and Budget (OMB) provide interested Federal agencies and the public an early opportunity to comment on information collection requests. OMB may amend or waive the requirement for public consultation to the extent that public participation in the approval process would defeat the purpose of the information collection, violate State or Federal law, or substantially interfere with any agency's ability to perform its statutory obligations. The Acting Director, Information Collection Clearance Division, Regulatory Information Management Services, Office of Management, publishes that notice containing proposed information collection requests prior to submission of these requests to OMB. Each proposed information collection, grouped by office, contains the following: (1) Type of review requested, *e.g.* new, revision, extension, existing or reinstatement; (2) Title; (3) Summary of the collection; (4) Description of the need for, and proposed use of, the information; (5) Respondents and frequency of collection; and (6) Reporting and/or Recordkeeping burden. OMB invites public comment.

The Department of Education is especially interested in public comment addressing the following issues: (1) Is this collection necessary to the proper functions of the Department; (2) will this information be processed and used in a timely manner; (3) is the estimate of burden accurate; (4) how might the Department enhance the quality, utility, and clarity of the information to be collected; and (5) how might the Department minimize the burden of this collection on the respondents, including through the use of information technology.

Dated: December 15, 2009.

James Hyler,

Acting Director, Information Collection Clearance Division, Regulatory Information Management Services, Office of Management.

Office of Postsecondary Education

Type of Review: New.

Title: IEPS Fulbright-Hays Group Projects Abroad Customer Surveys.

Frequency: On occasion.

Affected Public: Individuals or households.

Reporting and Recordkeeping Hour Burden:

Responses: 1,829.

Burden Hours: 809.

Abstract: The purpose of this evaluation is to assess the impact of the Group Projects Abroad (GPA) program in enhancing the foreign language capacity of the United States. Three surveys will be conducted: a survey of GPA Project Directors; a survey of 2002–2008 GPA alumni; and a survey of 2009 alumni. Results from the three surveys will inform the writing of a final report determining the impact of the GPA program.

Requests for copies of the proposed information collection request may be accessed from *http://edicsweb.ed.gov*, by selecting the ''Browse Pending Collections'' link and by clicking on link number 4182. When you access the information collection, click on ''Download Attachments'' to view. Written requests for information should be addressed to U.S. Department of Education, 400 Maryland Avenue, SW., LBJ, Washington, DC 20202–4537. Requests may also be electronically mailed to *ICDocketMgr@ed.gov* or faxed to 202–401–0920. Please specify the complete title of the information collection when making your request.

Comments regarding burden and/or the collection activity requirements should be electronically mailed to *ICDocketMgr@ed.gov* 202–401–0526. Individuals who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339.

[FR Doc. E9–30276 Filed 12–18–09; 8:45 am]

BILLING CODE 4000–01–P

Appendix B

Cooperating Agency Correspondence

TABLE OF CONTENTS

CORRESPONDENCE TO DR. JAMES W. BALSIGER, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) FISHERIES FROM REAR ADMIRAL RICE (CNO)

CORRESPONDENCE TO MR. TOM MELIUS, U.S. FISH AND WILDLIFE SERVICE – ALASKA REGION FROM CAPTAIN RIOS (COMMANDING OFFICER NAVFAC NORTHWEST)

CORRESPONDENCE TO MR. P. MICHAEL PAYNE, NATIONAL MARINE FISHERIES SERVICE (NMFS) FROM OPERATIONAL ENVIRONMENTAL READINESS AND PLANNING BRANCH HEAD RONALD TICKLE (CNO)

CORRESPONDENCE TO MS. AMY BURT, GULF OF ALASKA EIS/OEIS NAVAL FACILITIES ENGINEERING COMMAND, NORTHWEST DIVISION FROM BRANCH CHIEF FRANCES MANN

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DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO

5090
Ser N456E/8U158107
31 March 2008

Dr. James W. Balsiger
Assistant Administrator, Acting
National Oceanic and Atmospheric
Administration (NOAA) Fisheries
1315 East West Highway
Silver Spring, MD 20910

Dear Dr. Balsiger:

In accordance with the National Environmental Policy Act (NEPA) and Executive Order 12114, the Department of the Navy (Navy) is preparing an Environmental Impact Statement/ Overseas Environmental Impact Statement (EIS/OEIS) to evaluate potential environmental effects of conducting Navy training in and around the Gulf of Alaska (GOA). In order to adequately evaluate the potential environmental effects of the proposed action, Navy and the National Marine Fisheries Service need to work together on acoustic effects to marine species protected under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act. To assist in this effort and in accordance with 40 CFR Part 1501 and the Council on Environmental Quality Cooperating Agency guidance issued on January 30, 2002, Navy requests NMFS serve as a cooperating agency for the development of the GOA EIS/OEIS.

The No Action Alternative is the continuation of training activities associated with large-scale joint training events in the GOA. Two action alternatives are proposed to accomplish the proposed action. Alternative (1) consists of an increase in the number of training activities from levels described in the No Action Alternative, along with force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative (2) consists of all elements of Alternative (1) plus the addition of a second summertime carrier strike group exercise in the GOA each year.

The purpose of the proposed action is to:

- Support U.S. Pacific Command (PACOM) and U.S. Northern Command (NORTHCOM) training requirements;

- Achieve and maintain Fleet readiness using the GOA to support and conduct current, emerging, and future training activities;
- Accommodate new training requirements associated with the introduction of new weapons and systems to the Fleet; and
- Support civilian authorities in homeland defense training exercises.

The EIS/OEIS will address reasonably foreseeable activities in the particular geographical areas affected by the No Action Alternative and action alternatives. This EIS/OEIS will analyze the effects of sound in the water on marine mammals in the areas of the GOA where activities occur. In addition, other environmental resource areas that will be addressed as applicable in the EIS/OEIS include, but are not limited to: air quality; airspace; biological resources, including threatened and endangered species; cultural resources; geology and soils; hazardous materials and waste; health and safety; noise; socioeconomics; transportation; and water resources.

As the lead agency, the Navy will be responsible for preparing the EIS/OEIS which includes, but is not limited to the following:

- Gathering all necessary background information and preparing the EIS/OEIS and all necessary permit applications associated with acoustic issues on the GOA study area.
- Working with NMFS personnel to determine the method of estimating potential effects to protected marine species, including threatened and endangered species.
- Determining the scope of the EIS/OEIS, including the alternatives evaluated.
- Circulating the appropriate NEPA documentation to the general public and any other interested parties.
- Scheduling and supervising meetings held in support of the NEPA process and compiling any comments received.
- Maintaining an administrative record and responding to any Freedom of Information Act requests relating to the EIS/OEIS.

As a cooperating agency, the Navy requests NMFS support the Navy in the following manner:

- Providing timely comments after the Agency Information Meeting (which will be held at the onset of the EIS/OEIS process) and on working drafts of the EIS/OEIS documents. The Navy requests that comments on draft EIS/OEIS documents be provided within 30 calendar days.

- Responding to Navy requests for information in a timely manner.

- Coordinating, to the maximum extent practicable, any public comment periods that are necessary in the MMPA permitting process with the Navy's NEPA public comment periods.

- Participating, as necessary, in meetings hosted by the Navy for discussion of EIS/OEIS-related issues.

- Adhering to the overall schedule as set forth by the Navy.

- Providing a formal, written response to this request.

The Navy views this agreement as important to the successful completion of the NEPA process for the GOA EIS/OEIS. It is the Navy's goal to complete the analysis as expeditiously as possible, while using best scientific information available. NOAA Fisheries assistance will be invaluable in that endeavor.

My point of contact for this action is Ms. Karen M. Foskey, (703) 602-2859, email: Karen.Foskey@navy.mil.

Sincerely,

L. RICE
Read Admiral, U.S. Navy
Director, Environmental Readiness
Division (OPNAV N45)

Copy to:
Deputy Assistant Secretary of the Navy (Environment)
Office of Assistant General Counsel (Installation & Environment)

Commander, U.S. Pacific Fleet (N01CE, N7)
Commander, U.S. Fleet Forces Command (N73, N77)
Commander, Naval Installations Command (N45)
Commander, Navy Region Northwest (N40)
Commander, Naval Facilities Engineering Command, Northwest (N45)

DEPARTMENT OF THE NAVY
COMMANDER
UNITED STATES PACIFIC FLEET
250 MAKALAPA DRIVE
PEARL HARBOR, HAWAII 96860-3131

IN REPLY REFER TO:
5090
Ser N01CE1/0379
4 Apr 08

Mr. Tom Melius
Regional Director
U.S. Fish & Wildlife Service – Alaska Region
1011 East Tudor Road
Anchorage, Alaska 99503

Dear Mr. Melius:

SUBJECT: GULF OF ALASKA ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT FOR NAVY TRAINING ACTIVITIES

In accordance with the Council on Environmental Quality regulations implementing the National Environmental Policy Act, the Department of the Navy (Navy) requests that the U.S. Fish & Wildlife Service serve as a cooperating agency for the development of the Gulf of Alaska (GOA) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS).

This EIS/OEIS will evaluate several alternatives based on intensity and frequency of training within an identified geographic area.

The proposed action will allow the Navy to:

- Maintain baseline training activities at current levels;
- Increase training activities from current levels to support future Fleet exercise requirements;
- Accommodate new training requirements associated with the introduction of new weapons and systems to the Fleet; and
- Support civilian authorities in homeland defense training exercises.

The EIS/OEIS will address reasonably foreseeable activities in the particular geographical areas affected by the alternatives and analyze the potential effects of additional training activities. Areas of analysis will the potential effects of sound in the water on marine mammals in the areas of

the GOA where training activities occur. Other environmental resource areas that will be addressed include, but are not limited to: air quality; airspace; biological resources, including threatened and endangered species; historic and cultural resources; water resources; geology; hazardous materials and waste; health and safety; noise; socioeconomics; transportation; fishing; and recreation.

As the lead agency, the Navy will prepare the EIS/OEIS that includes but is not limited to the following:

- Gathering all necessary background information and preparing the EIS/OEIS.

  Working with U.S. Fish & Wildlife Service personnel to evaluate potential impacts of changes and enhancements on wildlife refuges, critical habitat, and wildlife resources including threatened and endangered species.

- Identifying the scope of the EIS/OEIS, including the alternatives evaluated.

- Circulating the appropriate NEPA documentation to the general public and any other interested parties.

- Scheduling and supervising meetings held in support of the NEPA process, and compiling any comments received.

- Maintaining an administrative record and responding to any Freedom of Information Act requests relating to the EIS/OEIS.

As a cooperating agency, the Navy requests the U.S. Fish & Wildlife Service support the Navy by:

Providing timely comments throughout the EIS process, to include, on working drafts of the EIS/OEIS documents. The Navy requests that comments on draft EIS/OEIS documents be provided within 30 calendar days.

- Responding to Navy requests for information. Timely U.S. Fish & Wildlife Service input will be critical to meeting our planned schedule.

- Participating, as necessary, in meetings hosted by the Navy for discussion of EIS/OEIS related issues including the preparation of the draft EIS/OEIS and responses to comments.

- Adhering to the overall schedule as set forth by the Navy.

The Navy views your participation as a cooperating agency important to the successful completion of the NEPA process for the Gulf of Alaska EIS/OEIS. It is the Navy's goal to complete the analysis as expeditiously as possible, while using best scientific information available. USFWS assistance will be invaluable in that endeavor.

Navy's timelines for the completion of this EIS/OEIS are aggressive. The schedule calls for the draft EIS/OEIS and public Hearings in Mid 2009, release of the final EIS/OEIS in early 2010 and a record of decision in Mid 2010.

My point of contact for this action is Ms. Carolyn L. Winters, (360) 315-5092, email: carolyn.winters@navy.mil.

Sincerely,

J. R. RIOS
Captain, U.S. Navy
Deputy Fleet Civil Engineer
By direction

Copy to:
Chief of Naval Operations (N45)
Commander, U.S. Fleet Forces Command (N73, N77)
Commander, U.S. Pacific Fleet (N7)
Commander, Naval Installations Command (N45)
Commander, Navy Region Northwest (N4, N40)
Commander, Naval Facilities Engineering Command, Northwest (EV1)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

IN REPLY REFER TO

5090
Ser N456M/8U158134
21 April 2008

Mr. P. Michael Payne
Division Chief
Permits, Conservation, and Education Division
National Marine Fisheries Service (NMFS)
National Oceanic and Atmospheric Administration
B-SSMC3, Room 13821
1315 East-West Highway
Silver Springs, MD 20910

Dear Mr. Payne:

The Commander, U.S. Pacific Fleet (CPF) is preparing an Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) to assess the potential environmental impacts associated with Navy training in the Gulf of Alaska (GOA). Specifically, the Proposed Action is to continue and increase training activities in the GOA. A collection of actions will be evaluated within the EIS/OEIS.

The No Action Alternative is the continuation of training activities associated with large-scale Joint training events in the GOA. Two action alternatives are proposed to accomplish the Proposed Action. Alternative 1 consists of an increase in the number of training activities from levels described in the No Action Alternative, along with force structure changes associated with the introduction of new weapon systems, vessels, and aircraft into the Fleet. Alternative 2 consists of all elements of Alternative 1 plus the addition of a second summertime carrier strike group exercise in the GOA each year.

The purpose of the Proposed Action is to:

- Support U.S. Pacific Command (PACOM) and U.S. Northern Command (NORTHCOM) training requirements;

  Support Joint Task Force 519 (JTF-519) training requirements;

- Achieve and maintain Fleet readiness using the GOA to support and conduct current, emerging, and future training activities;

  Accommodate new training requirements associated with the introduction of new weapons and systems to the Fleet; and

- Support civilian authorities in homeland defense training exercises.

More specific descriptions of the alternatives are included in enclosure (1).

Conduct of these activities will likely result in acoustic exposure of marine mammals listed under the Marine Mammal Protection Act (MMPA) from mid-frequency active sonar (MFAS) and impulsive sources, and likely requires a Letter of Authorization (LOA). As such, the Navy will be submitting an LOA request to your office in the coming months for these activities. It is expected that species for which an LOA is sought will include species listed under the Endangered Species Act.

As applicant for a Letter of Authorization, the Navy requests your office initiate early consultation procedures with the Endangered Species Division, in accordance with Section 7(a)(3) of the Endangered Species Act and its implementing regulation at 50 CFR §402.11. In accordance with these regulations, the attached Preliminary Draft Description of the Proposed Action and Alternatives for the GOA Navy Training Activities EIS/OEIS serves as the Navy's definitive proposal outlining the action (Enclosure 1). As previously stated, the effects of the proposed action for purposes of the MMPA permit will be from exposure to acoustic energy from MFAS and impulsive sources. The level of magnitude of these effects is still being modeled, and will be included in the Navy's request for an LOA.

Title 10, Section 5062 of the United States Code requires the Navy to be "organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea." The current and emerging training activities in the GOA will be used to meet this legal requirement. Thus, in accordance with 50 CFR §402.11(b), this letter serves as the Navy's statement that it intends to implement the proposal should an MMPA Letter of Authorization be obtained from your office.

We appreciate your continued support in helping us to meet our Section 7 responsibilities. My point of contact for this matter is Ms. Elizabeth Phelps, 703-604-5420 or Elizabeth.Phelps@navy.mil.

Sincerely,

R. E. Tickle

Ronald Tickle
Head, Operational Environmental
Readiness and Planning Branch
Environmental Readiness Division
(OPNAV N45)

Enclosure:
(1) DRAFT - Gulf of Alaska Navy Training Activities EIS/OEIS Description of Proposed Action and Alternatives (Dated March 2008)

Copy to:
Chief of Naval Operations (N43)
Commander, U.S. Fleet Forces Command (N73, N77)
Commander, U.S. Pacific Fleet (N01CE, N3, N7)
Commander, Naval Installations Command (N45)
Commander, Navy Region Northwest (N40)
Commander, Naval Facilities Engineering Command, Northwest (N45)

From: Frances_Mann@fws.gov
To: Burt, Amy E CIV NAVFAC NW, EV1;
cc: Ann_Rappoport@fws.gov; Frances_Mann@fws.gov;
Subject: FWS declines to be cooperators on EIS for Gulf of Alaska
Date: Monday, September 08, 2008 16:21:55

Dear Ms. Burt:

Thank you for your April 4, 2008, request for the U.S. Fish and Wildlife Service to be a cooperating agency in your preparation of an Environmental Impact Statement (EIS) for navy training exercises in the Gulf of Alaska. I regret that we must decline this opportunity due to staffing and timing constraints of other Service priorities. Nevertheless, we are concerned about potential effects of the proposed activities on Service trust resources in this area and surrounding areas where there could be secondary and indirect effects. Consequently we expect to maintain our status as a commenting agency throughout your National Environmental Policy Act process for this potential action. In that regard, we will involve pertinent Service programs and expect to work with your staff as the EIS is developed.

For further coordination and comments on this project, please contact Ann Rappoport or me (contact information provide below).

Thank you.

Frances

Ann Rappoport, Field Supervisor
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Ann_rappoport@fws.gov <mailto:Ann_rappoport@fws.gov>

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Address for both Ann and Fran:

Anchorage Fish and Wildlife Field Office
605 W. 4th Ave., Rm. G61
Anchorage, AK 99501

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Appendix C

Regulatory Consultations

APPENDIX C
AGENCY CONSULTATION

The Navy has consulted with regulatory agencies as appropriate during the National Environmental Policy Act process and prior to implementation of the Proposed Action to ensure requirements have been met. The following is a list of the Gulf of Alaska (GOA) regulatory agency consultation documentation. Agency correspondence and supporting documentation can be found on the GOA Environmental Impact Statement (EIS) website at www.gulfofalaskanavyeis.com.

U.S. Fish and Wildlife Service, Alaska Region, Endangered Species Act

- U.S. Navy, February 2010. Gulf of Alaska Navy Training Activities Biological Evaluation.
- U.S. Fish and Wildlife, March 24, 2010. Concurrence Letter, Gulf of Alaska Navy Training Activities (Consultation #2010-0075).

National Oceanic and Atmospheric Administration - National Marine Fisheries Service, Headquarters, Endangered Species Act

- U.S. Navy, April 2008. Request for Endangered Species Act Section 7 consultation.
- U.S. Navy, March 2010. Request for formal Endangered Species Act Section 7 consultation.

National Oceanic and Atmospheric Administration - National Marine Fisheries Service, Headquarters, Marine Mammal Protection Act

- U.S. Navy, March 2009. Request for five-year Letter of Authorization.
- U.S. Navy, August 2009. Request for review of working draft of Environmental Impact Statement (Draft EIS Version 3).
- U.S. Navy, November 2009. Revised request for five-year Letter of Authorization
- National Marine Fisheries Service, February 3, 2010. Taking and Importing Marine Mammals; Navy Training Activities Conducted in the Gulf of Alaska; Notice of receipt of application for letter of authorization. Published in the Federal Register (75 FR 5575 - 5576).
- National Marine Fisheries Service, October 19, 2010. Taking and Importing Marine Mammals; Military Training Activities Conducted Within the Gulf of Alaska (GoA) Temporary Maritime Activities Area (TMAA); Proposed Rule. Published in the Federal Register (75 FR 64508 - 64583).

National Oceanic and Atmospheric Administration - National Marine Fisheries Service, Magnuson-Stevens Fishery Conservation and Management Act

- U.S. Navy, August 2010. Gulf of Alaska (GOA) Navy Training Activities Essential Fish Habitat Assessment.
- National Marine Fisheries Service, January 4, 2011. Essential Fish Habitat Assessment consultation letter.
- U.S. Navy, January 24, 2011. Essential Fish Habitat Assessment consultation response letter.

Alaska Department of Natural Resources, Alaska Coastal Management Program, Coastal Zone Management Act

- U.S. Navy, June 2009. Request for Agency Preliminary Review of GoA Navy Training Activities EIS/OEIS for Alaska Coastal Management Program Applicability and Enforceable Policy Guidance.
- Alaska Department of Natural Resources, Alaska Coastal Management Program, August 27, 2009. Agency preliminary review response letter.
- U.S. Navy, July 2010. Coastal Zone Management Act *de minimis* statement letter.
- Alaska Department of Natural Resources, Alaska Coastal Management Program, October 14, 2010. De Minimis Consistency Response-Agreement.

Alaska Department of Natural Resources, Office of History and Archaeology, State Historic Preservation Office, National Historic Preservation Act, Section 106

- U.S. Navy, April 2010. National Historic Preservation Act Section 106 Determination for Gulf of Alaska Navy Training Activities.
- Alaska Department of Natural Resources, Office of History and Archaeology, State Historic Preservation Office, May 2010. Notice of No Historic Properties Affected.

Government to Government Consultation

- Department of Defense, March 2008. Kaguyak Tribal Council Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Defense, April 2008. Yakutat Tlingit Tribal Council Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Native Village of Port Lions, June 9, 2008. Letter of No Concerns.
- Department of Navy, June 2008. Internal Memo with Status of Response of Tribes to GOA EIS letters.
- Department of Navy, December 2009. Native Village of Afognak Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Chenega Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Eyak Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Kaguyak Village Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Lesnoi Village Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Old Harbor Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Ouzinkie Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Port Graham Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Port Lions Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Shoonaq' Tribe of Kodiak Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Native Village of Tatitlek Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Department of Navy, December 2009. Yakutat Tlingit Tribe Notification Letter of anticipated U.S. Navy training activities in the Gulf of Alaska.
- Native Village of Afognak, January 22, 2010. Native Village of Afognak Response Letter.
- Native Village of Eyak, January 22, 2010. Native Village of Eyak Response Letter

Federal Aviation Administration (FAA) Correspondence

- U.S. Navy, May 2009. OPNAV Recommendation ICO Navy Training Activities in the Gulf of Alaska letter.

Appendix D

Marine Mammal Modeling

TABLE OF CONTENTS

D MARINE MAMMAL MODELING D-1

D.1 BACKGROUND AND OVERVIEW D-1
D.1.1 ACOUSTIC SOUND SOURCES D-2
D.1.2 EXPLOSIVES D-3
D.2 ACOUSTIC SOURCES D-5
D.2.1 ACOUSTIC SOURCES D-5
D.2.2 EXPLOSIVES D-7
D.3 ENVIRONMENTAL PROVINCES D-9
D.3.1 IMPACT OF ENVIRONMENTAL PARAMETERS D-10
D.3.2 ENVIRONMENTAL PROVINCING METHODOLOGY D-10
D.3.3 DESCRIPTION OF ENVIRONMENTAL PROVINCES D-11
D.4 IMPACT VOLUMES AND IMPACT RANGES D-15
D.4.1 COMPUTING IMPACT VOLUMES FOR ACTIVE SOUND SOURCES D-16
D.4.1.1 Transmission Loss Calculations D-16
D.4.1.2 Energy Summation D-18
D.4.1.3 Impact Volume per Hour of Source Operation D-20
D.4.2 COMPUTING IMPACT VOLUMES FOR EXPLOSIVE SOURCES D-21
D.4.2.1 Transmission Loss Calculations D-21
D.4.2.2 Source Parameters D-22
D.4.2.3 Impact Volumes for Various Metrics D-24
D.4.2.4 Impact Volume per Explosive Detonation D-26
D.4.3 IMPACT VOLUME BY REGION D-26
D.5 RISK FUNCTION: THEORETICAL AND PRACTICAL IMPLEMENTATION D-26
D.5.1 THRESHOLDS AND METRICS D-26
D.5.2 MAXIMUM SOUND PRESSURE LEVEL D-28
D.5.3 INTEGRATION D-28
D.5.3.1 Three Dimensions versus Two Dimensions D-29
D.5.4 THRESHOLD D-30
D.5.5 CALCULATION OF EXPECTED EXPOSURES D-31
D.5.6 NUMERIC IMPLEMENTATION D-32
D.5.7 PRESERVING CALCULATIONS FOR FUTURE USE D-33
D.5.8 SOFTWARE DETAIL D-34
D.5.9 MODELING QUIET AND CONTINUOUS SOURCES D-39
D.6 HARRASSMENTS D-41
D.6.1 ANIMAL DENSITIES D-41
D.6.2 HARASSMENT ESTIMATES D-41
D.6.3 ADDITIONAL MODELING CONSIDERATIONS IN A GENERAL MODELING SCENARIO D-42
D.6.4 MULTIPLE EXPOSURES IN GENERAL MODELING SCENARIO D-43
D.6.4.1 Solution to the Ambiguity of Multiple Exposures in the General Modeling Scenario D-43
D.6.4.2 Local Population: Upper Bound on Harassments D-45
D.6.4.3 Animal Motion Expansion D-45
D.6.4.4 Risk Function Expansion D-47
D.6.5 LAND SHADOW D-49
D.6.5.1 Computing the Land Shadow Effect at Each Grid Point D-49
D.6.5.2 The Effect of Multiple Ships D-51
D.7 REFERENCES D-57

LIST OF FIGURES

FIGURE D-1. – WINTER SVPS IN GOA D-12
FIGURE D-2. – SUMMER SVPS IN GOA D-13
FIGURE D-3. – DISTRIBUTION OF ENVIRONMENTAL PROVINCES IN THE TMAA D-14
FIGURE D-4. HORIZONTAL PLANE OF VOLUMETRIC GRID FOR OMNI DIRECTIONAL SOURCE D-19
FIGURE D-5. HORIZONTAL PLANE OF VOLUMETRIC GRID FOR STARBOARD BEAM SOURCE D-19
FIGURE D-6. SQS-53 IMPACT VOLUME BY PING D-20
FIGURE D-7. EXAMPLE OF AN IMPACT VOLUME VECTOR D-21
FIGURE D-8. 80-HZ BEAM PATTERNS ACROSS NEAR FIELD OF EER SOURCE D-23
FIGURE D-9. 1250-HZ BEAM PATTERNS ACROSS NEAR FIELD OF SSQ-110 SOURCE D-24
FIGURE D-10. TIME SERIES D-27
FIGURE D-11. TIME SERIES SQUARED D-27
FIGURE D-12. MAX SPL OF TIME SERIES SQUARED D-28
FIGURE D-13. PTS HEAVYSIDE THRESHOLD FUNCTION D-30
FIGURE D-14. EXAMPLE OF A VOLUME HISTOGRAM D-34
FIGURE D-15. EXAMPLE OF THE DEPENDENCE OF IMPACT VOLUME ON DEPTH D-35
FIGURE D-16. CHANGE OF IMPACT VOLUME AS A FUNCTION OF *X*-AXIS GRID SIZE D-36
FIGURE D-17. CHANGE OF IMPACT VOLUME AS A FUNCTION OF Y-AXIS GRID SIZE D-36
FIGURE D-18. CHANGE OF IMPACT VOLUME AS A FUNCTION OF Y-AXIS GROWTH FACTOR D-37
FIGURE D-19. CHANGE OF IMPACT VOLUME AS A FUNCTION OF BIN WIDTH D-37
FIGURE D-20. DEPENDENCE OF IMPACT VOLUME ON THE NUMBER OF PINGS D-39
FIGURE D-21. EXAMPLE OF AN HOURLY IMPACT VOLUME VECTOR D-39
FIGURE D-22. – SINGLE PING MAXIMUM SPL FIELD D-40
FIGURE D-23. – QUIET CONTINUOUS SOUND SOURCE D-40
FIGURE D-24. – PROCESS OF CALCULATING *H* D-44
FIGURE D-25. PROCESS OF SETTING AN UPPER BOUND ON INDIVIDUALS PRESENT IN AREA D-46
FIGURE D-26. PROCESS OF EXPANDING AREA TO CREATE UPPER BOUND OF HARASSMENTS D-47
FIGURE D-27. – THE APPROXIMATE PERCENTAGE OF BEHAVIORAL HARASSMENTS FOR EVERY 3 DEGREE BAND OF RECEIVED LEVEL FROM THE SQS-53 DURING SUMMER MONTHS D-50
FIGURE D-28. – AVERAGE PERCENTAGE OF HARASSMENTS OCCURRING WITHIN A GIVEN DISTANCE DURING SUMMER MONTHS D-50
FIGURE D-29. – DEPICTION OF LAND SHADOW OVER THE TMAA D-51
FIGURE D-30. – FORMATION AND BEARING OF SHIPS IN 4-SHIP EXAMPLE D-52
FIGURE D-31. – SHIP TRACKS OF SHIPS IN 4-SHIP EXAMPLE D-53
FIGURE D-32. – SOUND FIELD PRODUCED BY MULTIPLE SHIPS D-54
FIGURE D-33. – UPPER AND LOWER PORTION OF SOUND FIELD D-55
FIGURE D-34.– CENTRAL PORTION OF SOUND FIELD D-56

LIST OF TABLES

TABLE D-1 - NON-EXPLOSIVE SOUND SOURCE THRESHOLD LEVELS D-3
TABLE D-2 - EXPLOSIVES THRESHOLD LEVELS D-4
TABLE D-3 - ACOUSTIC SOURCES ANALYZED FOR USE IN THE TMAA D-5
TABLE D-4 – SOURCE DESCRIPTION OF ACTIVE SOURCES USED IN THE TMAA D-7
TABLE D-5 – SONAR USAGE UNITS D-7
TABLE D-6 – REPRESENTATIVE SINKEX WEAPONS FIRING SEQUENCE D-9
TABLE D-7 – DISTRIBUTION OF BATHYMETRY PROVINCES IN GOA D-11
TABLE D-8 – DISTRIBUTION OF SOUND SPEED PROVINCES IN GOA D-12
TABLE D-9 – DISTRIBUTION OF HIGH-FREQUENCY BOTTOM LOSS CLASSES IN GOA D-13
TABLE D-10 – DISTRIBUTION OF ENVIRONMENTAL PROVINCES IN TMAA D-14
TABLE D-11 – DISTRIBUTION OF ENVIRONMENTAL PROVINCES IN THE TMAA SINKEX AREA D-15
TABLE D-12 – TL FREQUENCY AND SOURCE DEPTH BY TYPE D-17
TABLE D-13 – TL DEPTH AND RANGE SAMPLING PARAMETERS BY SONAR TYPE D-17
TABLE D-14 – UNKNOWNS AND ASSUMPTIONS D-42
TABLE D-15 – BEHAVIORAL HARASSMENTS AT EACH RECEIVED LEVEL BAND FROM SQS-53 DURING SUMMER MONTHS D-49

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D MARINE MAMMAL MODELING

D.1 BACKGROUND AND OVERVIEW

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the unauthorized take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A "species" is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. There are marine mammals, already protected under MMPA, listed as either endangered or threatened under ESA, and afforded special protections.

Actions involving sound in the water include the potential to harass marine animals in the surrounding waters. Demonstration of compliance with MMPA and the ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 United States Code [U.S.C.] 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region.

Authorization for incidental takings may be granted if the National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking, and requirements pertaining to the mitigation, monitoring and reporting of such taking are set forth.

NMFS has defined negligible impact in 50 Code of Federal Regulations (CFR) 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

Subsection 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law 108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or*
>
> (ii) *any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B Harassment].*

The primary potential impact to marine mammals from underwater acoustics is Level B harassment from exposure to various sources of sound in the water including sonar and explosives. The criteria for modeling impacts from these sources are detailed in the following sections.

D.1.1 Acoustic Sound Sources

The amount of Threshold Shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward 1997). For intermittent sounds, less Threshold Shift will occur than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al., 1966; Ward 1997). The magnitude of Threshold Shift normally decreases with the amount of time post-exposure (Miller 1974).

Permanent Threshold Shift (PTS) is non-recoverable and results from the destruction of tissues within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the MMPA. The smallest amount of PTS (onset- PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the Level A exposure zone.

If the TS eventually returns to zero (the threshold returns to the pre-exposure value), the TS is a Temporary Threshold Shift (TTS). TTS is, from recent rulings (NOAA 2001; 2002a), considered to result from the temporary, non-injurious distortion of hearing-related tissues. The smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the Level B exposure zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal's ability to react normally to the sounds around it. Therefore, the potential for TTS is considered as Level B harassment caused by physiological effects on the auditory system.

The exposure threshold established for onset-TTS is 195 dB re $1\mu Pa^2$-s. This result is supported by the short-duration tone data of Finneran et al. (2002, 2005) and the long-duration sound data from Nachtigall et al., (2003). Together, these data demonstrate that TTS in small odontocetes is correlated with the received EL and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re $1\mu Pa^2$-s. Absent any additional data for other species and being that it is likely that small odontocetes are more sensitive to the mid-frequency active/high-frequency active frequency levels of concern, this threshold is used for analysis for all cetacea.

The PTS thresholds established for use in this analysis are based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of TS, and on TS growth occurring at a rate of 1.6 dB/dB increase in exposure EL. This is conservative because: (1) 40 dB of TS is actually an upper limit for TTS used to approximate onset-PTS, and (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958, 1959). Using this estimation method (20 dB increase from onset-TTS) for analysis, the PTS threshold for cetacea is 215 dB re $1\mu Pa^2$-s.

Unlike cetaceans, the TTS and PTS thresholds used for pinnipeds vary with species. Otariids have thresholds of 206 dB re $1\mu Pa^2$-s for TTS and 226 dB re $1\mu Pa^2$-s for PTS. Northern elephant seals are similar to otariids (TTS = 204 dB re $1\mu Pa^2$-s, PTS = 224 dB re $1\mu Pa^2$-s) but are lower for harbor seals (TTS = 183 dB re $1\mu Pa^2$-s, PTS = 203 dB re $1\mu Pa^2$-s). A certain proportion of marine mammals is expected to experience behavioral disturbance at different received sound pressure levels and are counted as Level B harassment takes. The details of this theory and calculation are described in the Risk Function section. Table D-1 summarizes the threshold levels for analysis of non-explosive sound sources used during Navy training activities in the Gulf of Alaska (GOA) Temporary Maritime Activities Area (TMAA).

Table D-1 - Non-Explosive Sound Source Threshold Levels

Physiological Effects			
Animal	**Criteria**	**Threshold (re 1μPa^2-s)**	**MMPA Effect**
Cetacean	TTS PTS	195 215	Level B Harassment Level A Harassment
Pinnipeds			
Northern Elephant Seal	TTS PTS	204 224	Level B Harassment Level A Harassment
Steller Sea Lion	TTS PTS	206 226	Level B Harassment Level A Harassment
Northern Fur Seal	TTS PTS	206 226	Level B Harassment Level A Harassment

D.1.2 Explosives

For underwater explosions resulting from use of live ordnance in the TMAA, in the absence of any mitigation or monitoring measures, there is a very small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of sound and pressure impacts from underwater explosions is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as tympanic membrane (TM) rupture and the onset of slight lung injury. The threshold for Level A Harassment corresponds to a 50-percent rate of TM rupture, which can be stated in terms of an energy flux density (EFD) value of 205 dB re 1μPa^2-s. TM rupture is well-correlated with permanent hearing impairment. Ketten (1998) indicates a 30-percent incidence of permanent threshold shift (PTS) at the same threshold.

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al, 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. Impulse thresholds of 13.0 and 31.0 psi-msec, found to cause slight and extensive injury in a dolphin calf, were used as thresholds in the analysis contained in this document.

Level B (behavior response) Harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. One criterion used for TTS, the total energy flux density of the sound, is a threshold of 182 dB re 1μPa^2-s maximum EFD level in any 1/3-octave band above 100 Hz for toothed whales (e.g., dolphins). A second criterion, a maximum allowable peak pressure of 23 psi, has recently been established by NMFS to provide a more conservative range for TTS when the explosive or animal approaches the sea surface, in which case explosive energy is reduced, but the peak pressure is not. NMFS applies the more conservative of these two.

For multiple successive explosions (MSE) occurring underwater, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. The non-TTS threshold is derived following the approach of the Churchill Final Environmental Impact Statement (FEIS) for the energy-based TTS threshold. The research on pure-tone exposures reported in Schlundt et al. (2000) and Finneran and Schlundt (2004) provided a threshold of 192 dB re 1μPa^2-s as the lowest TTS value. This value for pure-tone exposures is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3 octave bands, the natural filter band of the ear. The resulting TTS threshold for explosives is 182 dB re 1μPa^2-s in any 1/3 octave band. As reported by Schlundt et al. (2000) and Finneran and Schlundt (2004), instances of altered behavior in the pure-tone research generally began five dB lower than those causing TTS. The non-TTS threshold is therefore derived by subtracting 5 dB from the 182 dB re 1μPa^2-s in any 1/3 octave band threshold, resulting in a 177 dB re 1μPa^2-s (EL) sub-TTS behavioral disturbance threshold for MSE. Table D-2 summarizes the threshold levels for analysis of explosives used in the GOA.

Table D-2 - Explosives Threshold Levels

Threshold Type	Threshold Level
Level A – 50% Eardrum rupture	205 dB re 1μPa^2-s
Temporary Threshold Shift (TTS) (peak 1/3 octave energy)	182 dB re 1μPa^2-s
Sub-TTS Threshold for Multiple Successive Explosions (peak 1/3 octave energy)	177 dB re 1μPa^2-s
Temporary Threshold Shift (TTS) (peak pressure)	23 psi
Level A – Slight lung injury (positive impulse)	13 psi-ms
Fatality – 1% Mortal lung injury (positive impulse)	31 psi-ms

The sound sources will be located in an area that is inhabited by species listed as threatened or endangered under the ESA (16 USC §§ 1531-1543). Operation of the sound sources, that is, transmission of acoustic signals in the water column, could potentially cause harm or harassment to listed species.

"Harm" defined under ESA regulations is "…an act which actually kills or injures…" (50 CFR 222.102) listed species. "Harassment" is an "intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR 17.3).

If a federal agency determines that its proposed action "may affect" a listed species, it is required to consult, either formally or informally, with the appropriate regulator. There is no permit issuance under ESA, rather consultation among the cognizant federal agencies under Section 7 of the ESA. Such consultations would likely be concluded favorably, subject to requirements that the activity will not appreciably reduce the likelihood of the species' survival and recovery and impacts are minimized and mitigated.

D.2 ACOUSTIC SOURCES

The acoustic sources employed in the TMAA are categorized as either broadband (producing sound over a wide frequency band) or narrowband (producing sound over a frequency band that that is small in comparison to the center frequency). In general, the majority of acoustic energy results from narrowband sonars utilized for Anti-Submarine Warfare (ASW) activities and underwater explosions as broadband sources. This delineation of source types has a couple of implications. First, the transmission loss used to determine the impact ranges of narrowband ASW sonars can be adequately characterized by model estimates at a single frequency. Broadband explosives, on the other hand, produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Second, the types of sources have different sets of harassment metrics and thresholds. Energy metrics are defined for both types. However, explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of both types of sources are provided in the following subsections.

D.2.1 Acoustic Sources

Operations in the TMAA involve four (4) types of narrowband sonars, as shown in Table D-3. Harassment estimates are calculated for each source according to the manner in which it operates. For example, the SQS-53 is a hull-mounted, surface ship sonar that operates for many hours at a time, so it is useful to calculate and report SQS-53 harassments per hour of operation. The AQS-22 is a helicopter-deployed sonar, which is lowered into the water, pings a number of times, and then moves to a new location. For the AQS-22, it is useful to calculate and report harassments per dip. The SSQ-62 sonobuoy is modeled at a single depth pinging for a fixed duration, so harassments are accordingly reported per sonobuoy deployed. The following table presents the deploying platform, frequency class, and the reporting metric for each acoustic source analyzed for use in the TMAA.

Table D-3 - Acoustic Sources Analyzed for use in the TMAA

Sonar	Description	Frequency Class	Harassments Reported
SQS-53	Surface ship sonar	Mid-frequency	Per hour
SSQ-62	Sonobuoy sonar	Mid-frequency	Per sonobuoy
AQS-22	Helicopter-dipping sonar	Mid-frequency	Per dip
SQS-56	Surface ship sonar	Mid-frequency	Per hour
MK-84 Range Pingers	Surface pingers	High-frequency	Per day
PUTR Transponders	Bottom pingers	Mid-frequency	Per day
MK-39 EMATT	Training target	Low frequency	Per hour
BQQ-10	Submarine sonar	Classified	Per hour
BQS-15	Submarine sonar	Classified	Per hour
SUS, MK-84	Expendable buoy	Mid-frequency	Per hour

The acoustic modeling that is necessary to support the harassment estimates for each of these sonars relies upon a generalized description of the manner of the sonar's operating modes. This description includes the following:

- "Effective" energy source level—This is the level relative to $1\mu Pa^2$-s of the integral over frequency and time of the square of the pressure and is given by the total energy level across the band of the source, scaled by the pulse length ($10 \log_{10}$ [pulse length]).

- Source depth—Depth of the source in meters.
- Nominal frequency - Typically the center band of the source emission. These are frequencies that have been reported in open literature and are used to avoid classification issues. Differences between these nominal values and actual source frequencies are small enough to be of little consequence to the output impact volumes.
- Source directivity - The source beam is modeled as the product of a horizontal beam pattern and a vertical beam pattern. Two parameters define the horizontal beam pattern:
  - Horizontal beam width—Width of the source beam (degrees) in the horizontal plane (assumed constant for all horizontal steer directions).
  - Horizontal steer direction—Direction in the horizontal in which the beam is steered relative to the direction in which the platform is heading.

  The horizontal beam is assumed to have constant level across the width of the beam with flat, 20-dB down side lobes at all other angles.

  Similarly, two parameters define the vertical beam pattern:

  - Vertical beam width - Width of the source beam (degrees) in the vertical plane measured at the 3-dB down point (assumed constant for all vertical steer directions).
  - Vertical steer direction - Direction in the vertical plane that the beam is steered relative to the horizontal (upward looking angles are positive).

  To avoid sharp transitions that a rectangular beam might introduce, the power response at vertical angle θ is

  $$\text{Power} = \max \{ \sin^2 [n(\theta_s - \theta)] / [n \sin (\theta_s - \theta)]^2,\ 0.01 \},$$

  where θ_s is the vertical beam steer direction, and $n = 2*L/\lambda$ (L = array length, λ = wavelength).

  The beamwidth of a line source is determined by n (the length of the array in half-wavelengths) as $\theta_w = 180^o/n$.

- Ping spacing - Distance between pings. For most sources this is generally just the product of the speed of advance of the platform and the repetition rate of the sonar. Animal motion is generally of no consequence as long as the source motion is greater than the speed of the animal (nominally, 3 knots). For stationary (or nearly stationary) sources, the "average" speed of the animal is used in place of the platform speed. The attendant assumption is that the animals are all moving in the same constant direction.

These parameters are defined for each of the active sound sources in Table D-4 and D-5.

Table D-4 – Source Description of Active Sources used in the TMAA

Sonar	Source Depth	Center Freq	Source Level	Emission Spacing	Vertical Directivity	Horizontal Directivity
SQS-53C	7 m	3.5 kHz	235 dB	154 m	Omni	240° Forward-looking
SSQ-62	27 m	8 kHz	201 dB	450 m	Omni	Omni
AQS-22	27 m	4.1 kHz	217 dB	15 m	Omni	Omni
SQS-56	7 m	7.5 kHz	225 dB	129 m	Omni	90° Forward-looking
MK-84 Range Pingers	7m, 100m	12.9 kHz	194 dB		90 Down	Omni
PUTR Transponders	1,800 m	8.8 kHz	186 dB	Variable	180 Upward	Omni
MK-39 EMATT	100 m	900 Hz	130 dB	Continuous	Omni	Omni
BQQ-10	100 m	Classified	Classified	Classified	Classified	Classified
BQS-15	50 m	Classified	Classified	Classified	Classified	Classified
SUS, MK-84	50 m	3.4 kHz	160 dB	Continuous	Omni	Omni

The following are the usage units for sonar sources in the TMAA (all modeled during the summer season):

Table D-5 – Sonar Usage Units

Sonar	2CSG	1CSG
SQS-53C	578 Hours	289 hours
SSQ-62	267 buoys	133 buoys
AQS-22	192 dips	96 dips
SQS-56	52 hours	26 hours
BQQ-10	48 hours	24 hours
BQS-15	24 hours	12 hours

D.2.2 Explosives

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

The detonation depth of an explosive is particularly important due to a propagation effect known as surface-image interference. For sources located near the sea surface, a distinct interference pattern arises from the coherent sum of the two paths that differ only by a single reflection from the pressure-release surface. As the source depth and/or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface-reflection scattering loss).

For the TMAA, explosive sources having detonations in the water include the following: SSQ-110 EER sonobuoys and MK-82, MK-83, MK-84, BDU-45 bombs, 5” rounds and 76 mm gunnery rounds, MK-48 torpedo, and Maverick missile. The SSQ-110 source can be detonated at several depths within the water column. For this analysis, a relatively shallow depth of 65 ft (20 m) is used to optimize the likelihood of

the source being positioned in a surface duct. A source depth of two meters is used for bombs and missiles that do not strike their target. The MK-48 torpedo detonates immediately below the target's hull and a nominal depth of 50 ft (14 m) is used as its source depth in this analysis. For the gunnery rounds, a source depth of one foot is used. The NEW modeled for these sources are as follows:

- SSQ-110 Sonobuoy - 5 pounds
- MK-82 bomb - 238 pounds
- MK-83 bomb - 238 pounds
- MK-83 bomb – 574 pounds
- MK-84 bomb – 945 pounds
- 5" rounds – 9.54 pounds
- 76 mm rounds – 1.6 pounds
- MK-48 torpedo – 851 pounds
- Air-to-Ground (AGM)-65 Maverick Missile – 78.5 pounds

The harassments expected to result from these sources are computed on a per in-water explosive basis. The cumulative effect of a series of explosives can often be derived by simple addition if the detonations are spaced widely in time or space, allowing for sufficient animal movements as to ensure a different population of animals is considered for each detonation.

The cases in which simple addition of the harassment estimates may not be appropriate are addressed by the modeling of a "representative" sinking exercise (SINKEX). In a SINKEX, a decommissioned vessel is towed to a specified deep-water location and there used as a target for a variety of weapons. Although no two SINKEXs are ever the same, a representative case derived from past exercises is described in the Programmatic SINKEX Overseas Environmental Assessment (March 2006) for the Western North Atlantic. Unguided weapons are more frequently off-target and are modeled according to the statistical hit/miss ratios. Note that these hit/miss ratios are artificially low in order to demonstrate a worst-case scenario; they should not be taken as indicative of weapon or platform reliability. With one exception, it is assumed that all missiles in a SINKEX will strike the target vessel. The Maverick missile and bombs used in SINKEX were modeled as missing the target vessel approximately 33 percent of the time. For all live rounds fired in a GUNEX and an estimated 32 percent of rounds fired in SINKEX may explode in the water.

In a SINKEX, weapons are typically fired in order of decreasing range from the source with weapons fired until the target is sunk. A torpedo is used after all munitions have been expended if the target is still afloat. Since the target may sink at any time during the exercise, the actual number of weapons used can vary widely. In the representative case, however, all of the ordnances are assumed expended; this represents the worst case with maximum exposure.

The sequence of weapons firing for the representative SINKEX is described in Table D-6. Guided weapons are nearly 100% accurate and are modeled as hitting the target (that is, no underwater acoustic effect) in all but two cases: (1) the Maverick is modeled as a miss to represent the occasional miss, and (2) the MK-48 torpedo intentionally detonates in the water column immediately below the hull of the target. Unguided weapons are more frequently off-target and are modeled according to the statistical hit/miss ratios. Note that these hit/miss ratios are artificially low in order to demonstrate a worst-case scenario; they should not be taken as indicative of weapon or platform reliability.

Table D-6 – Representative SINKEX Weapons Firing Sequence

Time (Local)	Event Description
0900	Range Control Officer receives reports that the exercise area is clear of non-participant ship traffic, marine mammals, and sea turtles.
0909	Hellfire missile fired, hits target.
0915	2 HARM missiles fired, both hit target (5 minutes apart).
0930	1 Penguin missile fired, hits target.
0940	3 Maverick missiles fired, 2 hit target, 1 misses (5 minutes apart).
1145	1 SM-1 fired, hits target.
1147	1 SM-2 fired, hits target.
1205	5 Harpoon missiles fired, all hit target (1 minute apart).
1300-1335	7 live and 3 inert MK 82 bombs dropped – 7 hit target, 2 live and 1 inert miss target (4 minutes apart).
1355-1410	4 MK 83 bombs dropped – 3 hit target, 1 misses target (5 minutes apart).
1500	Surface gunfire commences – 400 5-inch rounds fired (one every 6 seconds), 280 hit target, 120 miss target.
1700	MK 48 Torpedo fired, hits, and sinks target.

D.3 ENVIRONMENTAL PROVINCES

Propagation loss ultimately determines the extent of the Zone of Influence (ZOI) for a particular source activity. In turn, propagation loss as a function of range responds to a number of environmental parameters:

- Water depth
- Sound speed variability throughout the water column
- Bottom geo-acoustic properties, and
- Surface roughness, as determined by wind speed

Due to the importance that propagation loss plays in Anti-Submarine Warfare (ASW) exercises, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases of these environmental parameters, which are accepted as standards for Navy modeling efforts.

- Water depth - Digital Bathymetry Data Base Variable Resolution (DBDBV)
- Sound speed - Generalized Digital Environmental Model (GDEM)
- Bottom loss - Low-Frequency Bottom Loss (LFBL), Sediment Thickness Database, and High-Frequency Bottom Loss (HFBL), and
- Wind speed - U.S. Navy Marine Climatic Atlas of the World

This section provides a discussion of the relative impact of these various environmental parameters. These examples then are used as guidance for determining environmental provinces (that is, regions in which the environmental parameters are relatively homogeneous and can be represented by a single set of environmental parameters) within the TMAA.

D.3.1 Impact of Environmental Parameters

Within a typical operating area, the environmental parameter that tends to vary the most is bathymetry. It is not unusual for water depths to vary by an order of magnitude or more, resulting in significant impacts upon the ZOI calculations. Bottom loss can also vary considerably over typical operating areas but its impact upon ZOI calculations tends to be limited to waters on the continental shelf and the upper portion of the slope. Generally, the primary propagation paths in deep water, from the source to most of the ZOI volume, do not involve any interaction with bottom. In shallow water, particularly if the sound velocity profile directs all propagation paths to interact with the bottom, bottom loss variability can play a larger role.

The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled for each selected environment.

D.3.2 Environmental Provincing Methodology

The underwater acoustic environment can be quite variable over ranges in excess of ten kilometers. For ASW applications, ranges of interest are often sufficiently large as to warrant the modeling of the spatial variability of the environment. In the propagation loss calculations, each of the environmental parameters is allowed to vary (either continuously or discretely) along the path from acoustic source to receiver. In such applications, each propagation loss calculation is conditioned upon the particular locations of the source and receiver.

On the other hand, the range of interest for marine animal harassment by most Naval activities is more limited. This reduces the importance of the exact location of source and marine animal and makes the modeling required more manageable in scope.

In lieu of trying to model every environmental profile that can be encountered in an operating area, this effort utilizes a limited set of representative environments. Each environment is characterized by a fixed water depth, sound velocity profile, and bottom loss type. The operating area is then partitioned into homogeneous regions (or provinces) and the most appropriately representative environment is assigned to each. This process is aided by some initial provincing of the individual environmental parameters. The Navy-standard high-frequency bottom loss database in its native form is globally partitioned into nine classes. Low-frequency bottom loss is likewise provinced in its native form, although it is not considered in the process of selecting environmental provinces. Only the broadband sources produce acoustic energy at the frequencies of interest for low-frequency bottom loss (typically less than 1 kHz); even for those sources the low-frequency acoustic energy is secondary to the energy above 1 kHz. The Navy-standard sound velocity profiles database is also available as a provinced subset. Only the Navy-standard bathymetry database varies continuously over the world's oceans. However, even this environmental parameter is easily provinced by selecting a finite set of water depth intervals. For this analysis "octave-spaced" intervals (10, 20, 50, 100, 200, 500, 1000, 2000, and 5000 m) provide an adequate sampling of water depth dependence.

ZOI volumes are then computed using propagation loss estimates derived for the representative environments. Finally, a weighted average of the ZOI volumes is taken over all representative environments; the weighting factor is proportional to the geographic area spanned by the environmental province.

The selection of representative environments is subjective. However, the uncertainty introduced by this subjectivity can be mitigated by selecting more environments and by selecting the environments that occur most frequently over the operating area of interest.

As discussed in the previous subsection, ZOI estimates are most sensitive to water depth. Unless otherwise warranted, at least one representative environment is selected in each bathymetry province. Within a bathymetry province, additional representative environments are selected as needed to meet the following requirements.

- In shallow water (less than 1,000 meters), bottom interactions occur at shorter ranges and more frequently; thus significant variations in bottom loss need to be represented.
- Surface ducts provide an efficient propagation channel that can greatly influence ZOI estimates. Variations in the mixed layer depth need to be accounted for if the water is deep enough to support the full extent of the surface duct.

Depending upon the size and complexity of the operating area, the number of environmental provinces tends to range from 5 to 20.

D.3.3 Description of Environmental Provinces

The TMAA is approximately 92,246 square kilometers of ocean located south of Prince William Sound and east of Kodiak Island. The TMAA encompasses Warning Area W-612 and extends from the continental shelf to the deep waters of the Gulf of Alaska. The acoustic sources described in subsection D2 are deployed throughout the TMAA. This subsection describes the representative environmental provinces selected for the GOA. For all of these provinces, the average wind speed in the winter is 19 knots and in the summer 12 knots.

The GOA contains a total of 20 distinct environmental provinces. These represent various combinations of six bathymetry provinces, two Sound Velocity Profile (SVP) provinces, and four High-Frequency Bottom Loss (HFBL) classes.

The bathymetry provinces represent depths ranging from 100 meters to typical deep-water depths (slightly more than 5,000 meters). Nearly two-thirds of the Exercise Area is characterized as deep-water (depths of 2,000 meters or more). The second most prevalent water depth, covering nearly one-quarter of the Exercise Area, is representative of waters near the continental shelf break. The remaining water depths provide only small contributions (individually less than 5%) to the analysis. The distribution of the bathymetry provinces over the GOA is provided in D-7.

Table D-7 – Distribution of Bathymetry Provinces in GOA

Province Depth (m)	Frequency of Occurrence
100	4.85 %
200	22.29 %
500	4.22 %
1000	4.53 %
2000	12.67 %
5000	51.44 %

The distribution of the two sound speed provinces found in the TMAA is presented in Table D-8.

Table D-8 – Distribution of Sound Speed Provinces in GOA

SVP Province	Frequency of Occurrence
21	30.46 %
22	69.54 %

The variation in sound speed profiles associated with these two provinces is significant. This is illustrated in Figure D-1 and D-2 that display the upper 1,000 meters of the winter and summer profiles, respectively. In the winter, province 21 is a classic half-channel profile. The strong near-surface (within the upper 200 meters) gradient is the likely product of thorough mixing by strong winter winds and some fresh water sources. The winter profile for province 22 features a strong surface duct to a depth of 100 meters, also the result of thorough mixing by the winter winds. In contrast to province 21, however, the surface layer is modestly warmer. Nonetheless, both profiles are conducive to favorable sound propagation from a near-surface source.

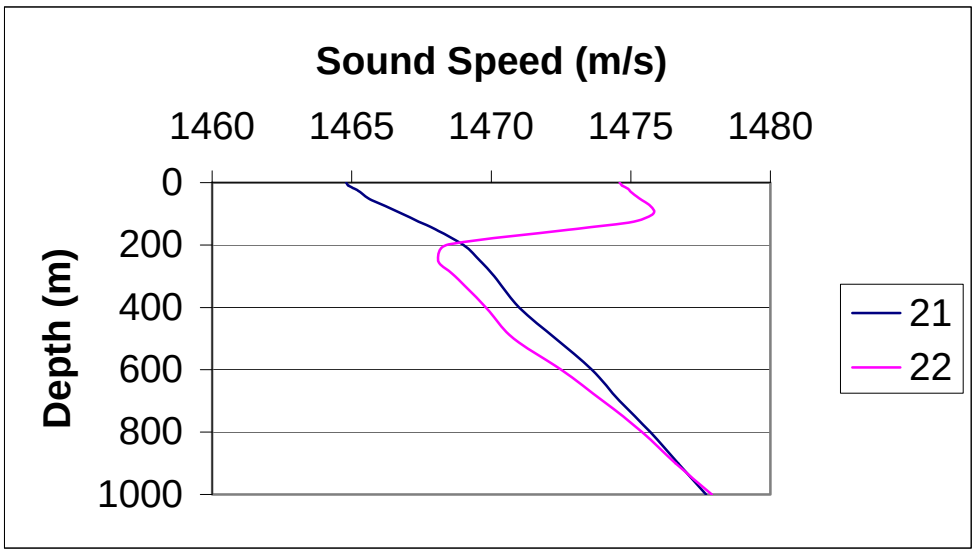

Figure D-1. – Winter SVPs in GOA

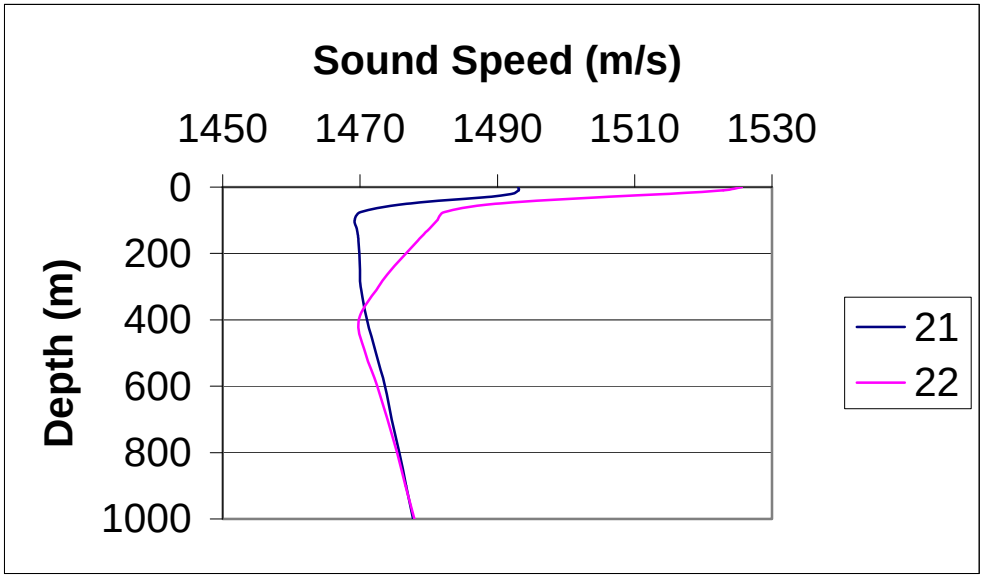

Figure D-2. – Summer SVPs in GOA

The summer profiles exhibit an even wider range of differences in the upper 200 meters (as much as 25 m/sec at the surface) with neither featuring a surface duct of significance. In the absence of surface loss considerations, both summer profiles would be less favorable than their winter counterparts for propagation from a near-surface source. However, the high wind speeds that are prevalent in the winter and the upward-refracting nature of the winter profiles appear to produce significantly higher surface scattering losses which can lead to summer being the season with the more favorable propagation.

The four HFBL classes represented in the GOA vary from low-loss bottoms (class 2, typically in shallow water) to high-loss bottoms (class 8). The four classes are fairly equally distributed as indicated in Table D-9 Distribution of High-Frequency Bottom Loss Classes in GOA. However, since two (classes 2 and 3) of the four classes are relatively low-loss, the bias in the environmental provinces will be towards low-loss bottoms.

Table D-9 – Distribution of High-Frequency Bottom Loss Classes in GOA

HFBL Class	Frequency of Occurrence
2	28.28 %
3	22.60 %
5	22.70 %
8	26.42 %

The logic for consolidating the environmental provinces focuses upon water depth, using the sound speed profile (in deep water) and the HFBL class (in shallow water) as secondary differentiating factors. The first consideration was to ensure that all six bathymetry provinces are represented. Then within each bathymetry province further partitioning of provinces proceeded as follows:

- The three shallowest bathymetry provinces are each represented by one environmental province. In each case, the bathymetry province is dominated (in some cases almost exclusively) by a single HFBL class, so that the secondary differentiating environmental parameter is of no consequence.
- The 1000-meter bathymetry province has two environmental provinces (differing in SVP province only) that occur in small, but relatively equal portions. Although they collectively

represent less than 5% of the TMAA, both are included in the analysis to ensure thoroughness. A third environmental province with a different HFBL class is not encountered enough to warrant consideration.

- The 2000-meter bathymetry province contains two environmental provinces that feature different SVP provinces. Both occur with sufficient frequency to warrant inclusion in the analysis.
- The 5000-meter bathymetry province consists of five environmental provinces. Four of these provinces are maintained for analysis; the fifth province is representative of less than one percent of the TMAA and for that reason, is excluded from consideration.

The distribution of the resulting eleven environmental provinces used in the acoustic modeling is summarized in Table D-10 and depicted in Figure D-3.

Table D-10 – Distribution of Environmental Provinces in TMAA

Environmental Province	Water Depth	SVP Province	Frequency of Occurrence
1	100 m	21	4.85 %
2	200 m	21	22.29 %
3	500 m	21	4.22 %
4	1000 m	21	2.32 %
5	1000 m	22	2.21 %
6	2000 m	21	10.61 %
7	2000 m	22	2.06 %
8	5000 m	21	22.60 %
9	5000 m	21	21.20 %
10	5000 m	22	1.51 %
11	5000 m	21	6.13 %

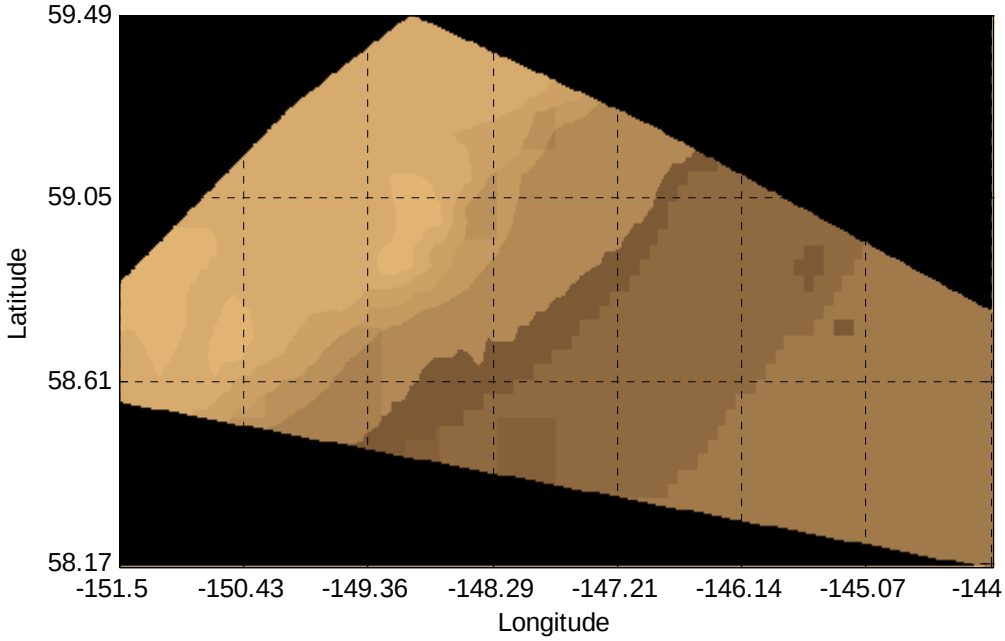

Figure D-3. – Distribution of Environmental Provinces in the TMAA

On this plot, darker-colored regions correspond to higher environmental province numbers, and hence depict deeper regions of the TMAA.

SINKEX operations are restricted to areas outside of 50 nautical miles (nm) from land and in waters deeper than 1,000 fathoms (or 1,852 meters). These limitations result not only in a smaller set of environments for analysis but also different frequencies of occurrence as indicated in Table D-11.

Table D-11 – Distribution of Environmental Provinces in the TMAA SINKEX Area

Environmental Province	Water Depth	SVP Province	Sediment Thickness	Frequency of Occurrence
1	2000 m	21	0.2 secs	7.15 %
2	5000 m	21	0.94 secs	35.55 %
3	5000 m	21	0.29 secs	9.04 %
4	5000 m	21	0.81 secs	45.93 %
5	5000 m	22	0.92 secs	1.75 %
6	5000 m	22	0.67 secs	0.58 %

D.4 IMPACT VOLUMES AND IMPACT RANGES

Many naval actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

The impact volume associated with a particular activity is defined as the volume of water in which some acoustic metric exceeds a specified threshold. The product of this impact volume with a volumetric animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact volume is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded for a single source emission, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements.

With the exception of explosive sources, the sole relevant measure of potential harm to the marine wildlife due to sonar operations is the accumulated (summed over all source emissions) energy flux density received by the animal over the duration of the activity. Harassment measures for explosive sources include energy flux density and pressure-related metrics (peak pressure and positive impulse).

Regardless of the type of source, estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- Each source emission is modeled according to the particular operating mode of the sonar. The “effective” energy source level is computed by integrating over the bandwidth of the source, scaling by the pulse length, and adjusting for gains due to source directivity. The location of the source at the time of each emission must also be specified.

- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL data are sampled at the typical depth(s) of the source and at the nominal center frequency of the source. If the source is relatively broadband, an average over several frequency samples is required.
- The accumulated energy within the waters that the source is "operating" is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric, over all emissions, is stored at each grid point.
- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point for which the appropriate metric exceeds that threshold.
- Finally, the number of harassments is estimated as the "product" (scalar or vector, depending upon whether an animal density depth profile is available) of the impact volume and the animal densities.

This section describes in detail the process of computing impact volumes (that is, the first four steps described above). This discussion is presented in two parts: active sonars and explosive sources. The relevant assumptions associated with this approach and the limitations that are implied are also presented. The final step, computing the number of harassments is discussed in subsection D.6.

D.4.1 Computing Impact Volumes for Active Sound Sources

This section provides a detailed description of the approach taken to compute impact volumes for active sonars. Included in this discussion are:

- Identification of the underwater propagation model used to compute transmission loss data, a listing of the source-related inputs to that model, and a description of the output parameters that are passed to the energy accumulation algorithm.
- Definitions of the parameters describing each sonar type.
- Description of the algorithms and sampling rates associated with the energy accumulation algorithm.

D.4.1.1 Transmission Loss Calculations

Transmission loss (TL) data are pre-computed for each of two seasons in each of the environmental provinces described in the previous subsection using the Gaussian Ray Bundle (GRAB) propagation loss model (Keenan, 2000). The TL output consists of a parametric description of each significant eigenray (or propagation path) from source to animal. The description of each eigenray includes the departure angle from the source (used to model the source vertical directivity later in this process), the propagation time from the source to the animal (used to make corrections to absorption loss for minor differences in frequency and to incorporate a surface-image interference correction at low frequencies), and the transmission loss suffered along the eigenray path.

The frequency and source depth TL inputs are specified in Table D-12.

Table D-12 – TL Frequency and Source Depth by Type

SONAR	FREQUENCY	SOURCE DEPTH
SQS-53	3.5 kHz	7 m
AQS-22	4.1 kHz	27 m
ASQ-62	8 kHz	27 m
SQS-56	7.5 kHz	7 m
MK-84 Range Pingers	12.9 kHz	7m, 100m
PUTR Transponders	8.8 kHz	1,800 m
MK-39 EMATT	900 Hz	100 m
BQQ-10	Classified	100 m
BQS-15	Classified	50 m
SUS, MK-84	3.4 kHz	50 m

The eigenray data for a single GRAB model run are sampled at uniform increments in range out to a maximum range for a specific "animal" (or "target" in GRAB terminology) depth. Multiple GRAB runs are made to sample the animal depth dependence. The depth and range sampling parameters are summarized in Table D-13. Note that some of the low-power sources do not require TL data to large maximum ranges.

Table D-13 – TL Depth and Range Sampling Parameters by Sonar Type

SONAR	RANGE STEP	MAXIMUM RANGE	DEPTH SAMPLING
SQS-53	10 m	200 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
AQS-22	10 m	10 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
ASQ-62	5 m	5 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
SQS-56	10 m	50 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
MK-84 Range Pingers	5 m	15 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
PUTR Transponders	5 m	15 km	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
MK-39 EMATT	5 m	1 km	1 m steps
BQQ-10	Classified	Classified	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
BQS-15	Classified	Classified	0 – 1 km in 5 m steps 1 km – Bottom in 10 m steps
SUS, MK-84	5 m	1 km	1 m steps

In a few cases, most notably the SQS-53 for levels below approximately 180 dB, TL data may be required by the energy summation algorithm at ranges greater than covered by the pre-computed GRAB data. In these cases, TL is extrapolated to the required range using a simple cylindrical spreading loss law in addition to the appropriate absorption loss. This extrapolation leads to a conservative (or under) estimate of transmission loss at the greater ranges.

Although GRAB provides the option of including the effect of source directivity in its eigenray output, this capability is not exercised. By preserving data at the eigenray level, this allows source directivity to be applied later in the process and results in fewer TL calculations.

The other important feature that storing eigenray data supports is the ability to model the effects of surface-image interference that persist over range. However, this is primarily important at frequencies lower than those associated with the sonars considered in this subsection. A detailed description of the modeling of surface-image interference is presented in the subsection on explosive sources.

D.4.1.2 Energy Summation

The summation of energy flux density over multiple pings in a range-independent environment is a trivial exercise for the most part. A volumetric grid that covers the waters in and around the area of sonar operation is initialized. The source then begins its set of pings. For the first ping, the TL from the source to each grid point is determined (summing the appropriate eigenrays after they have been modified by the vertical beam pattern), the "effective" energy source level is reduced by that TL, and the result is added to the accumulated energy flux density at that grid point. After each grid point has been updated, the accumulated energy at grid points in each depth layer is compared to the specified threshold. If the accumulated energy exceeds that threshold, then the incremental volume represented by that grid point is added to the impact volume for that depth layer. Once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for one ping.

The source is then moved along one of the axes in the horizontal plane by the specified ping separation range and the second ping is processed in a similar fashion. Again, once all grid points have been processed, the resulting sum of the incremental volumes represents the impact volume for two pings. This procedure continues until the maximum number of pings specified has been reached.

Defining the volumetric grid over which energy is accumulated is the trickiest aspect of this procedure. The volume must be large enough to contain all volumetric cells for which the accumulated energy is likely to exceed the threshold but not so large as to make the energy accumulation computationally unmanageable.

Determining the size of the volumetric grid begins with an iterative process to determine the lateral extent to be considered. Unless otherwise noted, throughout this process the source is treated as omni-directional and the only animal depth that is considered is the TL target depth that is closest to the source depth (placing source and receiver at the same depth is generally an optimal TL geometry).

The first step is to determine the impact range (R_{max}) for a single ping. The impact range in this case is the maximum range at which the effective energy source level reduced by the transmission loss is greater than the threshold. Next, the source is moved along a straight-line track and energy flux density is accumulated at a point that has a CPA range of R_{max} at the mid-point of the source track. That total energy flux density summed over all pings is then compared to the prescribed threshold. If it is greater than the threshold (which, for the first R_{max}, it must be) then R_{max} is increased by ten percent, the accumulation process is repeated, and the total energy is again compared to the threshold. This continues until R_{max} grows large enough to ensure that the accumulated energy flux density at that lateral range is less than the threshold. The lateral range dimension of the volumetric grid is then set at twice R_{max}, with the grid centered along the source track. In the direction of advance for the source, the volumetric grid extends on the interval from [$-R_{max}$, 3 R_{max}] with the first source position located at zero in this dimension. Note that the source motion in this direction is limited to the interval [0, 2 R_{max}]. Once the source reaches 2 R_{max} in this direction, the incremental volume contributions have approximately reached their asymptotic limit and further pings add essentially the same amount. This geometry is demonstrated in Figure D-4 below.

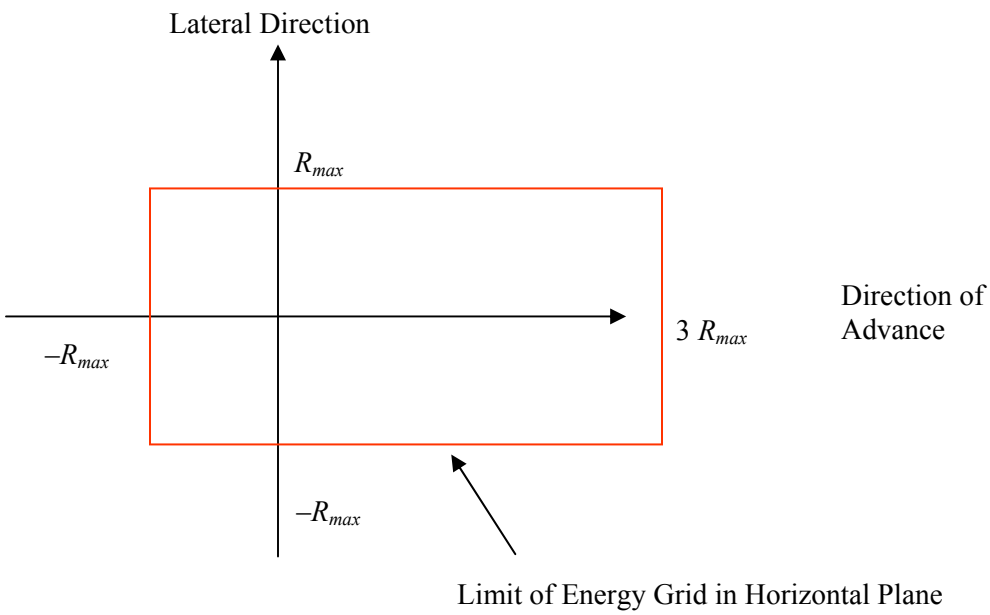

Figure D-4. Horizontal Plane of Volumetric Grid for Omni Directional Source

If the source is directive in the horizontal plane, then the lateral dimension of the grid may be reduced and the position of the source track adjusted accordingly. For example, if the main lobe of the horizontal source beam is limited to the starboard side of the source platform, then the port side of the track is reduced substantially as demonstrated in Figure D-5.

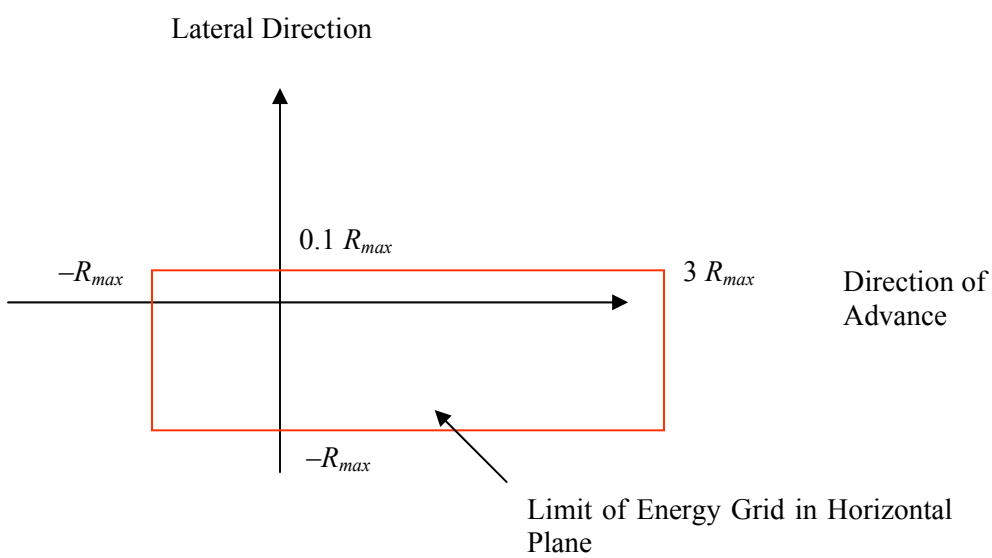

Figure D-5. Horizontal Plane of Volumetric Grid for Starboard Beam Source

Once the extent of the grid is established, the grid sampling can be defined. In both dimensions of the horizontal plane the sampling rate is approximately $R_{max}/100$. The round-off error associated with this sampling rate is roughly equivalent to the error in a numerical integration to determine the area of a circle with a radius of R_{max} with a partitioning rate of $R_{max}/100$ (approximately one percent). The depth-sampling rate of the grid is comparable to the sampling rates in the horizontal plane but discretized to match an actual TL sampling depth. The depth-sampling rate is also limited to no more than ten meters to ensure that significant TL variability over depth is captured.

D.4.1.3 Impact Volume per Hour of Source Operation

The impact volume for a source moving relative to the animal population increases with each additional ping. The rate at which the impact volume increases varies with a number of parameters but eventually approaches some asymptotic limit. Beyond that point the increase in impact volume becomes essentially linear as depicted in Figure D-6 using the SQS-53 as an example.

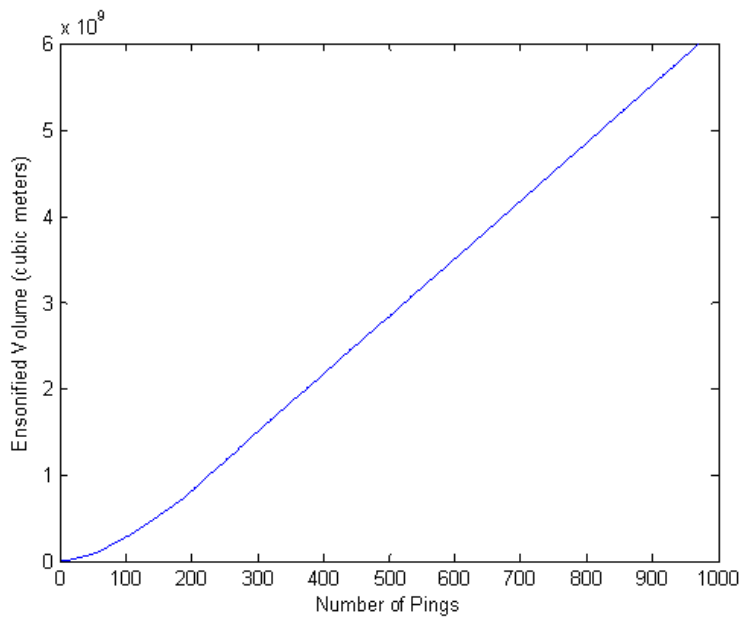

Figure D-6. SQS-53 Impact Volume by Ping

The slope of the asymptotic limit of the impact volume at a given depth is the impact volume added per ping. This number multiplied by the number of pings in an hour gives the hourly impact volume for the given depth increment. Completing this calculation for all depths in a province, for a given source, gives the hourly impact volume vector, v_n, which contains the hourly impact volumes by depth for province n. Figure D-7 provides an example of an hourly impact volume vector for a particular environment.

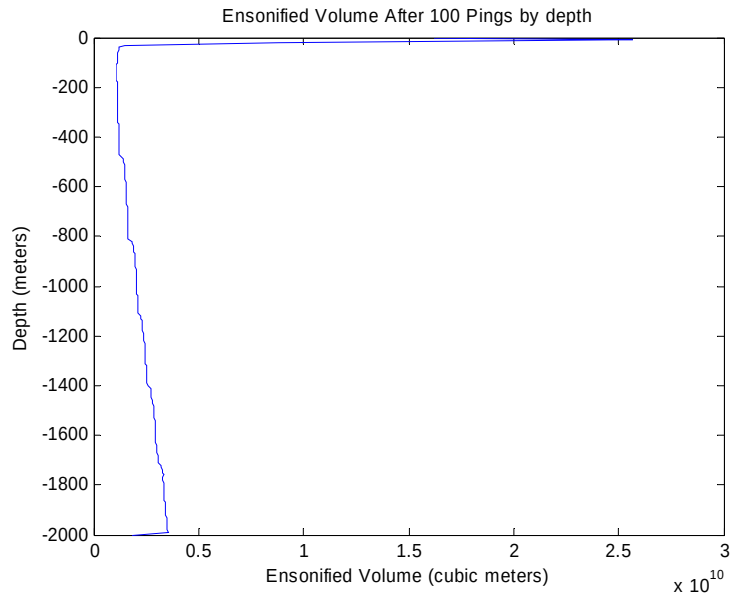

Figure D-7. Example of an Impact Volume Vector

D.4.2 Computing Impact Volumes for Explosive Sources

This section provides the details of the modeling of the explosive sources. This energy summation algorithm is similar to that used for sonars, only differing in details such as the sampling rates and source parameters. These differences are summarized in the following subsections. A more significant difference is that the explosive sources require the modeling of additional pressure metrics: (1) peak pressure, and (2) "modified" positive impulse. The modeling of each of these metrics is described in detail in the subsections of D.4.2.3.

D.4.2.1 Transmission Loss Calculations

Modeling impact volumes for explosive sources span requires the same type of TL data as needed for active sonars. However unlike active sonars, explosive ordnances and the EER source are broadband, contributing significant energy from tens of Hertz to tens of kilohertz. To accommodate the broadband nature of these sources, TL data are sampled at seven frequencies from 10 Hz to 40 kHz, spaced every two octaves.

An important propagation consideration at low frequencies is the effect of surface-image interference. As either source or target approach the surface, pairs of paths that differ by a single surface reflection set up an interference pattern that ultimately causes the two paths to cancel each other when the source or target is at the surface. A fully coherent summation of the eigenrays produces such a result but also introduces extreme fluctuations that would have to be highly sampled in range and depth, and then smoothed to give meaningful results. An alternative approach is to implement what is sometimes called a semi-coherent summation. A semi-coherent sum attempts to capture significant effects of surface-image interference (namely the reduction of the field due to destructive interference of reflected paths as the source or target approach the surface) without having to deal with the more rapid fluctuations associated with a fully coherent sum. The semi-coherent sum is formed by a random phase addition of paths that have already been multiplied by the expression:

$$\sin^2\left(\frac{4\pi f z_s z_a}{c^2 t}\right)$$

where f is the frequency, z_s is the source depth, z_a is the animal depth, c is the sound speed and t is the travel time from source to animal along the propagation path. For small arguments of the sine function this expression varies directly as the frequency and the two depths. It is this relationship that causes the propagation field to go to zero as the depths approach the surface or the frequency approaches zero.

This surface-image interference must be applied across the entire bandwidth of the explosive source. The TL field is sampled at several representative frequencies. However, the image-interference correction given above varies substantially over that frequency spacing. To avoid possible under sampling, the image-interference correction is averaged over each frequency interval.

D.4.2.2 Source Parameters

Unlike active sonars, explosive sources are defined by only two parameters: (1) net explosive weight, and (2) source detonation depth. Values for these source parameters are defined earlier in subsection D.2.2.

The effective energy source level, which is treated as a de facto input for the other sources, is instead modeled directly for SSQ-110 explosive sonobuoys and munitions. For both, the energy source level is comparable to the model used for other explosives (Arons (1954), Weston (1960), McGrath (1971), Urick (1983), Christian and Gaspin (1974)). The energy source level over a one-third octave band with a center frequency of f for a source with a net explosive weight of w pounds is given by:

$$\text{ESL} = 10 \log_{10} (0.26 f) + 10 \log_{10} (2 p_{max}^2 / [1/\theta^2 + 4 \pi f^2]) + 197 \text{ dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21600 (w^{1/3} / 3.28)^{1.13} \text{ psi} \qquad \text{(A-1)}$$

and the time constant is defined as:

$$\theta = [(0.058) (w^{1/3}) (3.28 / w^{1/3})^{0.22}] / 1000 \text{ msec} \qquad \text{(A-2)}$$

In contrast to munitions that are modeled as omni-directional sources, the SSQ-110 is a directed source consisting of two explosive strips that are fired simultaneously from the center of the array. Each strip generates a beam pattern with the steer direction of the main lobe determined by the burn rate. The resulting response of the entire array is a bifurcated beam for frequencies above 200 Hz, while at lower frequencies the two beams tend to merge into one.

Since very short ranges are under consideration, the loss of directivity of the array needs to be accounted for in the near field of the array. This is accomplished by modeling the sound pressure level across the field as the coherent sum of contributions of infinitesimal sources along the array that are delayed according to the burn rate. For example, for frequency f the complex pressure contribution at a depth z and horizontal range r from an infinitesimal source located at a distance z' above the center of the array is

$$p(r,z) = e^{i\phi}$$

where

$\phi = kr' + \alpha z'$, and

$\alpha = 2\,\pi f / c_b$

with k the acoustic wave number, c_b the burn rate of the explosive ribbon, and r' the slant range from the infinitesimal source to the field point (x,z).

Beam patterns as function of vertical angle are then sampled at various ranges out to a maximum range that is approximately L^2 / λ where L is the array length and λ is the wavelength. This maximum range is a rule-of-thumb estimate for the end of the near field (Bartberger, 1965). Finally, commensurate with the resolution of the TL samples, these beam patterns are averaged over octave bands.

A couple of sample beam patterns are provided in Figure D-8 and Figure D-9. In both cases, the beam response is sampled at various ranges from the source array to demonstrate the variability across the near field. The 80-Hz family of beam patterns presented in Figure D-8 shows the rise of a single main lobe as range increases.

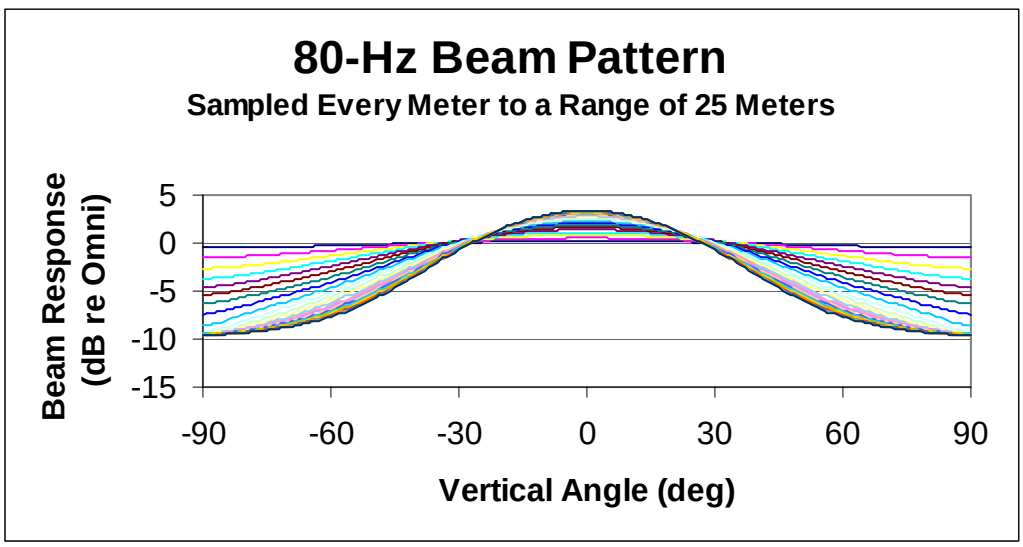

Figure D-8. 80-Hz Beam Patterns across Near Field of EER Source

On the other hand, the 1,250-Hz family of beam patterns depicted in Figure D-9 demonstrates the typical high-frequency bifurcated beam.

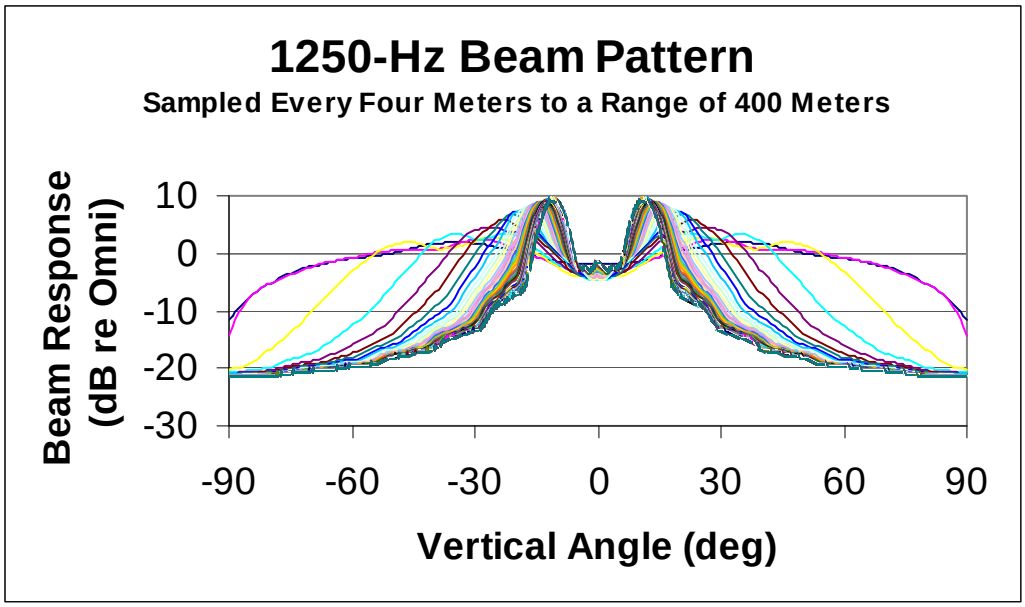

Figure D-9. 1250-Hz Beam Patterns across Near Field of SSQ-110 Source

D.4.2.3 Impact Volumes for Various Metrics

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, peak one-third octave, is treated in similar fashion as the energy metric used for the active sonars, including the summation of energy if there are multiple source emissions. The other two, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

Peak One-Third Octave Energy Metric

The computation of impact volumes for the energy metric closely follows the approach taken to model the energy metric for the active sonars. The only significant difference is that energy flux density is sampled at several frequencies in one-third-octave bands and only the peak one-third-octave level is accumulated over time.

Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission ratio, modified by the source level in a one-octave band and the vertical beam pattern, is averaged across frequency on an eigenray-by-eigenray basis. This averaged transmission ratio (normalized by the total broadband source level) is then compared across all eigenrays with the maximum designated as the peak arrival. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the averaged transmission ratio of the peak arrival,
- The peak pressure at a range of 1 meter (given by equation A-1), and
- The similitude correction (given by $r^{-0.13}$, where r is the slant range along the eigenray estimated as *tc* with *t* the travel time along the dominant eigenray and *c* the nominal speed of sound).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

"Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$\int_{0}^{T_{min}} p(t)\, dt$$

where $p(t)$ is the pressure wave from the explosive as a function of time t, defined so that $p(t) = 0$ for $t < 0$. This pressure wave is modeled as

$$p(t) = p_{max}\, e^{-t/\theta}$$

where p_{max} is the peak pressure at 1 meter (see, equation B-1), and θ is the time constant defined as

$$\theta = 0.058\, w^{1/3}\, (r/w^{1/3})^{0.22} \text{ seconds}$$

with w the net explosive weight (pounds), and r the slant range between source and animal.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min\, \{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-*reflected* path in an isospeed environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c\, \{\, [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2}\, \}$$

where c is the speed of sound.

The *animal* lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17\, M^{1/3}\, (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\, (M/42)^{1/3}\, (1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 19.7; for the onset of extensive lung hemorrhaging (1% mortality), K is 47.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1% mortality), the threshold at the surface is approximately 31 psi-msec.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

D.4.2.4 Impact Volume per Explosive Detonation

The detonations of explosive sources are generally widely spaced in time and/or space. This implies that the impact volume for multiple firings can be easily derived by scaling the impact volume for a single detonation. Thus the typical impact volume vector for an explosive source is presented on a per-detonation basis.

D.4.3 Impact Volume by Region

The TMAA is described by eleven (11) environmental provinces. The hourly impact volume vector for operations involving any particular source is a linear combination of the eleven impact volume vectors with the weighting determined by the distribution of those eleven environmental provinces within the range. Unique hourly impact volume vectors for winter and summer are calculated for each type of source and each metric/threshold combination.

D.5 RISK FUNCTION: THEORETICAL AND PRACTICAL IMPLEMENTATION

This section discusses the recent addition of a risk function response "threshold" to acoustic effects analysis procedure. This approach includes two parts, a metric, and a function to map exposure level under the metric to probability of harassment for acoustic sources. What these two parts mean, how they affect exposure calculations, and how they are implemented are the objects of discussion.

D.5.1 Thresholds and Metrics

The term "thresholds" is broadly used to refer to both thresholds and metrics. The difference, and the distinct roles of each in effects analyses, will be the foundation for understanding the dose-response approach, putting it in perspective, and showing that, conceptually, it is similar to past approaches.

Sound is a pressure wave, so at a certain point in space, sound is simply rapidly changing pressure. Pressure at a point is a function of time. Define $p(t)$ as pressure (in micropascals) at a given point at time t (in seconds); this function is called a "time series." Figure D-10 gives the time series of the first "hallelujah" in Handel's Hallelujah Chorus.

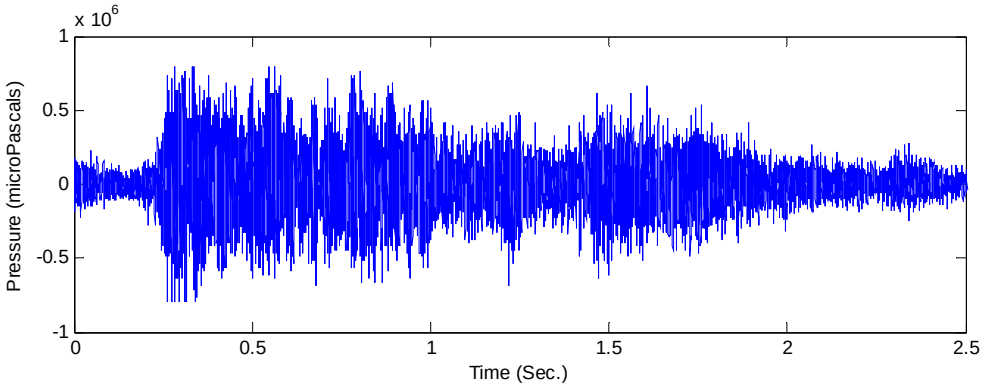

Figure D-10. Time Series

The time-series of a source can be different at different places. Therefore, sound, or pressure, is not only a function of time, but also of location. Let the function $p(t)$, then be expanded to $p(t;x,y,z)$ and denote the time series at point (x,y,z) in space. Thus, the series in Figure D-10 $p(t)$ is for a given point (x,y,z). At a different point in space, it would be different.

Assume that the location of the source is (0,0,0) and this series is recorded at (0,10,-4). The time series above would be p(t;0,10,-4) for 0<t<2.5.

As in Figure D-10, pressure can be positive or negative, but acoustic power, which is proportional to the square of the pressure, is always positive, this makes integration meaningful. Figure D-11 is $p^2(t;0,10,-4)$.

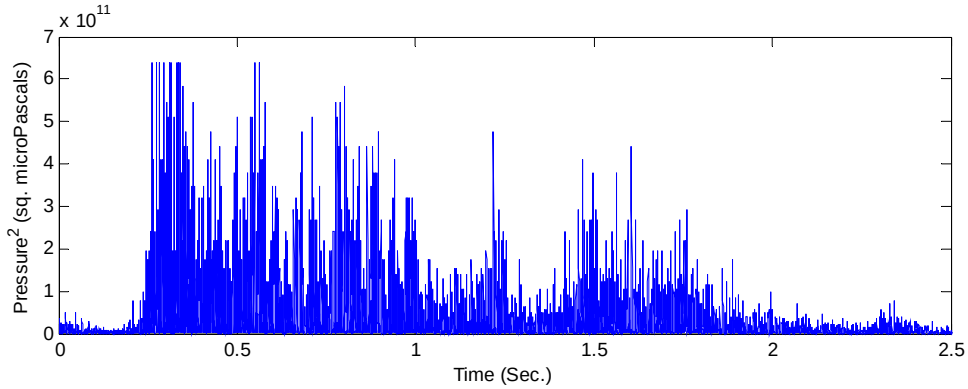

Figure D-11. Time Series Squared

The metric chosen to evaluate the sound field at the end of this first "hallelujah" determines how the time series is summarized from thousands of points, as in Figure D-10, to a single value for each point (x,y,z) in the space. The metric essentially "boils down" the four dimensional $p(t,x,y,z)$ into a three dimensional function $m(x,y,z)$ by dealing with time. There is more than one way to summarize the time component, so there is more than one metric.

D.5.2 Maximum Sound Pressure Level

Because of the large dynamic range of the acoustic power, it is generally represented on a logarithmic scale using sound pressure levels (SPLs). SPL is actually the ratio of acoustic power and density (power/unit area = $\frac{p^2}{Z}$ where Z = ρc is the acoustic impedance). This ratio is presented on a logarithmic scale relative to a reference pressure level, and is defined as:

$$SPL = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right) = 20\log_{10}\left(abs\left(\frac{p}{p_{ref}}\right)\right)$$

(Note that SPL is defined in dB re a reference pressure, even though it comes from a ratio of powers.)

One way to characterize the power of the time series $p(t;x,y,z)$ with a single number over the 2.5 seconds is to only report the maximum SPL value of the function over time or,

$SPL_{\max} = \max\left\{10\log_{10}\left(p^2(t,x,y,z)\right)\right\}$ (relative to a reference pressure of 1μPa^2-s) for 0<t<2.5

The $SPL_{\max}$ for this snippet of the Hallelujah Chorus is $10\log_{10}\left(6.4\times10^{11}\,\mu Pa^2/1\mu Pa^2\right) = 118\,dB$ re 1μPa^2-s and occurs at 0.2606 seconds, as shown in Figure D-12.

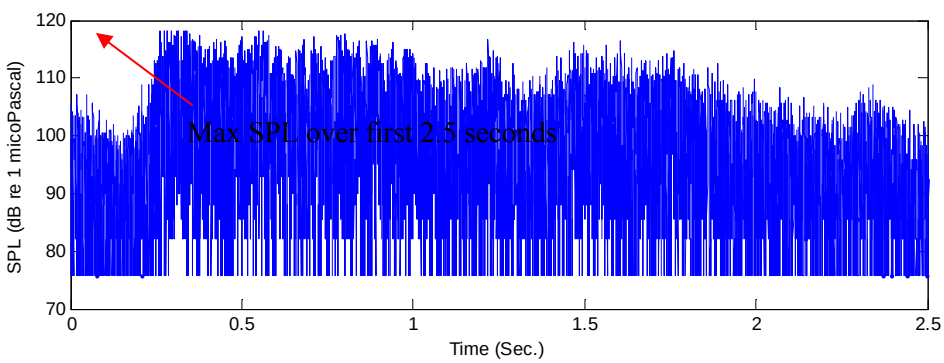

Figure D-12. Max SPL of Time Series Squared

D.5.3 Integration

$SPL_{\max}$ is not necessarily influenced by the duration of the sound (2.5 seconds in this case). Integrating the function over time gives the EFD, which accounts for this duration. A simple integration of $p^2(t;x,y,z)$ over t is common and is proportional to the EFD at (x,y,z). Because we will again be dealing in levels (logarithms of ratios), we neglect the impedance and simply measure the square of the pressure:

$$Energy = \int_0^T p^2(t,x,y,z)dt$$, where T is the maximum time of interest in this case 2.5.

The energy for this snippet of the Hallelujah Chorus is $8.47 \times 10^{10}\ \mu Pa^2 \cdot s$. This would more commonly be reported as an energy level (EL):

$$EL = 10\log_{10}\left(\frac{\int_0^T p^2(t,x,y,z)dt}{1.0\mu Pa^2 s}\right) = 109.3 \text{ dB re } 1\mu Pa^2\text{-s}$$

Energy is sometimes called "equal energy" because if $p(t)$ is a constant function and the duration is doubled, the effect is the same as doubling the signal amplitude (y value). Thus, the duration and the signal have an "equal" influence on the energy metric.

Mathematically we have

$$\int_0^{2T} p(t)^2\,dt = 2\int_0^T p(t)^2\,dt = \int_0^T 2\,p(t)^2\,dt$$

or a doubling in duration equals a doubling in energy equals a doubling in signal.

Sometimes, the integration metrics are referred to as having a "3 dB exchange rate" because if the duration is doubled, this integral increases by a factor of two, or 10log10(2)=3.01 dB. Thus, equal energy has "a 3 dB exchange rate."

After *p(t)* is determined (i.e., when the stimulus is over), propagation models can be used to determine *p(t;x,y,z)* for every point in the vicinity and for a given metric. Define

$$m_a(x,y,z,T) = \text{value of metric "}a\text{" at point }(x,y,z)\text{ after time }T$$

So,

$$m_{energy}(x,y,z;T) = \int_0^T p(t)^2\,dt$$

$$m_{\max SPL}(x,y,z;T) = \max 10\log_{10}\left(p^2(t)\right) over\ [0,T]$$

Since modeling is concerned with the effects of an entire event, T is usually implicitly defined: a number that captures the duration of the event. This means that $m_a(x,y,z)$ is assumed to be measured over the duration of the received signal.

D.5.3.1 Three Dimensions versus Two Dimensions

To further reduce the calculation burden, it is possible to reduce the domain of $m_a(x,y,z)$ to two dimensions by defining $m_a(x,y) = \max\{m_a(x,y,z)\}$ over all z. This reduction is not used for this analysis, which is exclusively three-dimensional.

D.5.4 Threshold

For a given metric, a threshold is a function that gives the probability of exposure at every value of m_a. This threshold function will be defined as

$$D(m_a(x,y,z)) = P(effect\ at\ m_a(x,y,z))$$

The domain of *D* is the range of $m_a(x,y,z)$, and the range of *D* is [0,1].

An example of threshold functions is the heavyside (or unit step) function, currently used to determine permanent and temporary threshold shift (PTS and TTS) in cetaceans. For PTS, the metric is $m_{energy}(x,y,z)$, defined above, and the threshold function is a heavyside function with a discontinuity at 215 dB, shown in Figure D-13.

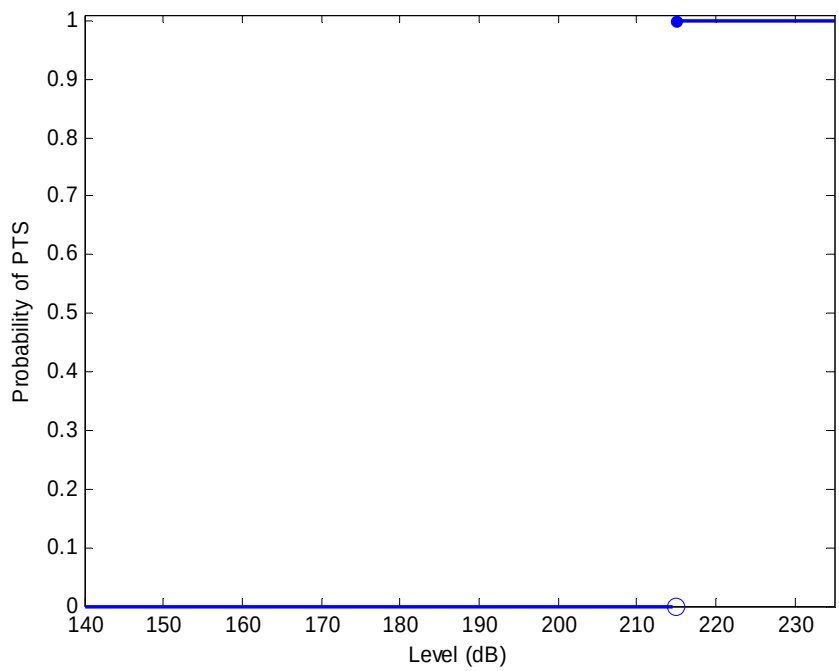

Figure D-13. PTS Heavyside Threshold Function

Symbolically, this *D* is defined as:

$$D(m_{energy}) = \begin{cases} 0\ for\ m_{energy} < 215 \\ 1\ for\ m_{energy} \geq 215 \end{cases}$$

Any function can be used for D, as long as its range is in [0,1]. The risk function uses normal Feller risk functions (defined below) instead of heavyside functions, and use the max SPL metric instead of the energy metric. While a heavyside function is specified by a single parameter, the discontinuity, a Feller function requires three parameters: the basement cutoff value, the level above the basement for 50% effect, and a steepness parameter. Mathematically, these Feller, "risk" functions, *D*, are defined as

$$D(m_{\max SPL}) = \begin{cases} \dfrac{1}{1+\left(\dfrac{K}{m_{\max SPL}-B}\right)^{A}} & for\ m_{\max SPL} \geq B \\ 0 & for\ m_{\max SPL} < B \end{cases} \quad 1$$

where B = cutoff (or basement), K = the difference in level (dB) between the basement and the median (50% effect) harassment level, and A = the steepness factor. The dose function for odontocetes and pinnipeds uses the parameters:

B = 120 dB,

K = 45 dB, and

A = 10.

The dose function for mysticetes uses:

B = 120 dB,

K = 45 dB, and

A = 8.

Harbor porpoises are a special case. Though the metric for their behavioral harassment is also SPL, their risk function is a heavyside step function with a harassment threshold discontinuity (0 % to 100 %) at 120 dB. All other species use the continuous Feller risk-function for evaluating expected harassment.

D.5.5 Calculation of Expected Exposures

Determining the number of expected exposures for disturbance is the object of this analysis.

$$\text{Expected exposures in volume V=} \int_V \rho(V) D(m_a(V)) dV$$

For this analysis, $m_a = m_{\max SPL}$, so

$$\int_V \rho(V) D\big(m_a(V)\big) dV = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \rho(x,y,z) D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$$

In this analysis, the densities are constant over the xy-plane, and the z dimension is always negative, so this reduces to

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$$

1 The equation can also be represented as shown in Section 3.8.6.3 of this EIS/OEIS

D.5.6 Numeric Implementation

Numeric integration of $\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz$ can be involved because, although the bounds are infinite, D is non-negative out to 120 dB, which, depending on the environmental specifics, can drive propagation loss calculations and their numerical integration out to more than 100 km.

The first step in the solution is to separate out the *xy*-plane portion of the integral:

$$\text{Define } f(z) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\,.$$

Calculation of this integral is the most involved and time consuming part of the calculation. Once it is complete,

$$\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))\, dx\, dy\, dz = \int_{-\infty}^{0} \rho(z) f(z) dz\,,$$

which, when numerically integrated, is a simple dot product of two vectors.

Thus, the calculation of *f(z)* requires the majority of the computation resources for the numerical integration. The rest of this section presents a brief outline of the steps to calculate *f(z)* and preserve the results efficiently.

The concept of numerical integration is, instead of integrating over continuous functions, to sample the functions at small intervals and sum the samples to approximate the integral. Smaller sized intervals yield closer approximations with longer calculation time, so a balance between accuracy and time is determined in the decision of step size. For this analysis, z is sampled in 5 meter steps to 1000 meters in depth and 10 meter steps to 2000 meters, which is the limit of animal depth in this analysis. The step size for x is 5 meters, and y is sampled with an interval that increases as the distance from the source increases. Mathematically,

$$\begin{aligned}
&z \in Z = \{0,5,...1000,1010,...,2000\} \\
&x \in X = \{0,\pm 5,...,\pm 5k\} \\
&y \in Y = \left\{0, \pm 5 * (1.005)^0, \pm 5 * \left[(1.005)^0 + (1.005)^1\right], ..., \pm 5 * \left[\sum_{i=0}^{j} (1.005)^i\right]\right\}
\end{aligned}$$

for integers k, j, which depend on the propagation distance for the source. For this analysis, k = 20,000 and j = 600.

With these steps, $f(z_0) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z_0)) dxdy$ is approximated as

$$\sum_{z \in Y} \sum_{x \in X} D(m_{\max SPL}(x,y,z_0)) \Delta x \Delta y$$

where X,Y are defined as above.

This calculation must be repeated for each $z_0 \in Z$, to build the discrete function *f*(*z*).

With the calculation of *f*(*z*) complete, the integral of its product with $\rho(z)$ must be calculated to complete evaluation of

$$\int_{-\infty}^{\infty} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))dxdydz = \int_{-\infty}^{0} \rho(z) f(z) dz$$

Since *f*(*z*) is discrete, and $\rho(z)$ can be readily made discrete, this equation is approximated numerically as $\sum_{z \in Z} \rho(z) f(z)$, a dot product.

D.5.7 Preserving Calculations for Future Use

Calculating *f*(*z*) is the most time-consuming part of the numerical integration, but the most time-consuming portion of the entire process is calculating $m_{\max SPL}(x,y,z)$ over the area range required for the minimum cutoff value (120 dB). The calculations usually require propagation estimates out to over 100 km, and those estimates, with the beam pattern, are used to construct a sound field that extends 200 km × 200 km = 40,000 sq km, with a calculation at the steps for every value of *X* and *Y*, defined above. This is repeated for each depth, to a maximum of 2,000 meters.

Saving the entire $m_{\max SPL}$ for each *z* is unrealistic, requiring great amounts of time and disk space. Instead, the different levels in the range of $m_{\max SPL}$ are sorted into 0.5 dB wide bins; the volume of water at each bin level is taken from $m_{\max SPL}$, and associated with its bin. Saving this, the amount of water ensonified at each level, at a 0.5 dB resolution, preserves the ensonification information without using the space and time required to save $m_{\max SPL}$ itself. Practically, this is a histogram of occurrence of level at each depth, with 0.5 dB bins. Mathematically, this is simply defining the discrete functions $V_z(L)$, where $L = \{.5a\}$ for every positive integer *a*, and for all $z \in Z$. These functions, or histograms, are saved for future work. The information lost by saving only the histograms is *where* in space the different levels occur, although *how often* they occur is saved. But the thresholds (risk function curves) are purely a function of level, not location, so this information is sufficient to calculate *f*(*z*).

Applying the risk function to the histograms is a dot product:

$$\sum_{\ell \in L_1} D(\ell) V_{z_0}(\ell) \approx \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z_0))dxdy$$

So, once the histograms are saved, neither $m_{\max SPL}(x,y,z)$ nor *f*(*z*) must be recalculated to generate $\int_{-\infty}^{0} \rho(z) \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} D(m_{\max SPL}(x,y,z))dxdydz$ for a new threshold function.

For the interested reader, the following section includes an in-depth discussion of the method, software, and other details of the *f*(*z*) calculation.

D.5.8 Software Detail

The risk-function metric uses the aforementioned Feller function to determine the probability that an animal is affected by a given sound pressure level. The acoustic quantity of interest is the maximum sound pressure level (SPL) experienced over multiple pings in a range-independent environment. The procedure for calculating the impact volume at a given depth is relatively simple. In brief, given the SPL of the source and the transmission loss (TL) curve, the received SPL is calculated on a volumetric grid. For a given depth, volume associated with each SPL interval is calculated. Then, this volume is multiplied by the probability that an animal will be affected by that sound pressure level. This gives the impact volume for that depth, which can be multiplied by the animal densities at that depth, to obtain the number of animals affected at that depth. The process repeats for each depth to construct the impact volume as a function of depth.

The case of a single emission of sound energy, one ping, illustrates the computational process in more detail. First, the sound pressure levels are segregated into a sequence of bins that cover the range encountered in the area. The SPL are used to define a volumetric grid of the local sound field. The impact volume for each depth is calculated as follows: for each depth in the volumetric grid, the SPL at each *xy*-plane grid point is calculated using the SPL of the source, the TL curve, the horizontal beam pattern of the source, and the vertical beam patterns of the source. The sound pressure levels in this grid become the bins in the volume histogram.

Figure D-14 shows an example volume histogram for a low-power source. Level bins are 0.5 dB in width and the depth is 50 meters in an environment with water depth of 100 meters. The oscillatory structure at very low levels is due to the flattening of the TL curve at long distances from the source, which magnifies the fluctuations of the TL as a function of range. The "expected" impact volume for a given level at a given depth is calculated by multiplying the volume in each level bin by the risk function evaluated at that level. Total expected impact volume for a given depth is the sum of these "expected" volumes.

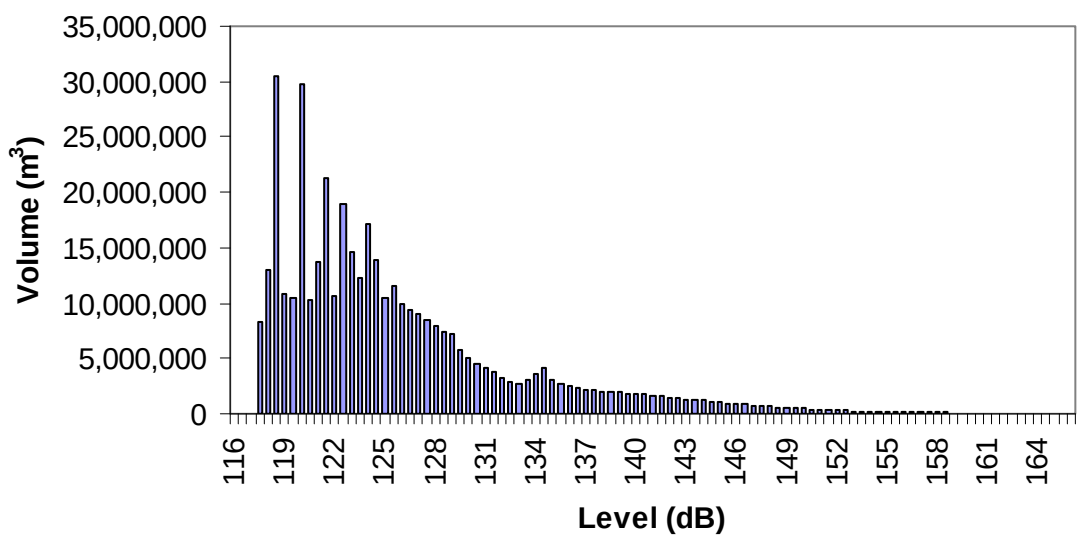

Figure D-14. Example of a Volume Histogram

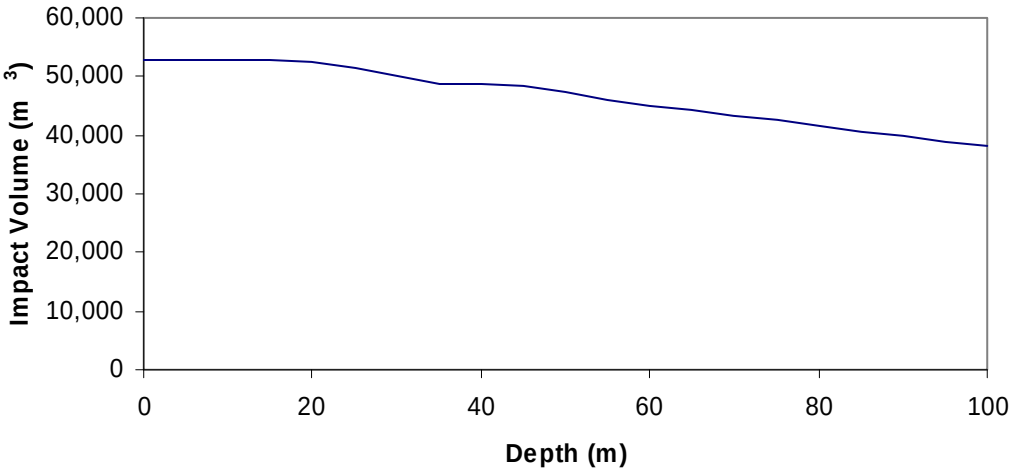

Figure D-15. Example of the Dependence of Impact Volume on Depth

The volumetric grid covers the waters in and around the area of a source's operation. The grid for this analysis has a uniform spacing of 5 meters in the *x*-coordinate and a slowly expanding spacing in the *y*-coordinate that starts with 5 meters spacing at the origin. The growth of the grid size along the *y*-axis is a geometric series where each successive grid size is obtained from the previous by multiplying it by $1 + Ry$, where Ry is the *y*-axis growth factor. The nth grid size is related to the first grid size by multiplying by $(1 + Ry)^{(n-1)}$. For an initial grid size of 5 meters and a growth factor of 0.005, the 100th grid increment is 8.19 meters. The constant spacing in the *x*-coordinate allows greater accuracy as the source moves along the *x*-axis. The slowly increasing spacing in *y* reduces computation time, while maintaining accuracy, by taking advantage of the fact that TL changes more slowly at longer distances from the source. The *x*-and *y*-coordinates extend from $-R_{max}$ to $+R_{max}$, where R_{max} is the maximum range used in the TL calculations. The *z* direction uses a uniform spacing of 5 meters down to 1000 meters and 10 meters from 1000 to 2000 meters. This is the same depth mesh used for the effective energy metric as described above. The depth mesh does not extend below 2000 meters, on the assumption that animals of interest are not found below this depth.

The next three figures indicate how the accuracy of the calculation of impact volume depends on the parameters used to generate the mesh in the horizontal plane. Figure D-16 shows the relative change of impact volume for one ping as a function of the grid size used for the *x*-axis. The *y*-axis grid size is fixed at 5 m and the *y*-axis growth factor is 0, i.e., uniform spacing. The impact volume for a 5 meters grid size is the reference. For grid sizes between 2.5 and 7.5 meters, the change is less than 0.1%. A grid size of 5 meters for the *x*-axis is used in the calculations.

Figure D-17 shows the relative change of impact volume for one ping as a function of the grid size used for the x-axis and the *y*-axis grids, respectively. The *x*-axis grid size is fixed at 5 meters and the *y*-axis growth factor is 0. The impact volume for a 5 meters grid size is the reference. This figure is very similar to that for the *x*-axis grid size. For grid sizes between 2.5 and 7.5 meters, the change is less than 0.1%. A grid size of 5 meters is used for the *y*-axis in our calculations. Figure D-18 shows the relative change of impact volume for one ping as a function of the *y*-axis growth factor. The *x*-axis grid size is fixed at 5 meters and the initial *y*-axis grid size is 5 meters. The impact volume for a growth factor of 0 is the reference. For growth factors from 0 to 0.01, the change is less than 0.1%. A growth factor of 0.005 is used in the calculations.

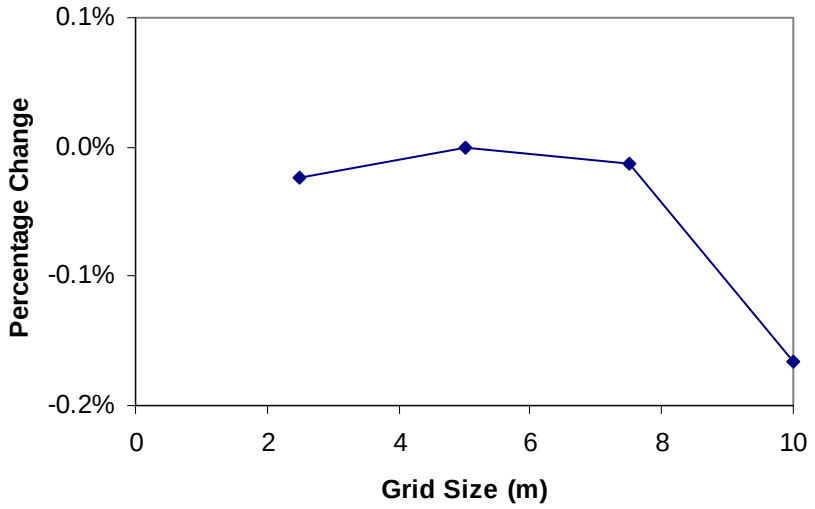

Figure D-16. Change of Impact Volume as a Function of *x*-axis Grid Size

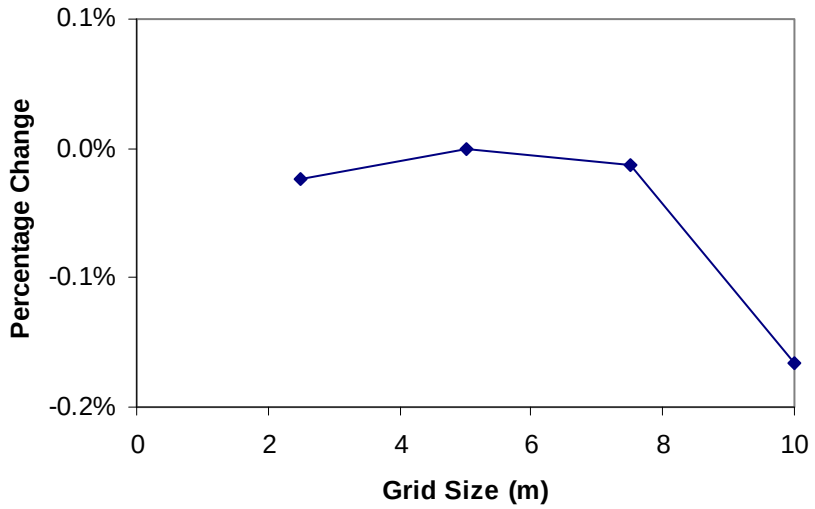

Figure D-17. Change of Impact Volume as a Function of y-axis Grid Size

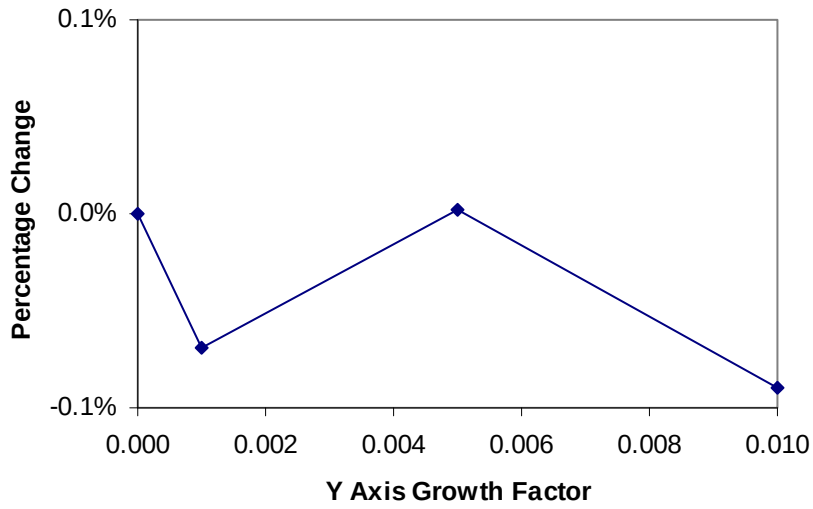

Figure D-18. Change of Impact Volume as a Function of y-axis Growth Factor

Another factor influencing the accuracy of the calculation of impact volumes is the size of the bins used for sound pressure level. The sound pressure level bins extend from 100 dB (far lower than required) up to 300 dB (much higher than that expected for any sonar system).

Figure D-19 shows the relative change of impact volume for one ping as a function of the bin width. The *x*-axis grid size is fixed at 5 meters, and the initial *y*-axis grid size is 5 meters with a *y*-axis growth factor of 0.005. The impact volume for a bin size of 0.5 dB is the reference. For bin widths from 0.25 dB to 1.00 dB, the change is about 0.1%. A bin width of 0.5 is used in our calculations.

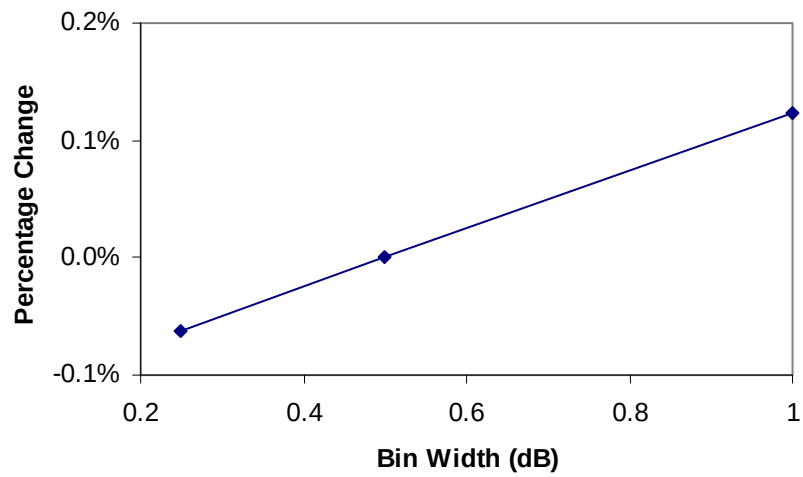

Figure D-19. Change of Impact Volume as a Function of Bin Width

Two other issues for discussion are the maximum range (R_{max}) and the spacing in range and depth used for calculating TL. The TL generated for the energy accumulation metric is used for dose-response analysis. The same sampling in range and depth is adequate for this metric because it requires a less

demanding computation (i.e., maximum value instead of accumulated energy). Using the same value of R_{max} needs some discussion since it is not clear that the same value can be used for both metrics. R_{max} was set so that the TL at R_{max} is more than needed to reach the energy accumulation threshold of 173 dB for 1000 pings. Since energy is accumulated, the same TL can be used for one ping with the source level increased by 30 dB (10 $\log_{10}(1000)$). Reducing the source level by 30 dB, to get back to its original value, permits the handling of a sound pressure level threshold down to 143 dB, comparable to the minimum required. Hence, the TL calculated to support energy accumulation for 1000 pings will also support calculation of impact volumes for the dose-response metric.

The process of obtaining the maximum sound pressure level at each grid point in the volumetric grid is straightforward. The active sonar starts at the origin and moves at constant speed along the positive *x*-axis emitting a burst of energy, a ping, at regularly spaced intervals. For each ping, the distance and horizontal angle connecting the source to each grid point is computed. Calculating the TL from the source to a grid point has several steps. The TL is made up of the sum of many eigenrays connecting the source to the grid point. The beam pattern of the source is applied to the eigenrays based on the angle at which they leave the source. After summing the vertically beamformed eigenrays on the range mesh used for the TL calculation, the vertically beamformed TL for the distance from the sonar to the grid point is derived by interpolation. Next, the horizontal beam pattern of the source is applied using the horizontal angle connecting the sonar to the grid point. To avoid problems in extrapolating TL, only grid points with distances less than R_{max} are used. To obtain the sound pressure level at a grid point, the sound pressure level of the source is reduced by that TL. For the first ping, the volumetric grid is populated by the calculated sound pressure level at each grid point. For the second ping and subsequent pings, the source location increments along the *x*-axis by the spacing between pings and the sound pressure level for each grid point is again calculated for the new source location. Since the risk-function metric uses the maximum of the sound pressure levels at each grid point, the newly calculated sound pressure level at each grid point is compared to the sound pressure level stored in the grid. If the new level is larger than the stored level, the value at that grid point is replaced by the new sound pressure level.

For each bin, a volume is determined by summing the ensonified volumes with a maximum SPL in the bin's interval. This forms the volume histogram shown in Figure D-14. Multiplying by the dose-response probability function for the level at the center of a bin gives the impact volume for that bin. The result can be seen in Figure D-15, which is an example of the impact volume as a function of depth.

The impact volume for a sonar moving relative to the animal population increases with each additional ping. The rate at which the impact volume increases for the risk function metric is essentially linear with the number of pings. Figure D-20 shows the dependence of impact volume on the number of pings. The slope of the line at a given depth is the impact volume added per ping. This number multiplied by the number of pings in an hour gives the hourly impact volume for the given depth increment. Completing this calculation for all depths in a province, for a given source, gives the hourly impact volume vector which contains the hourly impact volumes by depth for a province.

Figure D-21 provides an example of an hourly impact volume vector for a particular environment. Given the speed of the sonar platform, the hourly impact volume vector could be displayed as the impact volume vector per kilometer of track.

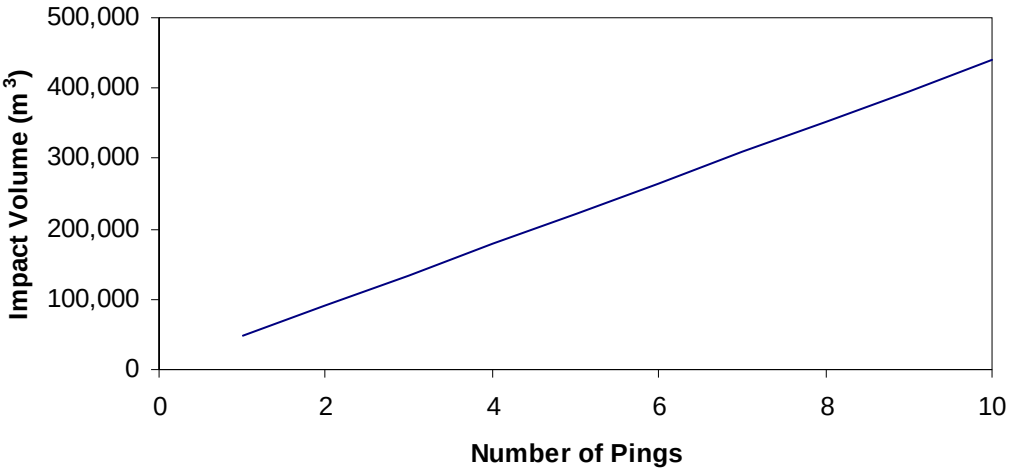

Figure D-20. Dependence of Impact Volume on the Number of Pings

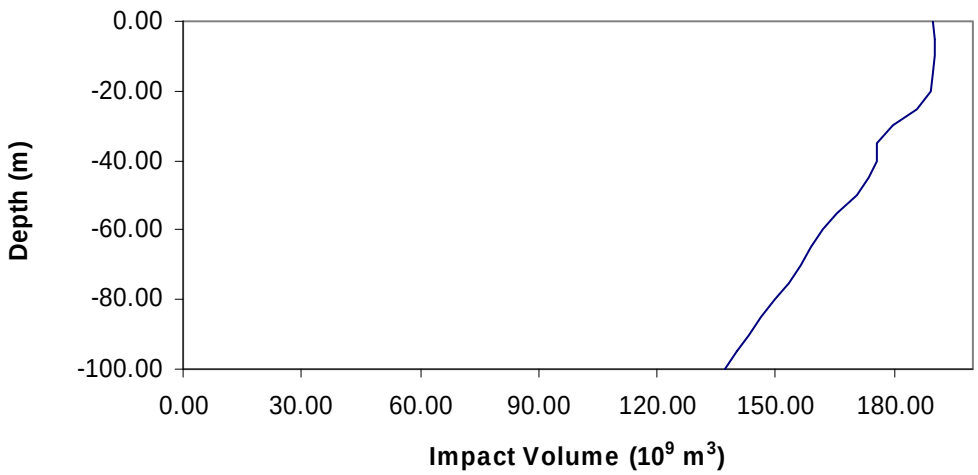

Figure D-21. Example of an Hourly Impact Volume Vector

D.5.9 Modeling Quiet and Continuous Sources

The TMAA has modeled sources whose energy contributions do not exceed EFDL thresholds, but have source levels above 120 dB, and move in a continuous fashion. The previous discussion of software detail would present under-sampling artifacts when applied to quiet sources, so an alternative approach is implemented.

Consider transmission loss with cylindrical symmetry surrounding an omni-directional source (Figure D-22):

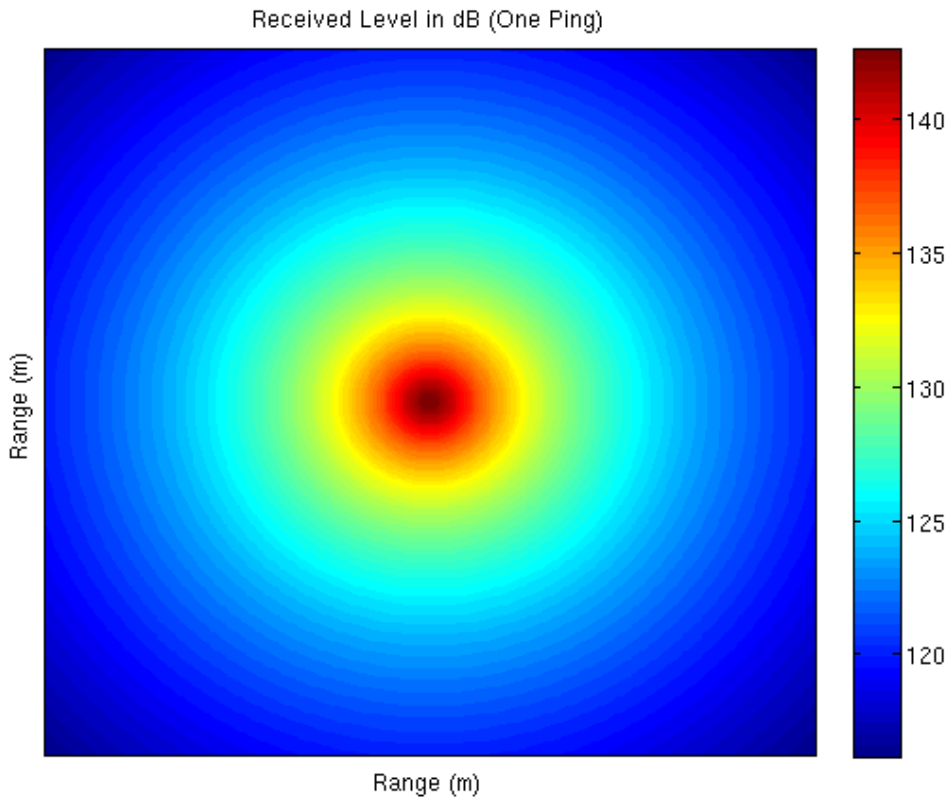

Figure D-22. – Single Ping Maximum SPL Field

When the factors of continuous pinging behavior, monotonic transmission loss in the short range, and maximum SPL as the input metric for the risk function, computing the maximum SPL field is a matter of extending the field as such (Figure D-23):

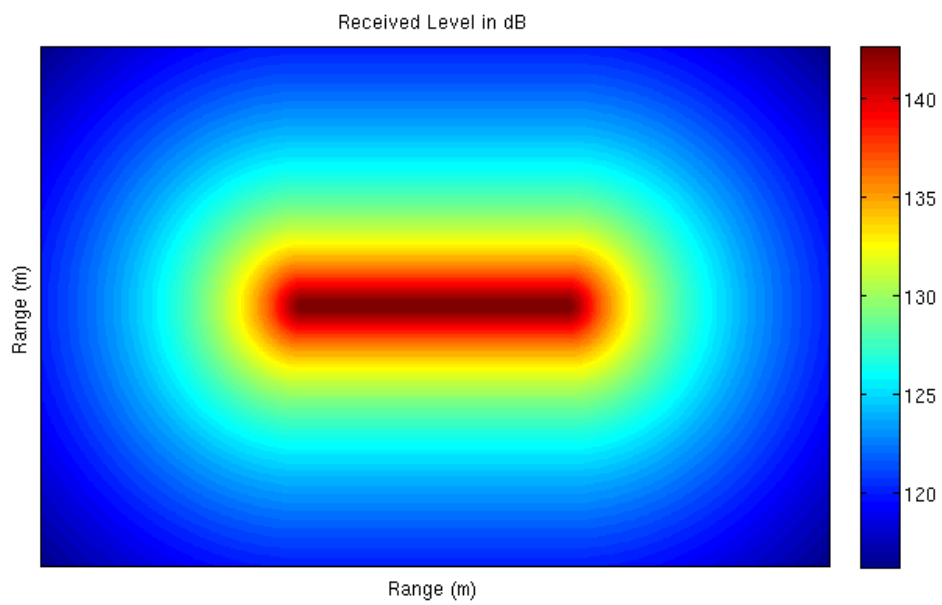

Figure D-23. – Quiet Continuous Sound Source

In the direction orthogonal to source motion, maximum SPL is achieved at CPA. This algorithm takes a 0.5-meter resolution frequency-dependent TL curve and proceeds as follows.

In a given depth interval:

- Find the received level in one meter increments about a source. In the first one meter step, calculate the area of circle ensonified at the matching received level.
- Calculate areas of subsequent n^{th} circles in 1 meter steps.
- Compute the area on a rectangular strip for a one-meter extent in parallel to annulus radius of equivalent received level. Scale by the probability of harassment based on received level at this n^{th} range. Note that received level at the outer-radius of the modified annulus was used to calculate the probability with the risk function.
- Convert annulus result to volume based on the depth increment.
- Sum all scaled volumes of interior cylinder and subsequent annuli to impact range at 120 dB to find a cumulative volume for this depth interval which inherits the probabilistic calculation.

This algorithm takes place over the entire water column to capture dynamics of ensonification over all depths, and hence produces an impact volume vector.

D.6 HARRASSMENTS

This section defines the animal densities and their depth distributions for the TMAA. This is followed by a series of tables providing MMPA harassment estimates per unit of operation for each source type (active sound sources and explosives).

D.6.1 Animal Densities

Densities are usually reported by marine biologists as animals per square kilometer, which is an area metric. This gives an estimate of the number of animals below the surface in a certain area, but does not provide any information about their distribution in depth. The impact volume vector (see subsection D.4.3) specifies the volume of water ensonified above the specified threshold in each depth interval. A corresponding animal density for each of those depth intervals is required to compute the expected value of the number of exposures. The two-dimensional area densities do not contain this information, so three-dimensional densities must be constructed by using animal depth distributions to extrapolate the density at each depth. The required depth distributions are presented in the biology subsection.

D.6.2 Harassment Estimates

The following sperm whale example demonstrates the methodology used to create a three-dimensional density by merging the area densities with the depth distributions. The sperm whale surface density is 0.0003 whales per square kilometer. From the depth distribution report, "depth distribution for sperm whales based on information in the Amano paper is: 31% in 0-10 m, 8% in 10-200 m, 9% in 201-400 m, 9% in 401-600 m, 9% in 601-800 m and 34% in >800 m." So the sperm whale density at 0-10 m is 0.0003*0.31/0.01 = 0.0093 per cubic km, at 10-200 m is 0.0003*0.08/0.19 = .00012632 per cubic km, and so forth.

In general, the impact volume vector samples depth in finer detail than given by the depth distribution data. When this is the case, the densities are apportioned uniformly over the appropriate intervals. For example, suppose the impact volume vector provides volumes for the intervals 0-10 meters, 10-50 meters, and 50-200 meters. Then for the depth-distributed densities discussed in the preceding paragraph,

- 0.0093 whales per cubic km is used for 0-10 meters,
- 0.00012632 whales per cubic km is used for the 10-50 meters, and
- 0.00012632 whales per cubic km is used for the 50-200 meters.

Once depth-varying, three-dimensional densities are specified for each species type, with the same depth intervals and the ensonified volume vector, the density calculations are finished. The expected number of ensonified animals within each depth interval is the ensonified volume at that interval multiplied by the volume density at that interval and this can be obtained as the dot product of the ensonified volume and animal density vectors.

Since the ensonified volume vector is the ensonified volume per unit operation (i.e. per hour, per sonobuoy, etc), the final harassment count for each animal is the unit operation harassment count multiplied by the number of units (hours, sonobuoys, etc).

D.6.3 Additional Modeling Considerations in a General Modeling Scenario

When modeling the effect of sound projectors in the water, the ideal task presents modelers with complete *a priori* knowledge of the location of the source(s) and transmission patterns during the times of interest. In these cases, calculation inputs include the details of source path, proximity of shoreline, high-resolution density estimates, and other details of the scenario. However, in the TMAA, there are sound-producing events for which the source locations and transmission patterns are unknown, but still require analysis to predict effects. For these cases, a more general modeling approach is required: "We will be operating somewhere in this large area for *X* minutes. What are the potential effects on average?"

Modeling these general scenarios requires a statistical approach to incorporate the scenario nuances into harassment calculations. For example, one may ask: "If an animal receives 130 dB SPL when the source passes at closest point of approach (CPA) on Tuesday morning, how do we know it doesn't receive a higher level on Tuesday afternoon?" This question cannot be answered without knowing the path of the source (and several other facts). Because the path of the source is unknown, the number of an individual's re-exposures cannot be calculated directly. But it can, on average, be accounted for by making appropriate assumptions.

Table D-14 lists unknowns created by uncertainty about the specifics of a future proposed action, the portion of the calculation to which they are relevant, and the assumption that allows the effect to be computed without the detailed information:

Table D-14 – Unknowns and Assumptions

Unknowns	Relevance	Assumption
Path of source (esp. with respect to animals)	Ambiguity of multiple exposures, Local population: upper bound of harassments	Most conservative case: sources can be anywhere within range
Source locations	Ambiguity of multiple exposures, land shadow	Equal distribution of action in each range
Direction of sonar transmission	Land shadow	Equal probability of pointing any direction

The following sections discuss two topics that require action details, and describe how the modeling calculations used the general knowledge and assumptions to overcome the future-action uncertainty with respect to re-exposure of animals, and land shadow.

D.6.4 Multiple Exposures in General Modeling Scenario

Consider the following hypothetical scenario. A box is painted on the surface of a well-studied ocean environment with well-known propagation. A sound source and 100 whales are inserted into that box and a curtain is drawn. What will happen? The details of what will happen behind the curtain are unknown, but the existing knowledge, and general assumptions, can allow for a calculation of average affects.

For the first period of time, the source is traveling in a straight line and pinging at a given rate. In this time, it is known how many animals, on average, receive their max SPLs from each ping. As long as the source travels in a straight line, this calculation is valid. However, after an undetermined amount of time, the source will change course to a new and unknown heading.

If the source changes direction 180 degrees and travels back through the same swath of water, all the animals the source passes at closest point of approach (CPA) before the next course change have already been exposed to what will be their maximum SPL, so the population is not "fresh." If the direction does not change, only new animals will receive what will be their maximum SPL from that source (though most have received sound from it), so the population is completely "fresh." Most source headings lead to a population of a mixed "freshness," varying by course direction. Since the route and position of the source over time are unknown, the freshness of the population at CPA with the source is unknown. This ambiguity continues through the remainder of the exercise.

What is known? The source and, in general, the animals remain in the vicinity of the range. Thus, if the farthest range to a possible effect from the source is *X* km, no animals farther than *X* km outside of the TMAA can be harassed. The intersection of this area with a given animal's habitat multiplied by the density of that animal in its habitat represents the maximum number of animals that can be harassed by activity in that TMAA, which shall be defined as "the local population." Two details: first, this maximum should be adjusted down if a risk function is being used, because not 100% of animals within *X* km of the TMAA border will be harassed. Second, it should be adjusted up to account for animal motion in and out of the area.

The ambiguity of population freshness throughout the exercise means that multiple exposures cannot be calculated for any individual animal. It must be dealt with generally at the population level.

D.6.4.1 Solution to the Ambiguity of Multiple Exposures in the General Modeling Scenario

At any given time, each member of the population has received a maximum SPL (possibly zero) that indicates the probability of harassment in the exercise. This probability indicates the contribution of that individual to the expected value of the number of harassments. For example, if an animal receives a level that indicates 50% probability of harassment, it contributes 0.5 to the sum of the expected number of harassments. If it is passed later with a higher level that indicates a 70% chance of harassment, its contribution increases to 0.7. If two animals receive a level that indicates 50% probability of harassment, they together contribute 1 to the sum of the expected number of harassments. That is, we statistically expect exactly one of them to be harassed. Let the expected value of harassments at a given time be defined as "the harassed population" and the difference between the local population (as defined above) and the harassed population be defined as "the unharassed population." As the exercise progresses, the harassed population will never decrease and the unharassed population will never increase.

The unharassed population represents the number of animals statistically "available" for harassment. Since we do not know where the source is, or where these animals are, we assume an average (uniform) distribution of the unharassed population over the area of interest. The densities of unharassed animals are lower than the total population density because some animals in the local population are in the harassed population.

Density relates linearly to expected harassments. If action A in an area with a density of 2 animals per square kilometer produces 100 expected harassments, then action A in an area with 1 animal per square kilometer produces 50 expected harassments. The modeling produces the number of expected harassments per ping starting with 100% of the population unharassed. The next ping will produce slightly fewer harassments because the pool of unharassed animals is slightly less.

For example, consider the case where 1 animal is harassed per ping when the local population is 100, 100% of which are initially unharassed. After the first ping, 99 animals are unharassed, so the number of animals harassed during the second ping are

$$1\left(\frac{99}{100}\right) = 1(.99) = 0.99 \text{ animals}$$

and so on for the subsequent pings.

Mathematics

A closed form function for this process can be derived as follows.

Define $H =$ number of animals harassed per ping with 100% unharassed population. H is calculated by determining the expected harassments for a source moving in a straight line for the duration of the exercise and dividing by the number of pings in the exercise (Figure D-24).

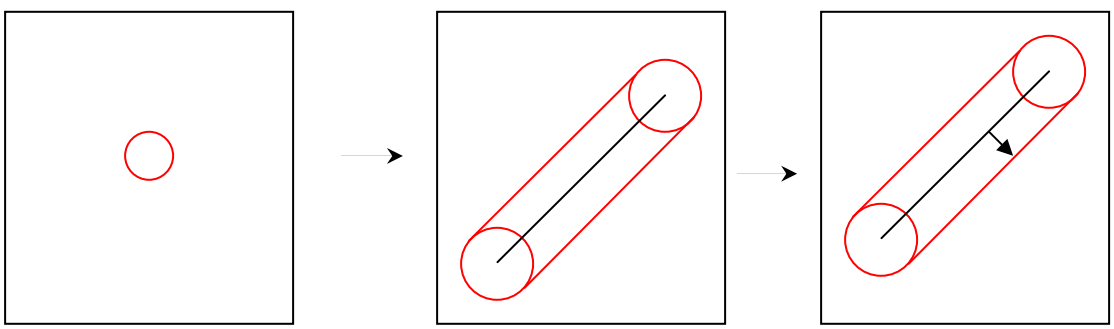

Figure D-24. – Process of calculating *H*

$$H = \frac{\iiint \rho(z) D(L(x,y,z)) dxdydz}{N_{pings}}$$

The total un-harassed population is then calculated by iteration. Each ping affects the un-harassed population left after all previous pings:

Define $P_n =$ unharassed population after n^{th} ping

$$P_0 = \text{local population}$$

$$P_1 = P_0 - H$$

$$P_2 = P_1 - H\left(\frac{P_1}{P_0}\right)$$

$$\ldots$$

$$P_n = P_{n-1} - H\left(\frac{P_{n-1}}{P_0}\right)$$

Therefore,

$$P_n = P_{n-1}\left(1-\left(\frac{H}{P_0}\right)\right) = P_{n-2}\left(1-\left(\frac{H}{P_0}\right)\right)^2 = \ldots = P_0\left(1-\left(\frac{H}{P_0}\right)\right)^n$$

Thus, the total number of harassments depends on the per-ping harassment rate in an un-harassed population, the local population size, and the number of operation hours.

D.6.4.2 Local Population: Upper Bound on Harassments

As discussed above, Navy planners have confined periods of sonar use to operation areas. The size of the harassed population of animals for an action depends on animal re-exposure, so uncertainty about the precise source path creates variability in the "harassable" population. Confinement of sonar use to a sonar operating area allows modelers to compute an upper bound, or worst case, for the number of harassments with respect to location uncertainty. This is done by assuming that every animal which enters the operation area at any time in the exercise (and also many outside) is "harassable" and creates an upper bound on the number of harassments for the exercise. Since this is equivalent to assuming that there are sonars transmitting simultaneously from each point in the confined area throughout the action length, this greatly overestimates the harassments from an exercise.

NMFS has defined a twenty-four hour "refresh rate," or amount of time in which an individual animal can be harassed no more than once. The Navy has determined that, in a twenty-four hour period, all training events in the TMAA involve sources that transmit for no longer than sixteen (16) hours.

The most conservative assumption for a single ping is that it harasses the entire population within the range (a gross over-estimate). However, the total harassable population for multiple pings will be even greater since animal motion over the period in the above table can bring animals into range that otherwise would be out of the harassable population.

D.6.4.3 Animal Motion Expansion

Though animals often change course to swim in different directions, straight-line animal motion would bring the more animals into the harassment area than a "random walk" motion model. Since precise and accurate animal motion models exist more as speculation than documented fact and because the modeling requires an undisputable upper bound, calculation of the upper bound for TMAA modeling areas uses a straight-line animal motion assumption. This is a conservative assumption.

For a circular area, the straight-line motion in any direction produces the same increase in harassable population. However, since the ranges are non-circular polygons, choosing the initial fixed direction as perpendicular to the longest diagonal produces greater results than any other direction. Thus, the product of the longest diagonal and the distance the animals move in the period of interest gives an overestimate

of the expansion in range modeling areas due to animal motion. The expansions use this estimate as an absolute upper bound on animal-motion expansion.

Figure D-25 illustrates the overestimation, which occurs during the second arrow:

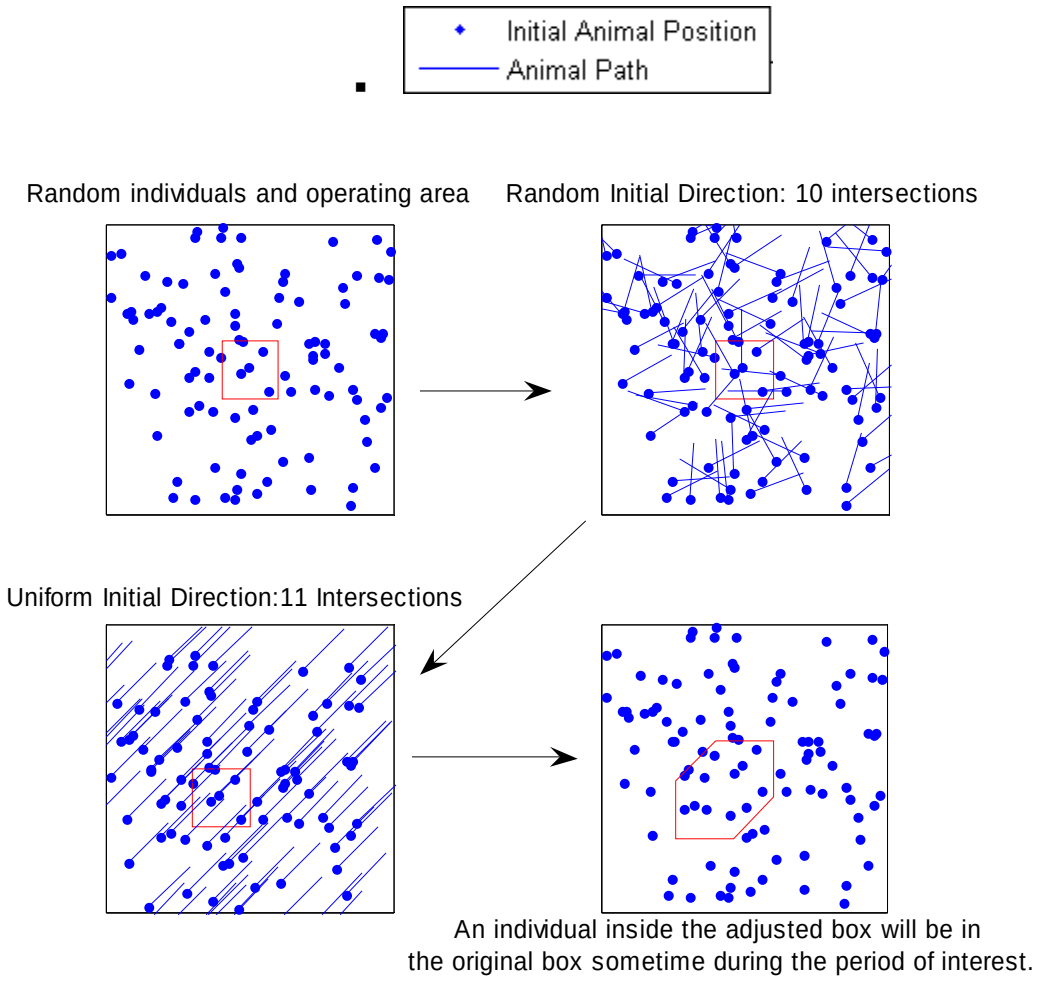

Figure D-25. Process of Setting an Upper Bound on Individuals Present in Area

It is important to recognize that the area used to calculate the harassable population, shown in Figure D-25 will, in general, be much larger than the area that will be within the ZOI of a ship for the duration of its broadcasts. For a ship moving faster than the speed of the marine animals, a better (and much smaller) estimate of the harassable population would be that within the straight line ZOI cylinder shown in Figure D-26. Using this smaller population would lead to a greater dilution of the unharassed population per ping and would greatly reduce the estimated harassments.

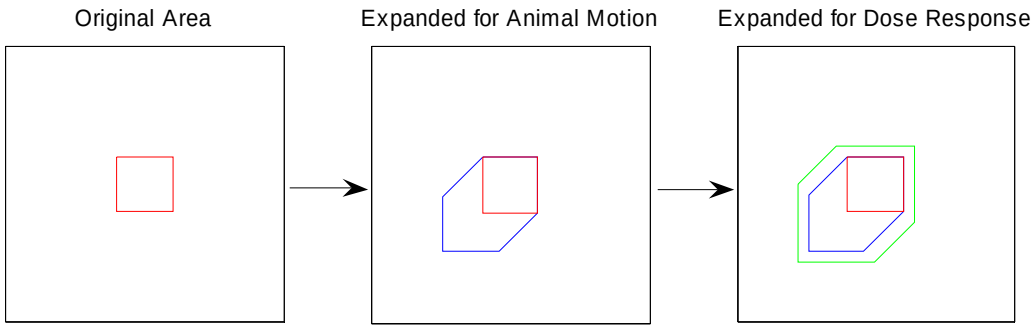

Figure D-26. Process of Expanding Area to Create Upper Bound of Harassments

D.6.4.4 Risk Function Expansion

The expanded area contains the number of animals that will enter the range over the period of interest. However, an upper bound on harassments must also include animals outside the area that would be affected by a source transmitting from the area's edge. A gross overestimation could simply assume pinging at every point on the range border throughout the exercise and would include all area with levels from a source on the closest border point greater than the risk function basement. In the case of GOA, this would include all area within approximately 105 km from the edge of the adjusted box. (See Table D-15). This basic method would give a crude and exaggerated upper bound, since only a tiny fraction of this out-of-range area can be ensonified above threshold for a given ping. A more refined upper bound on harassments can be found by maintaining the assumption that a source is transmitting from each point in the adjusted box and calculating the expected ensonified area, which would give all animals inside the area a 100% probability of harassment, and those outside the area a varying probability, based on the risk function.

$$\int_0^{L^{-1}(120\,dB)} D(L(r))dr\,,$$

Where L is the SPL function with domain in range and range in level,

r is the range from the sonar operating area,

L^{-1}(120 dB) is the range at which the received level drops to 120 dB, and

D is the risk function (probability of harassment vs. Level).

At the corners of the polygon, additional area can be expressed as

$$\frac{[\pi-\theta]\int_0^{L^{-1}(120\,dB)} D(L(r))rdr}{2\pi}$$

with D, L, and r as above, and

θ the inner angle of the polygon corner, in radians.

For the risk function and transmission loss of the TMAA, this method adds an area equivalent by expanding the boundaries of the adjusted box by four kilometers. The resulting shape, the adjusted box with a boundary expansion of 4 km, does not possess special meaning for the problem. But the number of individuals contained by that shape, is the harassable population and an absolute upper bound on possible harassments for that operation.

The following plots illustrate the growth of area for the sample case above. The shapes of the boxes are unimportant. The area after the final expansion, though, gives an upper bound on the "harassable", or initially unharassed population which could be affected by operations.

Example Case

Consider a sample case from the TMAA. For the most powerful source, the SQS-53, the expected winter rate of exposures under the risk function considered behaviorial MMPA Level B harassment for minke whales is approximately 0.068985832 harassments per ping. The exercise will transmit sonar pings for 16 hours in a 24 hour period as consistent with planned use, with 120 pings per minute, a total of 120 * 16 = 1,920 pings in a 24 hour period.

The TMAA has an area of approximately 92,246 square kilometers and a diagonal of 486.5 km. Adjusting this with straight-line (upper bound) animal motion of 5.5 kilometers per hour for 16 hours, animal motion adds 486.5 * 5.5 * 16 = 42,812 square kilometers to the area. Using the risk function to calculate the expected range outside the OA approximately adds another 5,068 square kilometers, bringing the total upper-bound of the affected area to 140,126 square km.

For example, minke whales have an average winter density of 0.0006 animals per square kilometer, so the upper bound number of minke whales that can be affected by SQS-53 activity in the GOA during a 24 hour period is 140,126 * 0.0006 = 84.0756 whales.

In the first ping, 0.068985832 minke whales will be harassed. With the second ping,

$0.068985832 \left(\frac{84.0756 - 0.068985832}{84.0756}\right) = 0.068929228$ minke whales will be harassed. Using the formula derived above, after 16 hours of continuous operation, the remaining **unharassed** population is

$$P_{1920} = P_0\left(1-\left(\frac{h}{P_0}\right)\right)^{1920} = 84.0756\left(1-\left(\frac{0.068985832}{84.0756}\right)\right)^{1920} \approx 17.3861$$

So the **harassed** population will be 84.0756 – 17.3861 = 66.6895 animals.

Contrast this with linear accumulation of harassments without consideration of the local population and the dilution of the unharassed population:

Harassments = 0.068985832 * 1920 = 132.45 whales,

which is 57% greater than the estimated local population of 84.0756 minke whales. Because linear accumulation assumes an infinite local population, it always overestimates the number of harassments, sometimes to the point of producing impossible results.

D.6.5 Land Shadow

The risk function considers the possibility of harassment possible if an animal receives 120 dB sound pressure level, or above. In the open ocean of the GOA, this can occur as far away as 105 km, so over a large "effect" area, sonar sound could, but does not necessarily, harass an animal. The harassment calculations for a general modeling case must assume that this effect area covers only water fully populated with animals, but in some portions of the GOA, land partially encroaches on the area, obstructing sound propagation.

As discussed in the introduction of "Additional Modeling Considerations" Navy planners do not know the exact location and transmission direction of the sonars at future times. These factors however, completely determine the interference of the land with the sound, or "land shadow," so a general modeling approach does not have enough information to compute the land shadow effects directly. However, modelers can predict the reduction in harassments at any point due to land shadow for different pointing directions and use expected probability distribution of activity to calculate the average land shadow for operations in each range.

For each of the coastal points that are within 105 km of the grid, the azimuth and distance are computed. In the computation, only the minimum range at each azimuth is computed.

Now, the average of the distances to shore, along with the angular profile of land is computed (by summing the unique azimuths that intersect the coast) for each grid point. The values are then used to compute the land shadow for the grid points.

D.6.5.1 Computing the Land Shadow Effect at Each Grid Point

The effect of land shadow is computed by determining the levels, and thus the distances from the sources, that the harassments occur. The levels vary according to acoustic propagation conditions, so the analysis breaks down according to two seasons. Table D-15 gives a mathematical extrapolation of the distances and levels at which harassments occur, with average seasonal propagation in the GOA using the SQS-53 as an example and as displayed in Figures D-27 and D-28.

Table D-15 – Behavioral Harassments at each Received Level Band from SQS-53 During Summer Months

Received Level (dB SPL)	Distance at which Levels Occur in GOA	Percent of Behavioral Harassments Occurring at Given Levels
Below 138	42 km – 105 km	~ 0 %
138<Level<144	28 km – 42 km	< 1 %
144<Level<150	17 km – 28 km	~1 %
150<Level<156	9 km – 17 km	7 %
156<Level<162	5 km – 9 km	18 %
162<Level<168	2.5 km – 5 km	26 %
168<Level<174	1.2 km – 2.5 km	22 %
174<Level<180	0.5 km – 1.2 km	14 %
180<Level<186	335 m – 0.5 km	6 %
186<Level<TTS	178 m – 335 m	5 %

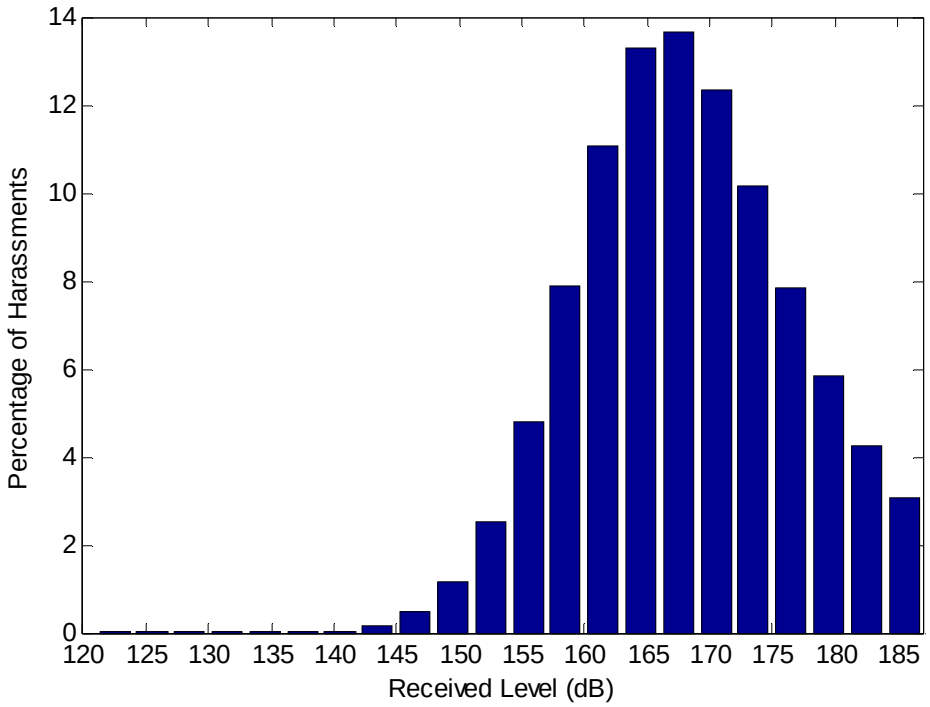

Figure D-27. – The Approximate Percentage of Behavioral Harassments for Every 3 Degree Band of Received Level from the SQS-53 During Summer Months

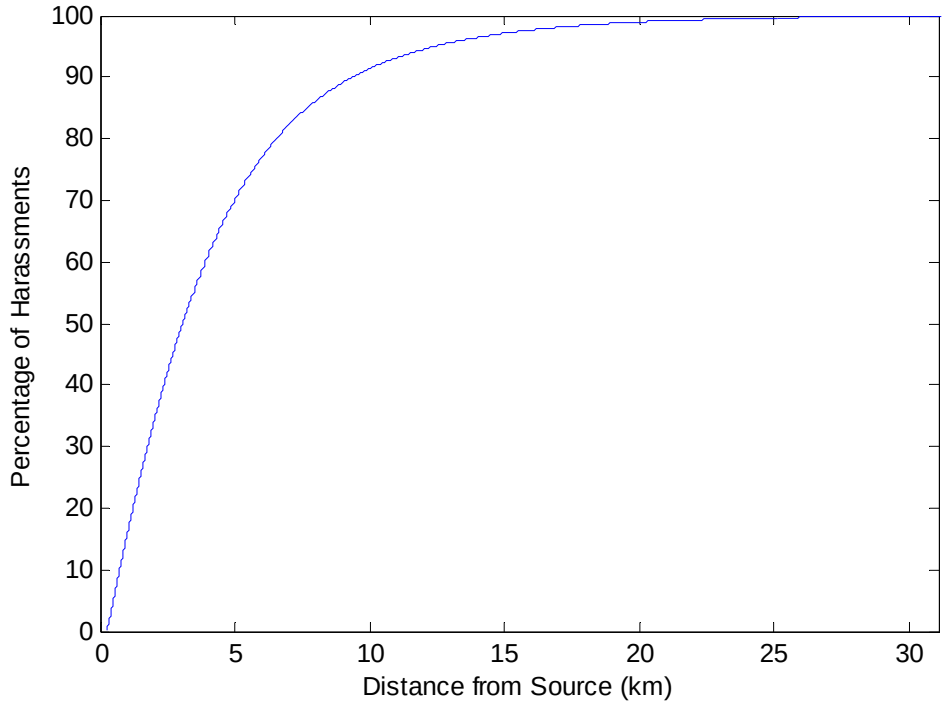

Figure D-28. – Average Percentage of Harassments Occurring Within a Given Distance during Summer Months

With the data used to produce the previous figure, the average effect reduction during summer months for a sound path blocked by land can be calculated. For the SQS-53, since approximately 92% of harassments occur within 10 km of the source, a sound path blocked by land at 10 km will, on average, cause approximately 92% of the effect of an unblocked path.

As described above, the mapping process determines the angular profile of and distance to the coastline(s) from each grid point. The distance, then, determines the reduction due to land shadow when the sonar is pointed in that direction. The angular profile, then, determines the probability that the sonar is pointed at the coast.

Define θ_n = angular profile of coastline at point n in radians

Define r_n = mean distance to shoreline

Define $A(r)$ = average effect adjustment factor for sound blocked at distance r

The land shadow at point n can be approximated by $A(r_n)\theta_n/(2\pi)$. For illustration, the following plot gives the land shadow reduction factor at each point in each range area for the SQS-53 (Figure D-29) . The white portions of the plot indicate the areas outside the range and the blue lines indicate the coastline. The color plots inside the ranges give the land shadow factor at each point. The average land shadow factor for the SQS-53 in the GOA is essentially 1, or the reduction in effect is 0% for both seasons. For the other, lower-power sources it follows that this reduction is also negligible.

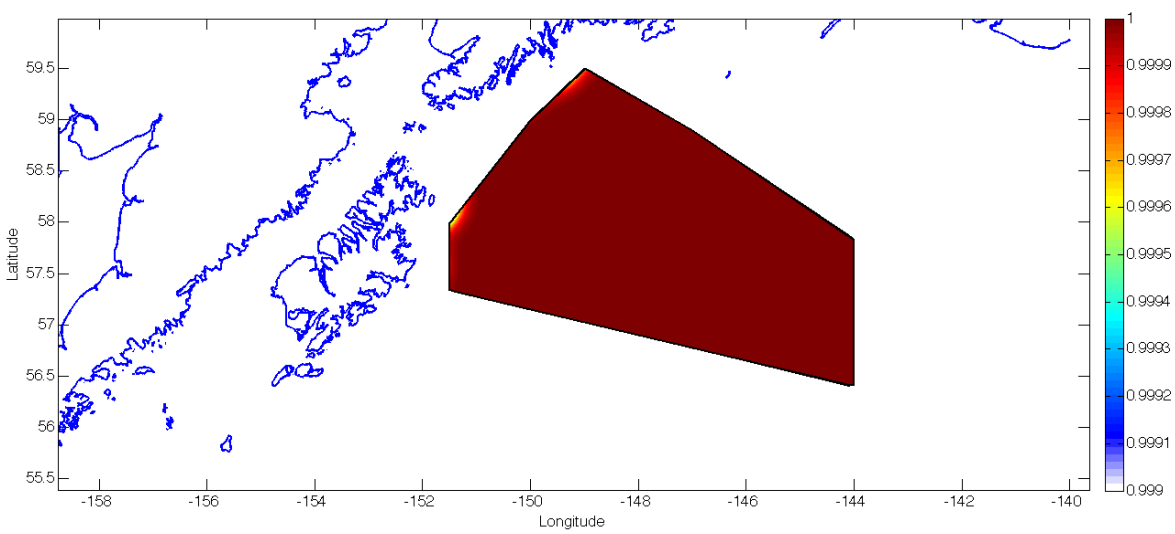

Figure D-29. – Depiction of Land Shadow over the TMAA

D.6.5.2 The Effect of Multiple Ships

Behavioral harassment, under dose response (risk function), uses maximum sound pressure level over a 24 hour period as the metric for determining the probability of harassment. An animal that receives sound from two sonars, operating simultaneously, receives its maximum sound pressure level from one of the ships. Thus, the effects of the louder, or closer, sonar determine the probability of harassment, and the more distant sonar does not. If the distant sonar operated by itself, it would create a lesser effect on the animal, but in the presence of a more dominating sound, its effects are cancelled. When two sources are sufficiently close together, their sound fields within the cutoff range will partially overlap and the larger

of the two sound fields at each point in that overlap cancel the weaker. If the distance between sources is twice as large as the range to cutoff, there will be no overlap.

Computation of the overlap between sound fields requires the precise locations and number of the source ships. The general modeling scenarios of the TMAA do not have these parameters, so the effect was modeled using an average ship distance, 20 km, and an average number of ships per exercise, in this case three ships.

The formation of ships in any of the above exercised has been determined by Navy planners. The ships are located in a straight line, perpendicular to the direction has traveled. The figures below (D-30 to D-34) show examples with four ships, and their ship tracks.

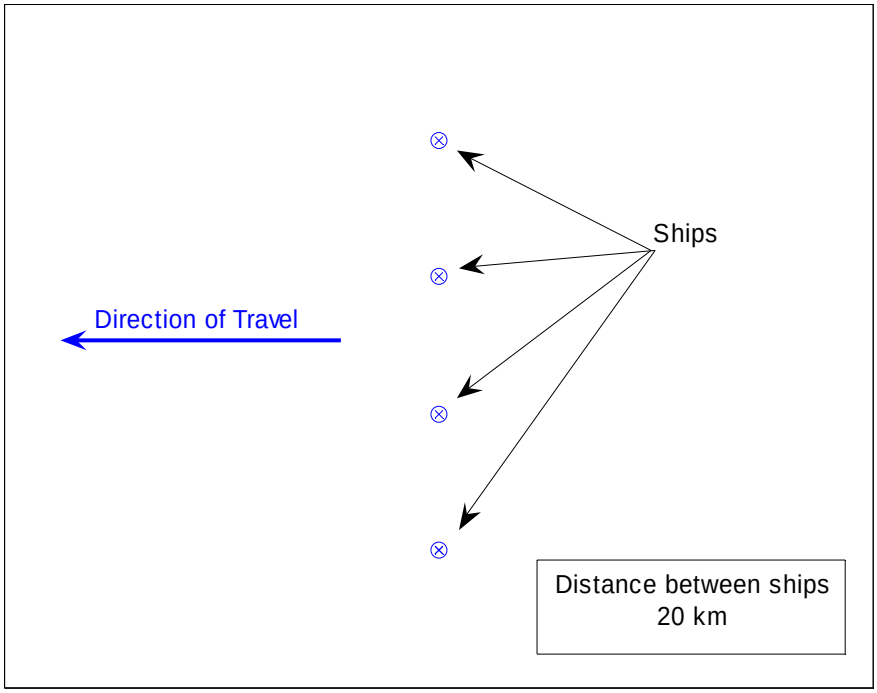

Figure D-30. – Formation and Bearing of Ships in 4-Ship Example

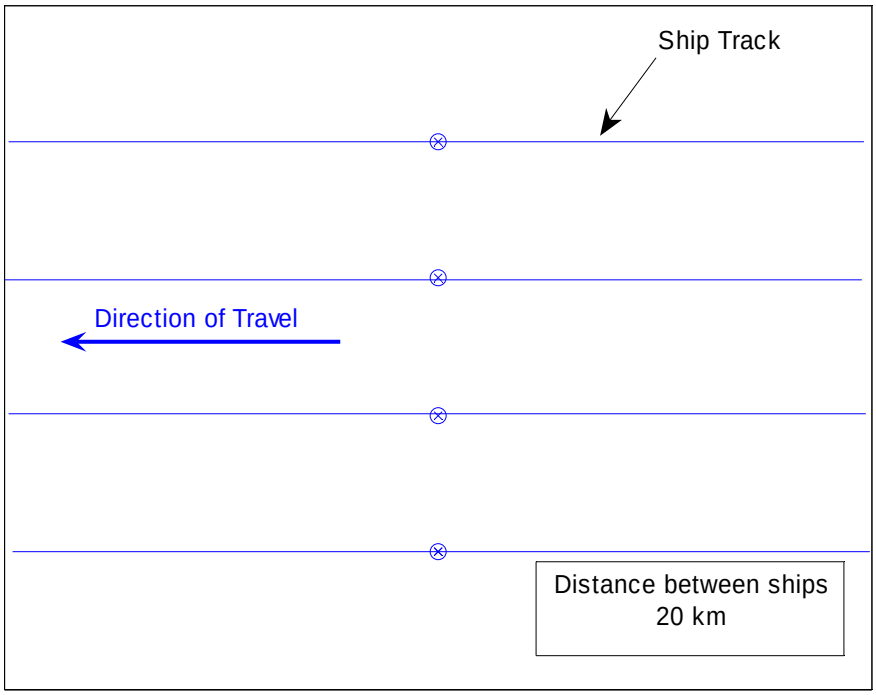

Figure D-31. – Ship Tracks of Ships in 4-Ship Example

The sound field created by these ships, which transmit sonar continually as they travel will be uniform in the direction of travel (or the "*x*" direction), and vary by distance from the ship track in the direction perpendicular to the direction of travel (or the "*y*" direction).

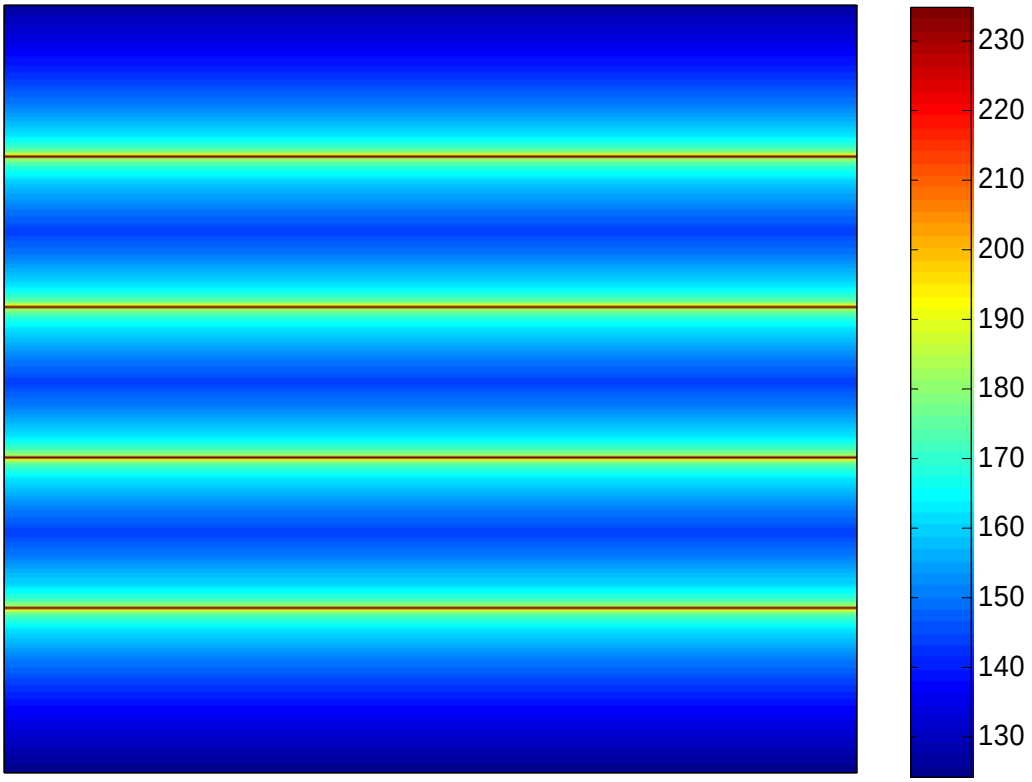

Figure D-32. – Sound Field Produced by Multiple Ships

This sound field of the four ships operating together (Figure D-32) ensonifies less area than four ships operating individually. However, because at the time of modeling, even the average number of ships and mean distances between them were unknown, a post-calculation correction should be applied.

As shown on Figure D-32, the sound field around the ship tracks, the portion above the upper-most ship track, and the portion below the lower-most ship track sum to produce exactly the sound field as an individual ship (Figure D-33).

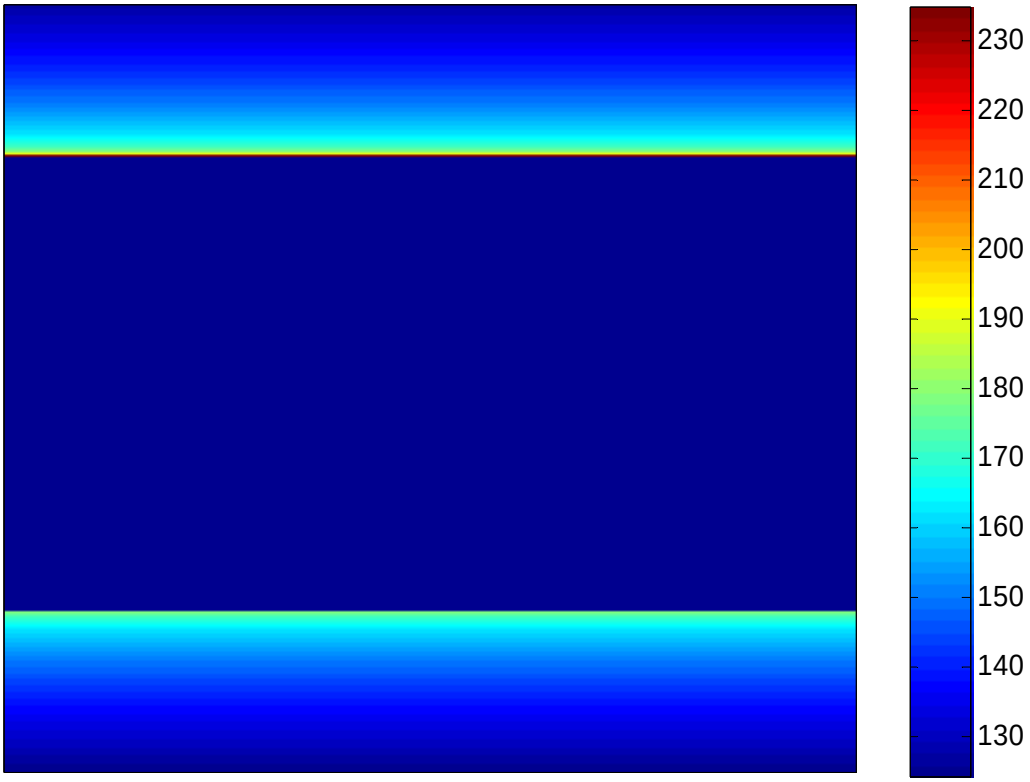

Figure D-33. – Upper and Lower Portion of Sound Field

Therefore, the remaining portion of the sound field, between the uppermost ship track and the lowermost ship track, is the contribution of the three additional ships (Figure D-34).

This remaining sound field is made up of three bands. Each of the three additional ships contributes one band to the sound field. Each band is somewhat less than the contribution of the individual ship because its sound is overcome by the nearer source at the center of the band. Since each ship maintains 20 km distance between it and the next, the height of these bands is 20 km, and the sound from each side projects 10 km before it is overcome by the source on the other side of the band. Thus, the contribution to a sound field for an additional ship is identical to that produced by an individual ship whose sound path is obstructed at 10 km. The work in the previous discussion on land shadow provides a calculation of effect reduction for obstructed sound at each range. An SQS-53-transmitting ship with obstructed signal at 10 kilometers across both seasons causes an average of 95% of the number of harassments as a ship with an unobstructed signal. Therefore, each additional ship causes 0.95 times the harassments of the individual ship. Applying this single-ship factor to the exercise type described earlier (three ships), the adjustment factor given this formation is approximately 2.90.

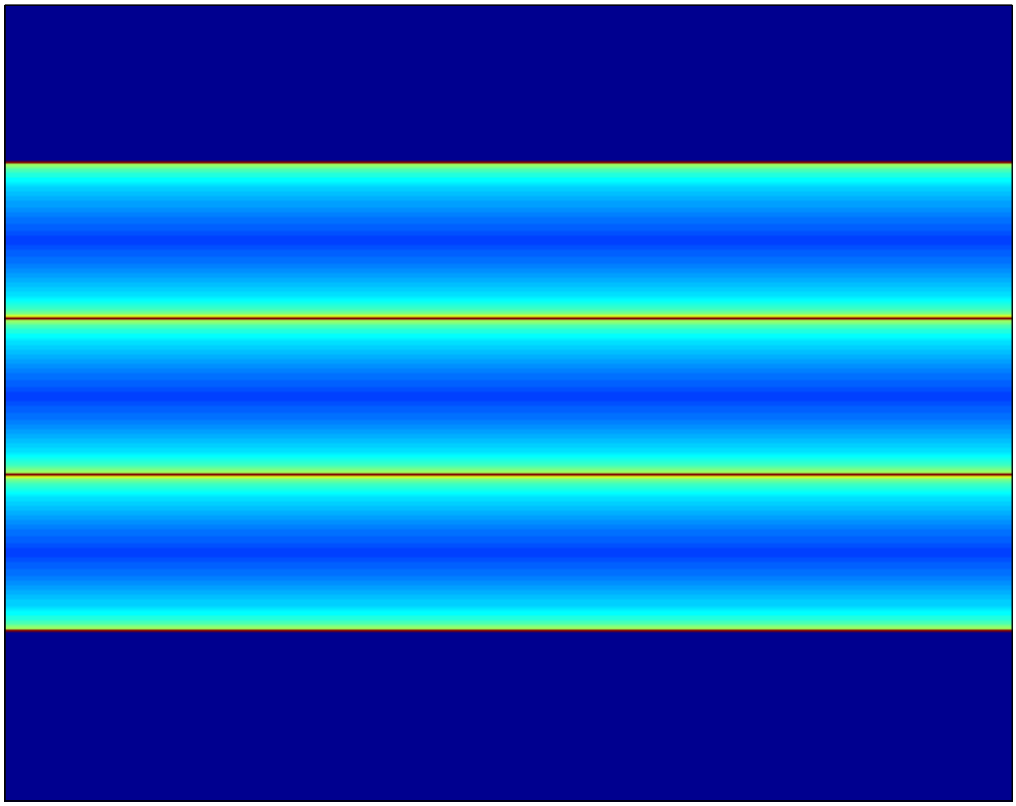

Figure D-34.– Central Portion of Sound Field

D.7 REFERENCES

Arons, A.B. (1954). "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," J. Acoust. Soc. Am. 26, 343.

Bartberger, C.L. (1965). "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E.A. and J.B. Gaspin, (1974). Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy (1998), "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy (2001), "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

Finneran, J.J., R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America. 111:2929-2940.

Finneran, J.J., and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J.J., D.A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of Acoustical Society of America. 118:2696-2705.

Goertner, J.F. (1982), "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R.E., Denise Brown, Emily McCarthy, Henry Weinberg, and Frank Aidala (2000). "Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)", NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Kryter, K.D., W.D. Ward, J.D. Miller, and D.H. Eldredge. 1966. Hazardous exposure to intermittent and steady-state noise. Journal of the Acoustical Society of America. 48:513-523.

McGrath, J.R. (1971). "Scaling Laws for Underwater Exploding Wires," J. Acoust. Soc. Am. 50, 1030-1033 (UNCLASSIFIED).

Miller, J.D. 1974. Effects of noise on people. Journal of the Acoustical Society of America. 56:729–764.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America. 113:3425-3429.

National Oceanic and Atmospheric Administration (NOAA). 2001. Final Rule Taking and Importing Marine Mammals: Taking Marne Mammals Incidental to Naval Activities --The Shock Trial of the WINSTON S. CHURCHILL (DDG-81), Federal Register, Department of Commerce; NMFS, FR 66, No. 87, 22450-67.

National Oceanic and Atmospheric Administration, 2002. "Final Rule SURTASS LFA Sonar," *Federal Register*, Department of Commerce; NMFS, *Federal Register,* Vol 67, No. 136, pp. 46712-46789.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterous leucas*, after exposure to intense tones. Journal of the Acoustical Society of America. 107:3496-3508.

Urick, R.J. (1983). Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975, third edition: 1983) (UNCLASSIFIED).

Ward, W.D. 1997. Effects of high-intensity sound. In Encyclopedia of Acoustics, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Weston, D.E. (1960). "Underwater Explosions as Acoustic Sources," Proc. Phys. Soc. 76, 233 (UNCLASSIFIED).

Yelverton, J.T., D.R. Richmond, E.R. Fletcher, and R.K. Jones, 1973. "Safe Distance from Underwater Explosive for Mammals and Birds", Technical Progress Report, DNA 3114T, Department of Defense, Defense Nuclear Agency, Washington, D.C., April.

Yelverton, J.T. 1981, Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December, 1982. 32pp.

Appendix E

Marine Mammal Density Report

TABLE OF CONTENTS

E MARINE MAMMAL DENSITY AND DEPTH DISTRIBUTION E-1

E.1 BACKGROUND AND OVERVIEW E-1
E.1.1 DENSITY E-1
E.1.2 DEPTH DISTRIBUTION E-6
E.1.3 DENSITY AND DEPTH DISTRIBUTION COMBINED E-6
E.2 MYSTICETES E-7
E.2.1 BLUE WHALE, *BALAENOPTERA MUSCULUS* E-7
E.2.2 FIN WHALE, *BALAENOPTERA PHYSALUS* E-8
E.2.3 SEI WHALE, *BALAENOPTERA BOREALIS* E-8
E.2.4 MINKE WHALE, *BALAENOPTERA ACUTOROSTRATA* E-8
E.2.5 HUMPBACK WHALE, *MEGAPTERA NOVAEANGLIAE* E-9
E.2.6 NORTH PACIFIC RIGHT WHALE, *EUBALAENA JAPONICA* E-9
E.2.7 GRAY WHALE, *ESCHRICHTIUS ROBUSTUS* E-10
E.3 ODONTOCETES E-11
E.3.1 SPERM WHALE, *PHYSETER CATODON* E-11
E.3.2 CUVIER'S BEAKED WHALE, *ZIPHIUS CAVIROSTRIS* E-12
E.3.3 BAIRD'S BEAKED WHALE, *BERARDIUS BAIRDII* E-13
E.3.4 STEJNEGER'S BEAKED WHALE, *MESOPLODON STEJNEGERI* E-14
E.3.5 KILLER WHALE, *ORCINUS ORCA* E-14
E.3.6 BELUGA, *DELPHINAPTERUS LEUCAS* E-14
E.3.7 PACIFIC WHITE-SIDED DOLPHIN, *LAGENORHYCHUS OBLIQUIDENS* E-14
E.3.8 NORTHERN RIGHT WHALE DOLPHIN, *LISSODELPHIS BOREALIS* E-15
E.3.9 RISSO'S DOLPHIN, *GRAMPUS GRISEUS* E-15
E.3.10 FALSE KILLER WHALE, *PSEUDORCA CRASSIDENS* E-15
E.3.11 SHORT-FINNED PILOT WHALE, *GLOBICEPHALA MACRORHYNCHUS* E-15
E.3.12 DALL'S PORPOISE, *PHOCOENOIDES DALLI* E-15
E.3.13 HARBOR PORPOISE, *PHOCOENA PHOCOENA* E-16
E.4 PINNIPEDS E-16
E.4.1 STELLER'S SEA LION, *EUMETOPIAS JUBATUS* E-16
E.4.2 NORTHERN FUR SEAL, *CALLORHINUS URSINUS* E-18
E.4.3 CALIFORNIA SEA LION, *ZALOPHUS CALIFORNIANUS* E-19
E.4.4 NORTHERN ELEPHANT SEAL, *MIROUNGA ANGUSTIROSTRIS* E-20
E.4.5 HARBOR SEAL, *PHOCA VITULINA* E-21
E.5 REFERENCES E-22

LIST OF FIGURES

FIGURE E-1. TMAA, GOA LARGE MARINE ECOSYSTEM AND GRAY WHALE DENSITY AREA. E-11

LIST OF TABLES

TABLE E-1. MARINE MAMMALS IN THE GULF OF ALASKA; DENSITIES AND SEASON(S) INCLUDED FOR SPECIES REGULARLY SEEN. E-4
TABLE E-2. COMPARISON OF F(0) AND G(0) VALUES, FOR SPECIES BEING CONSIDERED FROM WAITE (2003) FROM SURVEY EFFORTS OUTSIDE OF THE TMAA. E-5
TABLE E-3. DENSITIES CALCULATED FROM DATA PRESENTED IN WAITE (2003) USING F(0) AND G(0) VALUES FROM TABLE 2. ..... E-5
TABLE E-4. SUMMARY OF MARINE MAMMAL DEPTH DISTRIBUTIONS FOR THE TMAA E-7
TABLE E-5. AVERAGING OF STELLERS SEA LION, NORTHERN FUR SEAL, AND NORTHERN ELEPHANT SEAL DENSITIES TO FIT WARM (JUNE-OCTOBER) AND COLD (NOVEMBER-MAY) WATER SEASONS. E-18
TABLE E-6. SUMMARY OF MARINE MAMMAL DEPTH AND DIVING INFORMATION FOR SPECIES FOUND IN THE TMAA E-33

E MARINE MAMMAL DENSITY AND DEPTH DISTRIBUTION

E.1 BACKGROUND AND OVERVIEW

Marine mammal species occurring in the Gulf of Alaska (GOA) and the GOA Temporary Maritime Activities Area (TMAA) include baleen whales (mysticetes), toothed whales (odontocetes), and seals and sea lions (commonly referred to as pinnipeds). Baleen and toothed whales, collectively known as cetaceans, spend their entire lives in the water and spend most of the time (>90% for most species) entirely submerged below the surface. When at the surface, cetacean bodies are almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This makes cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, essentially 100% of the time because their ears are nearly always below the water's surface. Seals and sea lions (pinnipeds) spend significant amounts of time out of the water during breeding, molting and hauling out periods. In the water, pinnipeds spend varying amounts of time underwater, as some species regularly undertake long, deep dives (e.g., elephant seals) and others are known to rest at the surface in large groups for long amounts of time (e.g., California sea lions). When not actively diving, pinnipeds at the surface often orient their bodies vertically in the water column and often hold their heads above the water surface. Consequently, pinnipeds may not be exposed to underwater sounds to the same extent as cetaceans.

For the purposes of this analysis, we have adopted a conservative approach to underwater noise and marine mammals:

- Cetaceans – assume 100% of time is spent underwater and therefore exposed to noise
- Pinnipeds – adjust densities to account for time periods spent at breeding areas, haulouts, etc.; but for those animals in the water, assume 100% of time is spent underwater and therefore exposed to noise.

E.1.1 Density

Mysticetes regularly occurring in the GOA include fin, minke, humpback and gray whales; blue and North Pacific right whales have been sighted in the GOA, but are considered rare and are included here only for discussion purposes because both are endangered species. Odontocetes regularly occurring include sperm whale, Cuvier's and Baird's beaked whales, killer whale, Pacific white-sided dolphin and Dall's porpoise. Belugas are occasionally sighted in the GOA, but most sightings are in coastal areas and their occurrence in the region is extremely low. Pinnipeds regularly occurring include Steller's sea lion, northern fur seal and northern elephant seal. California sea lion range extends as far north as the Pribilof Islands in the Bering Sea but their occurrence is likely rare.

Recent survey data for marine mammals in the GOA is limited. Most survey efforts are localized and extremely near shore. There is evidence of occurrence of several species based on acoustic studies, but these do not provide measurements of abundance. Best available density data were incorporated from several different sources which are described below and summarized in Table 1.

Fin and Humpback Whales

The Gulf of Alaska Line-Transect Survey (GOALS) was conducted in April 2009 (Rone et al., 2009) in the TMAA. Line-transect visual data and acoustic data were collected over a 10-day period, which resulted in sightings of several odontocete and mysticete species. Densities were derived for fin and humpback whales for inshore and offshore strata (Table 9 in Rone et al., 2009). Densities from each stratum were weighted by the percentage of stratum area compared to the TMAA: inshore stratum was 33% of the total area and offshore stratum was 67% of the total area.

Killer Whale

Vessel surveys were conducted in nearshore areas (within 85 km) of the TMAA in 2001-2003 (Zerbini et al., 2006), between Resurrection Bay on the Kenai Peninsula to Amchitka Island in the Aleutians. Densities were calculated for fin, humpback and killer whales; only those for killer whales are included here (Table 1) because more recent densities for fin and humpback whales are available from Rone et al. (2009). Killer whale densities are from "Block 1" in Zerbini et al. (2006).

Minke, Sperm and Beaked Whales, Pacific White-sided Dolphin and Dall's Porpoise

Waite (2003) conducted vessel surveys for cetaceans near Kenai Peninsula, within Prince William Sound and around Kodiak Island, during acoustic-trawl surveys for pollock in summer 2003. Surveys extended offshore to the 1000 m contour and therefore overlapped with some of the TMAA. Waite (2003) did not calculate densities, but did provide some of the elements necessary for calculating density.

Barlow (2003) provided the following equation for calculating density:

$$\text{Density/km}^2 = \frac{(n)\,(s)\,(f_0)}{(2L)\,(g_0)}$$

Where (n) = number of animal group sightings on effort

(s) = mean group size

f(0) = sighting probability density at zero perpendicular distance (influenced by species detectability and sighting cues such as body size, blows and number of animals in a group)

(L) = transect length completed (km)

g(0) = probability of seeing a group directly on trackline (influenced by perception bias and availability bias)

Three values, n, s, and L, were provided by Waite (2003). Values for f(0) and g(0) were not provided, and were instead assigned based on values from the literature for other vessel survey efforts in the North Pacific (Table 2). Using values calculated from other vessel survey efforts is acceptable in this situation because the correction factors were calculated from vessel surveys that were conducted similarly to the GOA effort. Specifically, factors such as number of observers (three), height of the flying bridge from the water's surface (12 m), ship's speed (11 kts), number of "Bigeyes" binoculars used (two), and acceptable sea state conditions (up to B05) during the GOA survey effort were all comparable to those used during NMFS survey efforts along the west coast of the US, in Hawaii and in the eastern tropical Pacific (see Table 2). Values for f(0) and g(0) are very similar per species between efforts, therefore the most conservative value was adopted for each species and applied to the density calculation.

Table 3 illustrates how the data from Waite (2003) were used to calculate densities using correction factors from Table 2. There are no variances attached to any of the resulting density values, so overall confidence in these values is unknown. Densities based on only one or two sightings generally have fairly high variance.

Gray whales

Gray whale density was calculated from data obtained from a feeding study near Kodiak Island (Moore et al. (2007).

Steller Sea Lion, Northern Fur Seal and Northern Elephant Seal

Pinniped at-sea density is not often available because pinniped abundance is obtained via shore counts of animals at known rookeries and haulouts. Therefore, densities of pinnipeds were derived quite differently from those of cetaceans. Several parameters were identified from the literature, including area of stock occurrence, number of animals (which may vary seasonally) and season, and those parameters were then used to calculate density. Once density per "pinniped season" was determined, those values were prorated to fit the warm water (June-October) and cold water (November-May) seasons. Determining density in this manner is risky as the parameters used usually contain error (e.g., geographic range is not exactly known and needs to be estimated, abundance estimates usually have large variances) and, as is true of all density estimates, it assumes that animals are always distributed evenly within an area which is likely never true. However, this remains one of the few means available to determine at-sea density for pinnipeds.

The Marine Resource Assessment for the Gulf of Alaska Operating Area (Department of the Navy, 2006), listed six mysticetes, twelve odontocetes, and five pinnipeds as occurring or possibly occurring in the GOA region (Department of the Navy, 2006; Table 3-1). However, several of the species listed are rare and do not regularly occur. Brief species summaries are included for all marine mammals whose distribution extends to the GOA, even if rarely seen, and additional information on all species can be found in the Marine Resources Assessment referenced above.

Table E-1. Marine mammals in the Gulf of Alaska; densities and season(s) included for species regularly seen.

Common Name	Scientific Name	Status	Density/km2 within TMAA	Season	Source
MYSTICETES					
Blue whale	*Balaenoptera musculus*	Endangered	-		
Fin whale	*B. physalus*	Endangered	0.010	Year round	Rone et al. (2009)
Sei whale	*B. borealis*	Endangered	-		
Minke whale	*B. acutorostrata*		0.0006	Year round	Waite (2003)
Humpback whale	*Megaptera novaeangliae*	Endangered	0.0019	Apr-Dec	Rone et al. (2009)
			-	Jan-Mar	Reeves et al. (2002)
North Pacific right whale	*Eubalaena japonica*	Endangered	-		
Gray whale	*Eschrichtius robustus*		0.0003	Year round	Moore et al. (2007)
ODONTOCETES					
Sperm whale	*Physeter catodon*	Endangered	0.0003	Year round	Waite (2003); Mellinger et al. (2004a)
Cuvier's beaked whale	*Ziphius cavirostris*		0.0022	Year round	Waite (2003)
Baird's beaked whale	*Berardius bairdii*		0.0005	Year round	Waite (2003)
Stejneger's beaked whale	*Mesoplodon stejnegeri*		-		
Killer whale	*Orcinus orca*		0.0100	Year round	Zerbini et al. (2007)
Beluga	*Delphinapterus leucas*		-		
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*		0.0208	Year round	Waite (2003)
Northern right whale dolphin	*Lissodelphis borealis*		-		
Risso's dolphin	*Grampus griseus*		-		
False killer whale	*Pseudorca crassidens*		-		
Short-finned pilot whale	*Globicephala macrorhynchus*		-		
Dall's porpoise	*Phocoenoides dalli*		0.1892	Year round	Waite (2003)
Harbor porpoise	*Phocoena phocoena*		-		
PINNIPEDS					
Steller's sea lion	*Eumetopias jubatus*	Endangered/ Threatened	0.0098	Year round	Angliss and Allen (2009); Bonnell and Bowlby (1992)
California sea lion	*Zalophus californianus*		-		
Harbor seal	*Phoca vitulina*		-		
Northern fur seal	*Callorhinus ursinus*		0.1180	June-October	Carretta et al., 2009
Northern elephant seal	*Mirounga angustirostris*		0.0022	June-October	Carretta et al., 2009

Table E-2. Comparison of f(0) and g(0) values, for species being considered from Waite (2003) from survey efforts outside of the TMAA.

Reference	Barlow (2003)		Ferguson and Barlow (2001)		Forney (2007)		Barlow and Forney (2007)		Barlow (2006)		Wade and Gerrodette (1993)
Species	f_0	g_0	f_0	g_0	f_0	g_0	f_0	g_0	f_0	g_0	f_0
Minke whale	**0.567**	**0.84**	0.362	0.84	0.38	0.856	0.46	0.856			
Sperm whale	0.217	**0.87**	**0.462**	0.87	0.36	0.87	0.34	0.87	0.27	0.87	0.14
Baird's beaked whale	0.354	**0.96**	0.215	0.96	0.37	0.96	**0.52**	0.96			
Cuvier's beaked whale	**0.567**	**0.23**	0.362	0.23	0.39	0.23	0.37	0.23	0.61	0.23	0.58
Pacific white-sided dolphin	**0.809**	1	0.519	1	0.4	**0.97**	0.45	0.97			
Dall's porpoise	**1.221**	**0.79**	0.855	0.79	0.74	0.822	0.91	0.822			
Survey region	US West Coast		US West Coast		US West Coast		US West Coast		Hawaii		Eastern Tropical Pacific
Number of observers	3		3		3		3		3		3
Speed of vessel (kts)	9-10		9-10		9-10		9-10		9-10		9-10
Height of flying bridge (m)	10.5		10.5		10.5 and 15.2		10.5 and 15.2		10.5		10.5
Big Eyes binoculars	two pair		two pair		two pair		two pair		two pair		two pair
Sea conditions	up to B05		up to B05		up to B05		up to B05		up to B05		up to B05

Conservative values for each species are bolded

Table E-3. Densities calculated from data presented in Waite (2003) using f(0) and g(0) values from Table 2.

Species	n = animal groups on effort[a]	s = mean group size[a]	L = transect length (km^2)[a]	f_0 = perpendicular sighting distance[b]	g_0 = probability of seeing group directly on trackline[b]	Density/km^2 = (n) (s) (f_0) / (2L) (g_0) [c]
Minke whale	3	1.3	2242	0.567	0.84	0.0006
Sperm whale	2	1.2	2242	0.462	0.87	0.0003
Baird's beaked whale	1	4	2242	0.52	0.96	0.0005
Cuvier's beaked whale	1	4	2242	0.567	0.23	0.0022
Pacific white-sided dolphin	2	56	2242	0.809	0.97	0.0208
Dall's porpoise	196	2.8	2242	1.221	0.79	0.1892

[a] from Waite (2003), [b] Values for f0 and g0 taken from Table 12, [c] Calculation taken from Barlow (2003).
There is no variance associated with these density calculations so there is no way to indicate the confidence in the value. Densities from sperm, Pacific white-sided, Baird's and Cuvier's beaked whales are quite weak as they are based on only 1-2 sightings.

E.1.2 Depth Distribution

There are limited depth distribution data for most marine mammals. This is especially true for cetaceans, as they must be tagged at-sea and by using a tag that either must be implanted in the skin/blubber in some manner or adhere to the skin. There is slightly more data for some pinnipeds, as they can be tagged while on shore during breeding or molting seasons and the tags can be glued to the pelage rather than implanted. There are a few different methodologies/ techniques that can be used to determine depth distribution percentages, but by far the most widely used technique currently is the time-depth recorder. These instruments are attached to the animal for a fairly short period of time (several hours to a few days) via a suction cup or glue, and then retrieved immediately after detachment or when the animal returns to the beach. Depth information can also be collected via satellite tags, sonic tags, digital tags, and, for sperm whales, via acoustic tracking of sounds produced by the animal itself.

There are somewhat suitable depth distribution data for a few marine mammal species. Sample sizes are usually extremely small, nearly always fewer than 10 animals total and often only one or two animals. Depth distribution information can also be interpreted from other dive and/or preferred prey characteristics, and from methods including behavioral observations, stomach content analysis and habitat preference analysis. Depth distributions for species for which no data are available were extrapolated from similar species.

Depth distribution information for marine mammal species with regular occurrence and for which densities are available is provided in Table 4. More detailed summary depth information for species in the GOA for which densities are available is included as Table 6.

E.1.3 DENSITY AND DEPTH DISTRIBUTION COMBINED

Density is nearly always reported for an area, e.g., animals/km^2. Analyses of survey results using Distance Sampling techniques include correction factors for animals at the surface but not seen as well as animals below the surface and not seen. Therefore, although the area (e.g., km^2) appears to represent only the surface of the water (two-dimensional), density actually implicitly includes animals anywhere within the water column under that surface area. Density assumes that animals are uniformly distributed within the prescribed area, even though this is likely rarely true. Marine mammals are usually clumped in areas of greater importance, for example, areas of high productivity, lower predation, safe calving, etc. Density can occasionally be calculated for smaller areas that are used regularly by marine mammals, but more often than not, there are insufficient data to calculate density for small areas. Therefore, assuming an even distribution within the prescribed area remains the norm.

The ever-expanding database of marine mammal behavioral and physiological parameters obtained through tagging and other technologies has demonstrated that marine mammals use the water column in various ways, with some species capable of regular deep dives (>800 m) and others regularly diving to <200 m, regardless of the bottom depth. Therefore, assuming that all species are evenly distributed within the water column does not accurately reflect behavior and can present a distorted view of marine mammal distribution in any region.

By combining marine mammal density with depth distribution information, a more accurate three-dimensional density estimate is possible. These 3-D estimates allow more accurate modeling of potential marine mammal exposures from specific noise sources.

This document is organized into taxonomic categories: Mysticetes, Odontocetes and the pseudo-taxonomic category Pinnipeds. Nomenclature was adopted from the Integrated Taxonomic Information System (www.itis.gov). Distribution and density summaries are followed by discussions of depth distribution for those species that have regular occurrence. Density and depth info are **bolded** in text.

Table E-4. Summary of marine mammal depth distributions for the TMAA

Common Name	Scientific Name	Depth Distribution	Reference
MYSTICETES - Baleen whales			
Fin whale	*B. physalus*	44% at <50m, 23% at 50-225m, 33% at >225m	Goldbogen et al. (2006)
Minke whale	*B. acutorostrata*	53% at <20m, 47% at 21-65m	Blix and Folkow (1995)
Humpback whale	*Megaptera novaeangliae*	37% at <4m, 25% at 4-20m, 7% at 21-35m,4% at 36-50m, 6% at 51-100m, 7% at 101-150m, 8% at 151-200m, 6% at 201-300m, <1% at >300m	Dietz et al. (2002)
Gray whale	*Eschrichtius robustus*	40% at <4 m, 38% at 4-30 m, 22% at >30 m	Malcolm et al. (1995/96); Malcolm and Duffus (2000)
ODONTOCETES - Toothed whales			
Sperm whale	*Physeter catodon*	31% at <10 m, 8% at 10-200 m, 9% at 201-400 m, 9% at 401-600 m, 9% at 601-800 m and 34% at >800 m	Amano and Yoshioka (2003)
Cuvier's beaked whale	*Ziphius cavirostris*	27% at <2 m, 29% at 2-220 m, 4% at 221-400 m, 4% at 401-600 m, 4% at 601-800 m, 5% at 801-1070 m and 27% at >1070 m	Tyack et al. (2006)
Baird's beaked whale	*Berardius bairdii*	34% at 0-40 m, 39% at 41-800 m, 27% at >800 m	extrapolated from northern bottlenose whale (Hooker and Baird, 1999)
Killer whale	*Orcinus orca*	96% at 0-30 m, 4% at >30 m	Baird et al. (2003)
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Daytime: 100% at 0-65 m; Nighttime: 100% at 0-130 m	extrapolated from other *Lagenorhynchus* (Mate et al., 1994; Benoit-Bird et al., 2004)
Dall's porpoise	*Phocoenoides dalli*	39% at <1 m, 8% at 1-10 m, 45% at 11-40 m, and 8% at >40 m	Hanson and Baird (1998)
PINNIPEDS			
Northern fur seal	*Callorhinus ursinus*	Daytime: 74% at <2 m; 26% at 2-260 m; Nighttime: 74% at <2 m; 26% at 2-75 m	Ponganis et al. (1992); Kooyman and Goebel (1986); Sterling and Ream (2004); Gentry et al. (1986)
Steller sea lion	*Eumetopias jubatus*	60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m	Merrick and Loughlin (1997)
Northern elephant seal	*Mirounga angustirostris*	9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m	Asaga et al. (1994)

E.2 MYSTICETES

E.2.1 Blue whale, *Balaenoptera musculus*

Blue whales were previously sighted and caught throughout the GOA, but are rarely seen in the post-whaling era; two blue whales seen in 2004 during a NMFS humpback whale study and approximately 150 nm southeast of Prince William Sound are the first documented sightings of blue whales in several decades. There may be two to five stocks of blue whale in the north Pacific (Angliss and Allen, 2009).

The Eastern North Pacific population, which winters as far south as the eastern tropical Pacific, has been sighted off Oregon and Washington although sightings are rare and there is no abundance estimate (Angliss and Allen, 2009). Blue whale calls attributed to this stock as well as the Northwestern stock were recorded in the Gulf of Alaska (Stafford, 2003) via hydrophones located offshore of the TMAA. Both call types were recorded seasonally, with peak occurrence from August-November. Blue whales are likely present in low numbers in the GOA; **there is no density estimate available (Table 1)**.

E.2.2 Fin whale, *Balaenoptera physalus*

Fin whales were extensively hunted in coastal waters of Alaska as they congregated at feeding areas in the spring and summer (Mizroch et al., 2009). There has been little effort in the GOA since the cessation of whaling activities to assess abundance of large whale stocks. Fin whale calls have been recorded year-round in the GOA, but are most prevalent from August-February (Moore et al., 1998; 2006). Zerbini et al. (2006) sighted fin whales south of the Kenai Peninsula, and calculated a density of 0.008/km^2 (see Table 4, Block 1 in Zerbini et al., 2006). Waite (2003) recorded 55 fin whale sightings on effort, with several occurring within the TMAA (see Figure 2 in Waite, 2003). Rone et al. (2009) recorded 24 sightings of 64 fin whales during a 10-day cruise in the TMAA in April 2009. Density for the inshore stratum was estimated as 0.012/km^2, while density in the offshore stratum was estimated as 0.009/km^2 (Table 9, Rone et al., 2009). **Combined density for the TMAA was 0.010/km^2, which is applicable to the entire region year round (Table 1).**

Fin whales feed on planktonic crustaceans, including *Thysanoessa* sp and *Calanus* sp, as well as schooling fish including herring, capelin and mackerel (Aguilar, 2002). Depth distribution data from the Ligurian Sea in the Mediterranean are the most complete (Panigada et al., 2003; Panigada et al., 2006), and showed differences between day and night diving; daytime dives were shallower (<100m) and night dives were deeper (>400m), likely taking advantage of nocturnal prey migrations into shallower depths; this data may be atypical of fin whales elsewhere in areas where they do not feed on vertically-migrating prey. Traveling dives in the Ligurian Sea were generally shorter and shallower (mean = 9.8 m, maximum = 20 m) than feeding dives (mean = 181m, maximum = 474 m) (Jahoda et al., 1999). Goldbogen et al. (2006) studied fin whales in southern California and found that ~56% of total time was spent diving, with the other 44% near surface (<50m); dives were to >225 m and were characterized by rapid gliding ascent, foraging lunges near the bottom of dive, and rapid ascent with flukes. Dives are somewhat V-shaped although the bottom of the V is wide. **Therefore, % of time at depth levels is estimated as 44% at <50m, 23% at 50-225 m (covering the ascent and descent times) and 33% at >225 m.**

E.2.3 Sei whale, *Balaenoptera borealis*

Sei whales occur in all oceans from subtropical to sub-arctic waters, and can be found on the shelf as well as in oceanic waters (Reeves et al., 2002). They are known to occur in the GOA and as far north as the Bering Sea in the north Pacific. However, their distribution is poorly understood. The only stock estimate for U.S. waters is for the eastern north Pacific stock offshore California, Oregon and Washington (Carretta et al., 2009); abundance in Alaskan waters is unknown and they were not been sighted during recent surveys (Waite, 2003; Rone et al., 2009). Sei whales are likely present in low numbers in the GOA; **there is no density estimate available (Table 1)**.

E.2.4 Minke whale, *Balaenoptera acutorostrata*

Minke whales are the smallest of all mysticete whales. They are widely distributed in the north Atlantic and Pacific, and appear to undergo migration between warmer waters in winter and colder waters in summer. Minke whales can be found in near shore shallow waters and have been detected acoustically in offshore deep waters. There is no current abundance estimate for the Alaska stock of minke whales (Angliss and Allen, 2009). Zerbini et al. (2006) sighted minke whales near Kodiak Island (and a single sighting nearshore off the Kenai Peninsula), and calculated a density of 0.006/km^2 (see Table 4, Block 3 in Zerbini et al., 2006). Waite (2003) recorded three minke sightings on effort, all southeast of the Kenai

Peninsula (see Figure 2 in Waite, 2003). Rone et al. (2009) sighted three minke whales in April 2009, all of which were in the Nearshore stratum, but no density was calculated. **Density calculated from Waite (2003) data yielded a density of 0.0006/km^2 (Table 1), which is applicable to the entire region year round.** Although this is lower than density calculated by Zerbini et al. (2006), it is likely more representative of minke whale abundance in the region as the Waite (2003) surveys were farther offshore.

Minke whales feed on small schooling fish and krill, and are the smallest of all balaenopterid species which may affect their ability to dive. Hoelzel et al. (1989) observed minke whales feeding off the San Juan Islands of Puget Sound, Washington, where 80% of the feeding occurred over depths of 20-100m and two types of feeding were observed near surface, lunge feeding and bird association. The only depth distribution data for this species were reported from a study on daily energy expenditure conducted off northern Norway and Svalbard (Blix and Folkow, 1995). The limited depth information available (from Figure 2 in Blix and Folkow, 1995) was representative of a 75-min diving sequence where the whale was apparently searching for capelin, then foraging, then searching for another school of capelin. Search dives were mostly to ~20 m, while foraging dives were to 65 m. **Based on this very limited depth information, rough estimates for % of time at depth are as follows: 53% at <20 m and 47% at 21-65 m.**

E.2.5 Humpback whale, *Megaptera novaeangliae*

Humpback whales are found in all oceans, in both coastal and continental waters as well as near seamounts and in deep water during migration (Reeves et al., 2002). Some populations have been extensively studied (e.g., Hawaii, Alaska, Caribbean), and details about migratory timing, feeding and breeding areas are fairly well known (e.g., Calambokidis et al., 2008). Humpbacks are highly migratory, feeding in summer at mid and high latitudes and calving and breeding in winter in tropical or subtropical waters. Humpbacks feeding in the TMAA in summer appear to winter in Hawaiian and Mexican waters (Calambokidis et al., 2008). Humpbacks are present in Alaskan waters during summer and fall, although there may be a few stragglers that remain year round. Waite (2003) recorded 41 humpback whale sightings on effort, with several occurring near shore around the Kenai Peninsula (see Figure 2 in Waite, 2003). Rone et al. (2009) recorded 11 sightings of 20 individuals during a 10-day cruise in the TMAA in April 2009. Density for the inshore stratum was estimated as 0.004/km^2, while density in the offshore stratum was estimated as 0.0005/km^2 (Table 9, Rone et al., 2009). **Combined density for the TMAA was 0.0019/km^2, which is applicable to the entire region year round (Table 1).** Calambokidis et al. (2008) estimated 3,000-5,000 humpbacks in the entire GOA, an area much larger than the TMAA.

Humpback whales feed on pelagic schooling euphausiids and small fish including capelin, herring and mackerel (Clapham, 2002). Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with open mouths through the middle. Dives appear to be closely correlated with the depths of prey patches, which vary from location to location. In the north Pacific, most dives were of fairly short duration (<4 min) with the deepest dive to 148 m (southeast Alaska; Dolphin, 1987), while whales observed feeding on Stellwagen Bank in the North Atlantic dove to <40 m (Hain et al., 1995). Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth. Depth distribution data collected at a feeding area in Greenland resulted in the following estimation of depth distribution: **37% of time at <4 m, 25% of time at 4-20 m, 7% of time at 21-35m, 4% of time at 36-50 m, 6% of time at 51-100 m, 7% of time at 101-150 m, 8% of time at 151-200 m, 6% of time at 201-300 m, and <1% at >300 m** (Dietz et al., 2002).

E.2.6 North Pacific right whale, *Eubalaena japonica*

North Pacific right whales were heavily hunted near Kodiak Island from the mid-1800s through the early 1900s. Despite international protection, the species has not recovered and remains one of the rarest of all

cetaceans. There have been only two verified sightings of right whales in the GOA since the 1970s, with one occurring very near Kodiak Island (Shelden et al., 2005). Regular sightings of right whales do occur in the southeastern Bering Sea in summer, where up to 13 individual whales have been identified based on photos and biopsy dart data, but their winter habitat remains unknown. Acoustic monitoring for right whales was carried out via autonomous hydrophones in 2000-2001 near Kodiak Island, and right whale calls were recorded in August and early September (Moore et al., 2006; Mellinger et al., 2004b). Right whales are likely present in extremely low numbers in the GOA; **there is no density estimate available (Table 1).**

E.2.7 Gray whale, *Eschrichtius robustus*

The current stock estimate for the eastern north Pacific stock of gray whales is 18,813 (Angliss and Allen, 2009). Gray whales undertake a well-documented migration from winter calving lagoons in Baja California to summer feeding areas in the Bering and Chukchi seas (Swartz et al., 2006). Their migration route is primarily near shore in shallow water, although gray whales have been documented swimming offshore near the Channel Islands in the Southern California Bight. In addition to the Bering and Chukchi sea feeding areas, gray whales are known to feed opportunistically at several locations along the migratory route. Two such areas are near Ugak Bay, Kodiak Island, and along the outer coast of southeast Alaska where 30-50 gray whales have been sighted feeding year round (Moore et al., 2007). Gray whales would not be found in most of the TMAA but likely do cross the northernmost section (estimated at 2,400 km^2 via ArcMap and representing 2.75% of the total TMAA; 2,400 km^2/87,250 km^2 as measured in ArcMap) migrating to and from both local and distant feeding grounds. Rone et al. (2009) recorded three sightings of eight gray whales (see Figure 3 in Rone), which were located nearshore at Kodiak Island to the west of the TMAA and in the westernmost section of the TMAA on the continental shelf. The number of gray whales within the TMAA at any given time is likely quite small as it is probably at the deeper limit of their occurrence. Therefore, the lower estimate of Kodiak Island feeding gray whales from Moore et al. (2007) was used to estimate density. **Density was estimated at 0.0125/km^2 (30 gray whales/2,400 km^2) year round, and is applicable only for the farthest north area of the TMAA (2.75 % of area, see Figure 1) for an overall density for the TMAA of 0.0003/km^2 (Table 1).**

Gray whales migrate from breeding and calving grounds in Baja California to primary feeding grounds in the Bering and Chukchi Seas between Alaska and Russia. Behavior, including diving depth and frequency, can vary greatly between geographic regions. Gray whales feed on the bottom, mainly on benthic amphipods that are filtered from the sediment (Reeves et al., 2002), so dive depth is dependent on depth at location for foraging whales. There have been several studies of gray whale movement within the Baja lagoons (Harvey and Mate, 1984; Mate and Harvey, 1984), but these are likely not applicable to gray whales elsewhere. Mate and Urban Ramirez (2003) noted that 30 of 36 locations for a migratory gray whale with a satellite tag were in water <100m deep, with the deeper water locations all in the southern California Bight within the Channel Islands. There has been only one study of a gray whale dive profile, and all information was collected from a single animal that was foraging off the west coast of Vancouver Island (Malcolm and Duffus, 2000; Malcolm et al.,1995/96). They noted that the majority of time was spent near the surface on interventilation dives (<3 m depth) and near the bottom (extremely nearshore in a protected bay with mean dive depth of 18 m, range 14-22 m depth). There was very little time spent in the water column between surface and bottom. Foraging depth on summer feeding grounds is generally between 50-60 m (Jones and Swartz, 2002). Based on this very limited information, **the following is a rough estimate of depth distribution for gray whales: 40% of time at <4 m (surface and interventilation dives), 38% of time at 3-30 m (active migration), 22% of time at >30 m (foraging).**

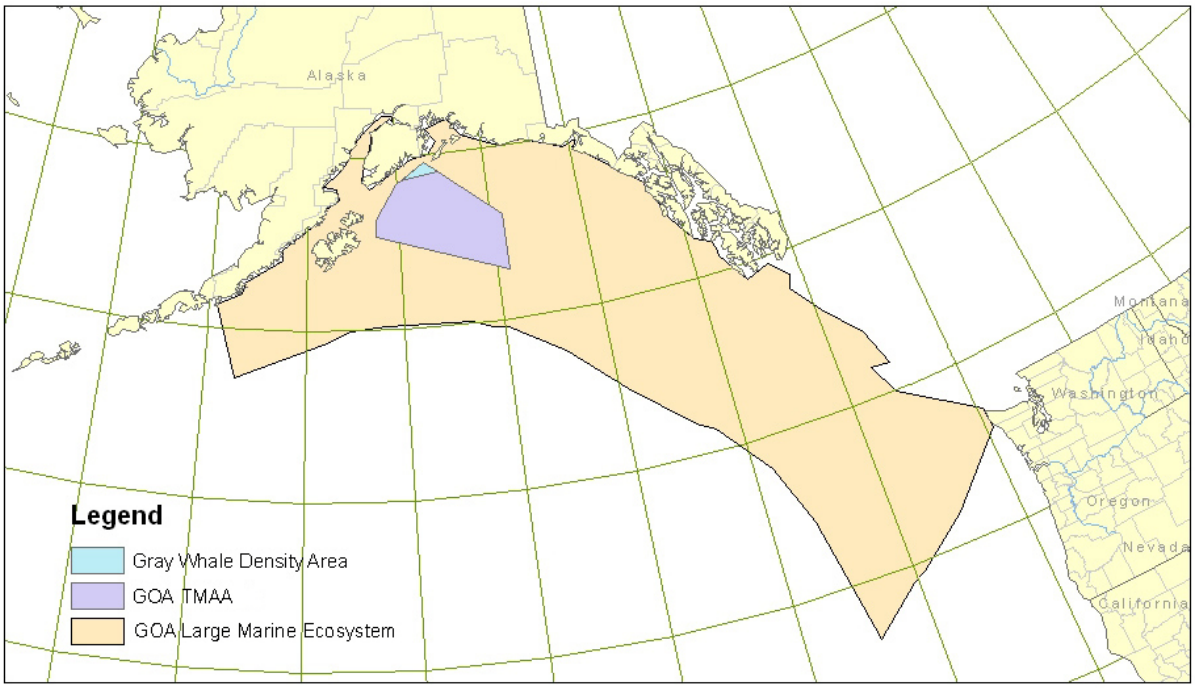

Figure E-1. TMAA, GOA Large Marine Ecosystem and Gray Whale Density Area.

E.3 ODONTOCETES

E.3.1 Sperm whale, *Physeter catodon*

Sperm whales are well known from the GOA region. Sperm whales are most often found in deep water, near submarine canyons, and along the edges of banks and over continental slopes (Reeves et al., 2002). Acoustic evidence collected via autonomous recorders suggests that sperm whales are present in the offshore regions of the GOA year round (see Figure 2 in Mellinger et al., 2004a). Rone et al. (2009; Figure 8) recorded sperm whales acoustically in both the inshore and offshore strata of the TMAA in April 2009; no sperm whales were detected visually. Waite (2003) recorded two on-effort sightings of sperm whales; both within the TMAA (see Figure 2 in Waite, 2003). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0003/km^2 (Table 1), which is applicable to the entire region year round.** Density was based on only two sightings, so confidence in the value is low, but it is the only density that exists at this time for the region.

Unlike other cetaceans, there is a preponderance of dive information for this species, most likely because it is the deepest diver of all cetacean species so generates a lot of interest. Sperm whales feed on large and medium-sized squid, octopus, rays and sharks, on or near the ocean floor (Whitehead, 2002; Clarke, 1986). Some evidence suggests that they do not always dive to the bottom of the sea floor (likely if food is elsewhere in the water column), but that they do generally feed at the bottom of the dive. Davis et al. (2007) report that dive-depths (100-500 m) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 m) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. Their research also showed that sperm whales foraged throughout a 24-hour period, and that they rarely dove to the sea floor bottom (>1000 m). The most consistent sperm whale dive type is U-shaped, during which the whale makes a rapid descent to the bottom of the dive, forages at various velocities while at depth (likely while chasing prey) and then ascends rapidly to the surface. There is some evidence that male sperm whales, feeding at higher latitudes

during summer months, may forage at several depths including <200 m, and utilize different strategies depending on position in the water column (Teloni et al., 2007). Perhaps the best source for depth distribution data comes from Amano and Yoshioka (2003), who attached a tag to a female sperm whale near Japan in an area where water depth was 1000-1500m. Based on values in Table 1 (in Amano and Yoskioka, 2003) for dives with active bottom periods, the total dive sequence was 45.9 min (mean surface time plus dive duration). Mean post-dive surface time divided by total time (8.5/45.9) plus time at surface between deep dive sequences yields a percentage of time at the surface (<10 m) of 31%. Mean bottom time divided by total time (17.5/45.9) and adjusted to include the percentage of time at the surface between dives, yields a percentage of time at the bottom of the dive (in this case >800 m as the mean maximum depth was 840 m) of 34%. Total time in the water column descending or ascending results from the duration of dive minus bottom time (37.4-17.5) or ~20 minutes. Assuming a fairly equal descent and ascent rate (as shown in Table 1 in Amano and Yoshioka) and a fairly consistent descent/ascent rate over depth, we assume 10 minutes each for descent and ascent and equal amounts of time in each depth gradient in either direction. Therefore, 0-200 m = 2.5 minutes one direction (which correlates well with the descent/ascent rates provided) and therefore 5 minutes for both directions. The same is applied to 201-400 m, 401-600 m and 601-800 m. **Therefore, the depth distribution for sperm whales based on information in the Amano paper is: 31% in <10 m, 8% in 10-200 m, 9% in 201-400 m, 9% in 401-600 m, 9% in 601-800 m and 34% in >800 m.** The percentages derived above from data in Amano and Yoshioka (2003) are in fairly close agreement with those derived from Table 1 in Watwood et al. (2006) for sperm whales in the Ligurian Sea, Atlantic Ocean and Gulf of Mexico.

E.3.2 Cuvier's beaked whale, *Ziphius cavirostris*

Cuvier's beaked whale has the widest distribution of all beaked whales, and occurs in all oceans. It is most often found in deep offshore waters, and appear to prefer slope waters with steep depth gradients. There are no reliable population estimates for this species in Alaskan waters (Angliss and Allen, 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0022/km^2 (Table 1), which is applicable to the entire region year round.** Density was based on a single sighting, so confidence in the value is low, but it is the only density available for this region.

Cuvier's feed on mesopelagic or deep water benthic organisms, particularly squid (Heyning, 2002). Stomach content analyses indicate that they take advantage of a larger range of prey species than do other deep divers (e.g., Santos et al., 2001; Blanco and Raga, 2000). Cuvier's, like other beaked whales, are likely suction feeders based on the relative lack of teeth and enlarged hyoid bone and tongue muscles. Foraging dive patterns appear to be U-shaped, although inter-ventilation dives are shallower and have a parabolic shape (Baird et al., 2006a). Depth distribution studies in Hawaii (Baird et al., 2005a; Baird et al., 2006a) found that Cuvier's undertook three or four different types of dives, including intermediate (to depths of 292-568 m), deep (>1000 m) and short-inter-ventilation (within 2-3 m of surface); this study was of a single animal. Studies in the Ligurian Sea indicated that Cuvier's beaked whales dived to >1000 m and usually started "clicking" (actively searching for prey) around 475 m (Johnson et al., 2004; Soto et al., 2006). Clicking continued at depths and ceased once ascent to the surface began, indicating active foraging at depth. In both locations, Cuvier's spent more time in deeper water than did Blainville's beaked whale, although maximum dive depths were similar. There was no significant difference between day and night diving indicating that preferred prey likely does not undergo vertical migrations.

Dive information for Cuvier's was collected in the Ligurian Sea (Mediterranean) via DTAGs on a total of seven animals (Tyack et al., 2006) and, despite the geographic difference and the author's cautions about the limits of the data set, the Ligurian Sea dataset represents a more complete snapshot than that from Hawaii (Baird et al., 2006a). Cuvier's conducted two types of dives – U-shaped deep foraging dives (DFD) and shallow duration dives. Dive cycle commenced at the start of a DFD and ended at the start of the next DFD, and included shallow duration dives made in between DFD.

Mean length of dive cycle = 121.4 min (mean DFD plus mean Inter-deep dive interval)

Number of DFD recorded = 28

Mean DFD depth = 1070 m (range 689-1888 m)

Mean length DFD = 58.0 min

Mean Vocal phase duration = 32.8 min

Mean inter-deep dive interval = 63.4 min

Mean shallow duration dive = 221 m (range 22-425 m)

Mean # shallow duration dives per cycle = 2 (range 0-7)

Mean length of shallow duration dives = 15.2 min

Total time at surface (0-2 m) was calculated by subtracting the mean length of DFD and two shallow duration dives from the total dive cycle (121.4 - 58.0 – 30.4 = 33 min). Total time at deepest depth was taken from the Vocal phase duration time, as echolocation clicks generally commenced when animals were deepest, and was 32.8 min. The amount of time spent descending and ascending on DFDs was calculated by subtracting the mean Vocal phase duration time from the mean total DFD (58.0 - 32.8 = 25.2 min) and then dividing by five (# of 200 m depth categories between surface and 1070 m) which equals ~five min per 200 m. The five-minute value was applied to each 200 m depth category from 400-1070 m; for the 2-220 m category, the mean length of shallow duration dives was added to the time for descent/ascent (30.4 + 5 = 35.4 min). **Therefore, the depth distribution for Cuvier's beaked whales based on best available information from Tyack et al. (2006) is: 27% at <2 m, 29% at 2-220 m, 4% at 221-400 m, 4% at 401-600 m, 4% at 601-800 m, 5% at 801-1070 m and 27% in >1070 m.**

E.3.3 Baird's beaked whale, *Berardius bairdii*

Baird's beaked whales, like most beaked whales, are a deep water species that inhabits the north Pacific. They generally occur close to shore only in areas with a narrow continental shelf. There is no reliable population estimate for this species in Alaskan waters (Angliss and Allen, 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0005/km^2 (Table 1), which is applicable to the entire region year round.** Density was based on a single sighting, so confidence in the value is low, but it is the only density available for this region.

There are no depth distribution data for this species. Studies conducted on the diet of Baird's from stomach content analysis reveal some insight into feeding patterns. Samples collected off the Pacific coast of Honshu, Japan, revealed a preference primarily for benthopelagic fish (87%) and cephalopods (13%), while samples collected in the southern Sea of Okhotsk were primarily cephalopods (Walker et al., 2002). Other stomach samples collected from same geographic regions indicated demersal fish were the most commonly identified prey, and that Baird's were feeding at the bottommost depths of at least 1000 m (Ohizumi et al., 2003). The overall dive behavior of this beaked whale is not known (e.g., shape of dive, interventilation dives, etc). In lieu of other information, the depth distribution for northern bottlenose whales, *Hyperoodon ampullatus,* will be extrapolated to Baird's. There has been one study on northern bottlenose whales, which provides some guidance as to depth distribution (Hooker and Baird, 1999). Most (62-70%, average = 66%) of the time was spent diving (deeper than 40 m), and most dives were somewhat V-shaped. Both shallow dives (<400 m) and deep dives (>800 m) were recorded, and whales spent 24-30% (therefore, average of 27%) of dives at 85% maximum depth indicating they feed near the bottom. Using these data points, we **estimate 34% of time at 0-40 m, 39% at 41-800 m, 27% at >800 m for *H. ampullatus* and extrapolate this to *B. berardius*.**

E.3.4 Stejneger's beaked whale, *Mesoplodon stejnegeri*

Stejneger's beaked whale is known from the north Pacific only, ranging in subarctic and cool temperate waters. It is likely the only mesoplodont whale to be found in the GOA, as other *Mesoplodon* species do not range that far north. There is no abundance estimate for this species, as it is rarely seen at-sea and is most often recorded via stranding events (Angliss and Allen, 2009). Stejneger's beaked whales are likely present in low numbers in the GOA; **there is no density estimate available (Table 1)**.

E.3.5 Killer whale, *Orcinus orca*

There are two stocks of killer whales in the north Pacific whose ranges overlap in the GOA, but who differ in feeding preferences, acoustics and genetics. The Alaska Resident stock feeds primarily on fish, ranges from southeast Alaska to the Aleutian Islands and Bering Sea, and has a minimum population estimate of 1,123 based on photo ID (Angliss and Allen, 2009). The Gulf of Alaska, Aleutian Islands and Bering Sea Transient stock feeds primarily on other marine mammals and ranges farther offshore in the GOA than the resident stock, as well as to the Aleutian Islands and Bering Sea. The minimum estimate based on photo ID for that population is 314. Vessel surveys for killer whales were conducted in July and August from 2001-2003 near Steller sea lion haulouts from the Kenai Peninsula to Amchitka Pass in the Aleutian Islands (Zerbini et al., 2007). The surveys did not venture far from shore but do provide density estimates for transient and resident stocks. **Survey blocks closest to the TMAA (blocks 2-5) had an average density of 0.010/km^2 resident killer whales (IGS density which the authors indicate is more appropriate for resident killer whales), which is applicable to the entire region year round (Table 3).** Killer whales were seen and heard during a vessel cruise in the TMAA in April 2009 (Rone et al., 2009; Figures 4 and 8), but density was not calculated.

Diving studies on killer whales have been undertaken mainly on "resident" (fish-eating) killer whales in the Puget Sound and may not be applicable across all populations of killer whales. Diving is usually related to foraging, and mammal-eating killer whales may display different dive patterns. Killer whales in one study (Baird et al., 2005b) dove as deep as 264 m, and males dove more frequently and more often to depths >100 m than females, with fewer deep dives at night. Using best available data from Baird et al. (2003), it would appear that **killer whales spend ~4% of time at depths >30 m and 96% of time at depths <30 m**. Dives to deeper depths were often characterized by velocity bursts which may be associated with foraging or social activities.

E.3.6 Beluga, *Delphinapterus leucas*

A genetically and geographically discrete population of belugas exists in Cook Inlet. Scattered sightings of belugas in the northern GOA have been recorded since the mid-1970s, and these animals may be part of the Cook Inlet stock (Laidre et al., 2000) or may be part of a group of belugas that appear to be resident to Yakutat Bay (O'Corry-Crowe et al., 2006). An in-depth review of 13 dedicated cetacean surveys in the GOA found that all northern GOA sightings were coastal and none were reported in offshore areas. **No density is available (Table 1).**

E.3.7 Pacific white-sided dolphin, *Lagenorhychus obliquidens*

Pacific white-sided dolphins range throughout the north Pacific in cold temperate waters. Movements between inshore/offshore and north/south are not well understood. The north Pacific stock of this species, which ranges from British Columbia across the north Pacific and including the GOA, is currently estimated to have a minimum abundance of 26,880 based on data collected from 1987-90 (Angliss and Allen, 2009). **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.0208/km^2 (Table 1), which is applicable to the entire region year round.** This density was based on just two sightings so confidence in this value is low, but it is the only density available for this region. Rone et al. (2009) collected one sighting of 60 Pacific white-sided dolphins during the April 2009 cruise; the sighting was outside of the TMAA, south of Kodiak Island (See Figure 4 in Rone).

Pacific white-sided dolphins are generalist feeders (von Waerebeek and Wursig, 2002). Studies on diving by this species have not been undertaken. Satellite tag studies of a rehabilitated related species (*Lagenorhynchus acutus*) in the Gulf of Maine indicated that nearly all time was spent in waters <100 m total depth with largely directed movement (Mate et al., 1994). Another related species, *Lagenorhynchus obscurus*, was observed feeding in two circumstances; at night to 130 m depth to take advantage of the deep scattering layer closer to the surface and during the day in shallower depths (<65 m) where they fed on schooling fish (Benoit-Bird et al., 2004). **In lieu of the lack of other data available for this Pacific lags, the following are very rough estimates of time at depth: daytime - 100% at 0-65 M; night time – 100% at 0-130 m.**

E.3.8 Northern right whale dolphin, *Lissodelphis borealis*

The northern right whale dolphin occurs in a band across the north Pacific, generally between 34° and 47°N (Reeves et al., 2002). They are primarily an open ocean species, and rarely come near shore. Their presence in the GOA is unknown but, based on the lack of sightings of this gregarious species, is likely rare; **there is no density for this species (Table 1)**.

E.3.9 Risso's dolphin, *Grampus griseus*

This species is known from tropical and warm temperate oceans, primarily in waters with surface temperatures between 50 and 82°F (Reeves et al., 2002). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table 1).**

E.3.10 False killer whale, *Pseudorca crassidens*

False killer whales are found from tropical to warm temperate waters, with well known populations near Japan and in the eastern tropical Pacific. They were not seen along the Pacific US coast during surveys conducted from 1986-2001 (Ferguson and Barlow, 2003; Barlow, 2003) nor in 2005 (Forney, 2007), although they have occasionally been sighted as far north as British Columbia (Reeves et al., 2002). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table 1).**

E.3.11 Short-finned pilot whale, *Globicephala macrorhynchus*

This species is known from tropical and warm temperate waters and, in the northeast Pacific, its distribution likely extends as far north as Vancouver Island (Reeves et al., 2002). Pilot whales were not seen during vessel surveys conducted offshore Washington and Oregon in 1996 or 2001 (Barlow, 2003) and there was only one sighting during surveys conducted in 2005 (Forney, 2007). Their presence in the GOA is likely extremely rare and extralimital; **there is no density for this species (Table 1).**

E.3.12 Dall's porpoise, *Phocoenoides dalli*

Dall's porpoises are endemic to the north Pacific, ranging north of ~52° into the Bering Sea. It is generally found in deep, cool waters but is also common in coastal areas. The Alaska stock is currently estimated at 83,400 animals (Angliss and Allen, 2009). Waite (2003) sighted Dall's porpoise frequently throughout their study area, including several sightings south of the Kenai Peninsula and therefore within the TMAA. **Data from vessel surveys conducted by Waite (2003) yielded a density of 0.1892/km^2 (Table 1), which is applicable to the entire region year round.** Rone et al. (2009; Figure 4) recorded 10 sightings of 59 Dall's porpoise in both the inshore and offshore strata, but density was not calculated.

Dall's porpoise feed on a wide variety of schooling fish, including herring and anchovies, mesopelagic fish including deep-sea smelts, and squids (a, 2002). One study of this species includes dive information for a single animal (Hanson and Baird, 1998). The authors concluded that the animal responded to the TDR tag for the initial eight minutes it was in place. Therefore, using data only from dives 7-17 (after the abnormally deep high velocity dive) in Table 2 of Hanson and Baird (1998), total time of the sequence

was 26.5 min (from start of dive 7 to end of dive 17). Total time at the surface was 10.27 min (time between dives minus the dive durations). Dives within 10 m totaled 2.11 min, dives to >60 m totaled 0.4 min, and dives with bottom time between 41 and 60 m totaled 1.83 min. The remaining time can be assumed to be spent diving between 11 and 40 m. **Based on this information, the depth distribution can be estimated as 39% at <1 m, 8% at 1-10 m, 45% at 11-40 m, and 8% at >40 m.**

E.3.13 Harbor porpoise, *Phocoena phocoena*

Harbor porpoise are found in coastal regions of northern temperate and subarctic waters (Reeves et al., 2002). To determine abundance of harbor porpoises in southern Alaska, Dahlheim et al. (2000) conducted aerial surveys from 1991-1993 only within 30 km of shore, based on data from Dohl et al. (1983) that indicated that harbor porpoise off California were almost exclusively within 0.25 nm of shore. Sightings around Kodiak Island were clustered in near shore bays on the north side of the island, with only two sightings up to 30 km offshore (see Figures 2 and 4 in Dahlheim et al., 2000). Harbor porpoise are generally not found in water deeper than 100 m, and decline linearly as depth increases (Carretta et al., 2001; Barlow, 1988; Angliss and Allen, 2009). A survey conducted in the GOA in June 2003 yielded a single sighting of two individuals (Waite, 2003). The vessel survey conducted in April 2009 yielded 30 sightings of 89 harbor porpoise, most of which were outside of the TMAA (Rone et al., 2009; Figure 4). The coastal distribution and limitation to shallower depths make it likely that harbor porpoises would not be within the TMAA; **there is no density for this species (Table 1)**.

E.4 PINNIPEDS

E.4.1 Steller's sea lion, *Eumetopias jubatus*

The range of the Steller's sea lion (SSL) crosses the north Pacific from Japan to northern California. This species does not undergo extensive migrations but will disperse widely during the non-breeding season. There are two US stocks, which are delineated based on location of rookeries. The Western US stock, listed as Endangered, encompasses SSL using rookeries west of 144°W, and the Eastern US stock, listed as Threatened, include SSL whose rookeries are east of 144°W. SSL from both stocks likely use the TMAA. Most SSL remain fairly close to rookeries and haulouts throughout the year, with adult females with pups averaging 17 km trip length in summer and 130 km trip length in winter; however foraging trips extended to >500 km offshore (Loughlin, 2002; Merrick and Loughlin, 1997) which encompasses the entire TMAA. Foraging trips are interspersed with time spent at haulouts throughout the year, and different age and sex classes molt at different times from late summer through early winter. Consequently, at any particular time during the year, at least some portion of the population will be at-sea. Call et al. (2007) found that the duration of at-sea and on-shore cycles of juvenile SSL differed between regions. In the Aleutian Islands and GOA, juvenile SSL departed at dusk and returned to haul out just prior to sunrise, while juvenile SSL in southeast Alaska departed throughout the day. Time of day departures and length of time at-sea are likely related to foraging opportunities and the distance/depth required for juveniles to travel finding food.

Pinniped at-sea density is not generally calculated because they are counted much more easily while on shore. Therefore, to determine densities of SSL in the TMAA, two sets of parameters need to be identified – the specific area and the number of animals. The area of the TMAA (measured in ArcMap) is ~87,250 km^2 (Figure 1). This represents 6.25% of the entire GOA Large Marine Ecosystem (LME) as defined by NOAA (www.lme.noaa.gov), and measured via ArcMap (~1,396,800 km^2, not including inland passages). The GOA LME extends from the Alaska Peninsula in the west to the British Columbia-Washington border in the east. To determine the number of SSL in the GOA LME, the most recent counts of adult, juvenile and pup SSL at rookeries in the GOA (pups = 4,518, non-pups = 13,892; data from 2004-2005), southeast Alaska (n=20,793, data from 2005) and British Columbia (n=15,402, data from 2002) were combined for a total of 54,605 SSL (Angliss and Allen, 2009). These are considered minimum counts, as they were not corrected for animals not counted because they were at sea. Bonnell and Bowlby (1992) estimated that 25% of the SSL sea lion population was feeding at sea at any given time. Therefore, 13,651

SSL (54,605 * 0.25) would be expected feeding at-sea in the GOA LME. To estimate the number within the TMAA, the number of SSL in the entire GOA (13,651) was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 853 SSL. **Density was then calculated as 853 SSL/87,250 km^2, or 0.0098/km^2, which is applicable to the entire region year round (Table 1).**

Acoustic modeling was calculated for two seasons, warm (June-October) and cold (November-May) water. Pinniped densities were therefore averaged to these two seasons by summing monthly densities and dividing by the number of months in each season (Table 5). For Steller sea lions the warm and cold water densities are the same, as densities are expected to remain consistent throughout the year.

Steller sea lions feed on fishes and invertebrates, including walleye pollock, Pacific cod, mackerel, octopus, squid and herring (Loughlin, 2002). Ongoing studies of SSL diving behavior have been conducted by NMFS in Alaska and Washington as part of an overall effort to determine why sea lion populations have been steadily declining (Merrick and Loughlin, 1997; Loughlin et al., 2003). Tagging studies often focus on different age classes (weanling, young of year, adult female). Steller sea lion prey changes depending on the season, with some prey moving farther offshore in winter, which affects maximum depth. Females dived the longest and deepest, with young of the year and weanlings having lesser values for both categories (Call et al., 2007; Loughlin et al., 2003). Adult males generally disperse farthest (commonly 120 km but as far as 500 km) from haulouts (Raum-Suryan et al., 2004). Loughlin et al. (2003) recorded maximum dive depth of 328 m, although most dives were shallower. Some SSL appear to take advantage of vertically migrating prey, leaving haulouts at dusk and returning at dawn (Call et al., 2007) but other SSL appear to feed throughout daylight hours as well. Because all age classes may be in the water at any given time, the depth distribution was estimated from the proportion of dives per depth range for all age classes (Merrick and Loughlin, 1997; Figures 4 and 2, respectively). **Based on this information, the depth distribution can be roughly estimated at 60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m.**

Table E-5. Averaging of Stellers sea lion, Northern fur seal, and Northern elephant seal densities to fit warm (June-October) and cold (November-May) water seasons.

Species	***Stellers sea lion***	***Northern fur seal***	***Northern elephant seal***
Month	***Density***		
June	0.0098	0.1059	0.0000
July	0.0098	0.0000	0.0000
August	0.0098	0.0000	0.0000
September	0.0098	0.0072	0.0055
October	0.0098	0.4768	0.0055
Average Warm Season	**0.0098**	**0.1180**	**0.0022**
November	0.0098	0.4768	0.0055
December	0.0098	0.4768	0.0000
January	0.0098	0.0072	0.0000
February	0.0098	0.0072	0.0000
March	0.0098	0.0072	0.0055
April	0.0098	0.0072	0.0055
May	0.0098	0.1059	0.0000
Average Cold Season	**0.0098**	**0.1555**	**0.0024**

E.4.2 Northern fur seal, *Callorhinus ursinus*

The northern fur seal is endemic to the north Pacific. Breeding sites are located in the Pribilof Islands (up to 70% of the world population) and Bogoslof Island in the Bering Sea, Kuril and Commander Islands in the northwest Pacific, and San Miguel Island in the southern California Bight. Abundance of the Eastern Pacific Stock has been decreasing at the Pribilof Islands since the 1940s although increasing on Bogoslof Island. The stock is currently estimated to number 665,550 (Angliss and Allen, 2009). The San Miguel Island Stock is much smaller, estimated at 9,424 (Carretta et al., 2009); this stock is believed to remain predominantly offshore California year round.

Males are present in the rookeries from around mid-May until August; females are present in the rookeries from mid-June to late-October. Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. Females and young males migrate through the Gulf of Alaska and feed primarily off the coasts of British Columbia, Washington, Oregon and California before migrating north to the rookeries (Ream et al., 2005). Immature males and females may remain in southern foraging areas year round until they are old enough to mate (National Marine Fisheries Service, 2006). Adult males migrate only as far as the Gulf of Alaska or to the west off the Kuril Islands. Therefore, adult males (September-April), adult females (October-December; May-June) and all non-adult fur seals (October-December) can potentially be found in the TMAA depending on the time of year.

Counts conducted in 2004 of males at Pribilof Island rookeries yielded a total 9,978 (Table 2 in National Marine Fisheries Service, 2006). Assuming an even distribution of fur seals throughout the GOA, and using a similar method as for other pinnipeds, the number of male fur seals was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 624 fur seals. **Density was then calculated as 624 fur seals/87,250 km^2, or 0.0072/km^2, which is applicable for the entire region in September and January through April.** Because some northern fur seal adult males feed near the Kuril Islands, this density is likely an over-estimate.

To determine density for migration time periods when adult female, adult male and non-adult fur seals would be present in the TMAA while enroute to feeding areas (October-December), the total number of fur seals in the eastern Pacific stock (665,550) was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 41,597 fur seals. **Density was then calculated as 41,597 fur seals/87,250 km^2, or 0.4768/km^2. This density is applicable for the entire TMAA for October-December.** Because this number includes pups of the year and first year mortality due to predation and other factors is very high, the density is very likely an over-estimate.

To account for migration time periods when adult females would be migrating north thru the TMAA enroute to the rookeries (May-June), the number of pups born (2006 Pribilof Islands and Bogoslof Island count= 147,900; Angliss and Allen, 2009) was used to estimate the number of adult females (assuming all adult females birthed a pup). Assuming an even distribution of fur seal females as they migrate through the GOA, the number of female fur seals was multiplied by the percent area of the TMAA compared to the GOA LME (0.0625) for a total of 9,244 fur seals**. Density was then calculated as 9,244 fur seals/87,250 km^2, or 0.1059/km^2. This density is applicable for the entire** TMAA **for May-June.**

In most years, northern fur seals would not be expected in the GOA in July and August, because adults would still be in the rookeries and non-adults would be foraging farther south, so density would be zero.

Acoustic modeling was calculated for two seasons, warm (June-October) and cold (November-May) water. Northern fur seal densities were therefore averaged to these two seasons by summing monthly densities and dividing by the number of months in each season (Table 5). **The warm water density for northern fur seals was 0.1180/km^2 and the cold water density was 0.1555/km^2 (see Table 1), which are applicable to the entire area.**

Northern fur seals feed on small fish and squid in deep water and along the shelf break; deep dives occur on the shelf and feeding probably occurs near the bottom (Gentry, 2002). There have been a few studies of this species' diving habits during feeding and migrating, although there is no information on dive depth distribution. Ponganis et al. (1992) identified two types of northern fur seal dives, shallow (<75 m) and deep (>75 m). Kooyman and Goebel (1986) found that the mean dive depth for seven tagged females was 68 m (range 32-150 m) and the mean maximum depth was 168 m (range 86-207). Sterling and Ream (2004) reported that the mean dive depth for 19 juvenile males was 17.5 m, with a maximum depth attained of 175 m. Diving was deeper in the daytime than during nighttime, perhaps reflecting the different distribution of prey (especially juvenile pollock), and also differed between inner-shelf, mid-shelf, outer-shelf and off-shelf locations. Deeper diving in the Sterling and Ream study tended to occur on-shelf, with shallower diving off-shelf. Diving patterns during migration tended to be shallower, with diving occurring mainly at night (indicating some feeding on vertically migrating prey) and most time during the day in the upper 5 m of the water column (Baker, 2007). **Based on these very limited depth data, the following are very rough order estimates of time at depth: daytime: 74% at <2 m; 26% at 2-260 m; nighttime: 74% at <2 m; 26% at 2-75 m.**

E.4.3 California sea lion, *Zalophus californianus*

California sea lions breed in the Channel Islands in the southern California Bight and south into Baja California. Males will migrate after the breeding season north to near shore waters of Washington, Oregon and British Columbia (some immature males will remain in northern feeding areas year round). Females generally do not migrate as far north as males. California sea lions have been documented at several locations in Alaska (Maniscalco et al., 2004), including southeast Alaska, Kenai Peninsula and as far north and west at St. Paul Island in the Bering Sea. There were a total of 52 animals documented between 1963 and 2003, and they were observed during all seasons of the year. Their presence in the GOA Exercise Area is likely extremely low both due to the extralimital nature of the occurrence and the species preference for near shore habitat. **No density estimate is available (Table 1).**

E.4.4 Northern elephant seal, *Mirounga angustirostris*

The California stock of elephant seals breeds at rookeries located along the California coast. The most recent population estimate (2005) was 124,000 animals, and was based primarily on pup counts and correction factors (Carretta et al., 2009). Only male elephant seals migrate as far north as the GOA during foraging trips, information known from extensive satellite tagging studies (LeBoeuf et al., 1986, 1993, 2000). Adult males are present at the California rookeries from December through February for mating, and again from May to August during molting. The number of males in the population is particularly difficult to estimate because all adult males are generally not present at the rookery at any one time.

Counts of males at rookeries in the Channel Islands and some central California sites in 2005 yielded 3,815 males and juveniles for which sex could not be determined. Some rookeries were not included in this estimate, including a rapidly growing rookery at Piedras Blancas, which in 2007 had an estimated population of 16,000 animals of all age and sex classes (www.elephantseal.org). The California elephant seal population has also been steadily increasing over time (Carretta et al., 2009). To account for males at rookeries not counted and an increase in the population since 2005, the number of males and juveniles reported in the 2009 stock assessment report (3,815) was doubled to 7,630. Using similar methods as described for Steller's, the number of male elephant seals (7,630) was multiplied by percent area of the TMAA compared to the GOA LME (0.0625) for a total of 477 elephant seals. **Density was then calculated as 475 seals/87,250 km^2, or 0.0055/km^2, which is applicable for the entire TMAA for March-April and September-November.** Because all elephant seal adult males are not at-sea at the same time, the density is probably an over-estimate.

As with northern fur seals, elephant seal densities were averaged to warm (June-October) and cold (November-May) water seasons to provide data suitable for acoustic modeling. To do so, monthly densities were summer and divided by the number of months in each season (Table 5). **The warm water density for elephant seals was 0.0022/km^2 and the cold water density was 0.0023/km^2 (see Table 1, which is applicable to the entire area.**

Elephant seals feed on deep-water squid and fish, and likely spend about 80% of their annual cycle at sea feeding (Hindell, 2002). There has been a disproportionate amount of research done in the diving capabilities of northern elephant seals. Breeding and molting beaches are all located in California and Baja California, and elephant seals are relatively easy to tag (compared to cetaceans) when they are hauled out on the beach; the tag package can be retrieved when the animal returns to shore rather than relying on finding it in the ocean. They are deep divers, and have been tracked to depths >1000 m, although mean depths are usually around 400-600 m. Elephant seals have more than one dive type, termed Types A-E, including rounded and squared-off U-shape, V-shape and others. Particular dive types appear to be used mainly during transit (Types A and B), "processing" of food (Type C), and foraging (Types D and E; Crocker et al., 1994). Asaga et al. (1994) collected dive information on three female seals and provided summary statistics for three dive types. Davis et al. (2001) recorded the diving behavior of a seal returning to the beach, and demonstrated transit depths averaging 186 m with range of depth from 8 m to 430 m. LeBoeuf et al. (1986; 1988), Stewart and DeLong (1993) and LeBoeuf (1994) provided histograms of dives per depth range for tagged females. LeBoeuf et al. (2000; 1988) and LeBoeuf (1994) provided details on foraging trips for males and females offshore California, including information on percentage of time at surface. Hassrick et al. (2007) noted that larger animals (adult males) exhibited longer bottom times and that surface swimming was not noted in the sixteen elephant seals that they tagged. Hindell (2002) noted that traveling likely takes place at depths >200m.

Even with this abundance of information, the numerous types of dives and lack of clear-cut depth distribution data means that the percentage of time at depth needs to be estimated. The closest information provided is from Asaga et al. (1994), which was used here. Note that this information is representative of type D foraging dives of female only. This is the type of dive that would be likely of an elephant seal at-sea. Summary stats from Table 17.3 (Asaga et al., 1994) were used; the data were collected from females

only but will be applied to both sexes and all age classes due to lack of other concise data. Mean dive duration and mean surface intervals were added together to come up with total dive cycle in minutes. Amount of time to traverse from surface to bottom and bottom to surface was calculated by subtracting bottom time (given) from dive duration. Values for total cycle, surface interval, bottom time and descent/ascent were then averaged for all three females. Roundtrip surface to bottom and back averaged 12.9 minutes. Assuming a mean rate of descent/ascent over 527 m (average mean dive depth for all three females combined), the average rate per 100 m was 2.4 min. **Based on these averaged numbers, the following are estimates of time at depth: 9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m.**

E.4.5 Harbor seal, *Phoca vitulina*

Harbor seals are distributed throughout coastal areas of the North Pacific. Their distribution is largely tied to suitable beaches for hauling out, pupping and molting, and areas offering good foraging and protection from predators such as killer whales. Most harbor seals are non-migratory. Satellite-tracking studies of movements of adults and pups near Kodiak Island and elsewhere in the GOA indicate that mean distance between haul out and at-sea foraging was 10-25 km for juveniles and 5-10 km for adults (e.g., Lowry et al., 2001; Rehberg and Small, 2001), and nearly all locations were in water <200 m deep, with an apparent preference for depths 20-100 m (Frost et al., 2001). The coastal distribution and limitation to shallower depths make it likely that harbor seals would not be within the TMAA; **there is no density for this species (Table 1).**

E.5 REFERENCES

Acevedo-Gutierrez, A., Croll, D. A. and Tershy, B. R**.** (2002). High feeding costs limit dive time in the largest whales. *J. Exp. Biol.* **205**, 1747-1753.

Aguilar, A. 2002. Fin whale. Pp. 435-438 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Amano, M and M Yoshioka. 2003. Sperm whale diving behavior monitored using a suction-cup-attached TDR tag. *Marine Ecology Progress Series* 258: 291-295.

Amano, M, M Yoshioka, T Kuramochi and K Mori. 1998. Diurnal feeding by Dall's porpoise, *Phocoenoides dalli. Marine Mammal Science* 14(1): 130-135.

Angliss, RP and BM Allen. 2009. Alaska Marine Mammal Stock Assessments, 2008. NOAA Technical Memorandum NMFS-AFSC-193. Available from http://www.nmfs.noaa.gov/pr/sars/region.htm.

Aoki, K, M Amano, M Yoshioka, K Mori, D Tokuda and N Miyazaki. 2007. Diel diving behavior of sperm whales off Japan. *Marine Ecology Progress Series* 349:277-287.

Asaga, T, Y Naito, BJ LeBoeuf and H Sakurai. 1994. Functional analysis of dive types of female northern elephant seals. Chapter 17 In: *Elephant seals: population ecology, behavior, and physiology*, BJ LeBoeuf and RM Laws (eds). University of California Press: Berkeley. 414 pp.

Baird, RW, DL Webster, DJ McSweeney, AD Ligon, GS Schorr and J. Barlow. 2006a. Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i. *Canadian Journal of Zoology* 84: 1120-1128.

Baird, RW, DJ McSweeney, C Bane, J Barlow, DR Salden, LK Antoine, R LeDuc and DL Webster. 2006b. Killer whales in Hawaiian waters: information on population identity and feeding habits. *Pacific Science* 60: 523-530.

Baird, RW, DL Webster, DJ McSweeney, AD Ligon, and GS Schorr. 2005a. Diving Behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai`i. Report prepared by Cascadia Research Collective for the Southwest Fisheries Science Center. Available from www.cascadiaresearch.org.

Baird, RW, MB Hanson and LM Dill. 2005b. Factors influencing the diving behaviour of fish-eating killer whale: Sex differences and diel and interannual variation in diving rates. *Canadian Journal of Zoology* 83(2):257-267.

Baird, RW, MB Hanson, EE Ashe, MR Heithaus and GJ Marshall. 2003. Studies of foraging in "southern resident" killer whales during July 2002: dive depths, bursts in speed, and the use of a "crittercam" system for examining sub-surface behavior. Report prepared under Order number AB133F-02-SE-1744 for the NMFS-NMML.

Baird, RW, AD Ligon and SK Hooker. 2000. Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: a Preliminary Report. Report under contract #40ABNC050729 from the Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, HI to the Hawaii Wildlife Fund, Paia, HI.

Baker, JD. 2007. Post-weaning migration of northern fur seal Callorhinus ursinus pups from the Pribilof Islands, Alaska. *Marine Ecology Progress Series* 341:243-255.

Bannister, JL. 2002. Baleen whales. Pp. 62-72 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Baraff, LS, PJ Clapham, DK Mattila and RS Bowman. 1991. Feeding behavior of a humpback whale in low-latitude waters. *Marine Mammal Science* 7(2): 197-202.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science* 22(2): 446-464.

Barlow, J. 2003. Preliminary estimates of the abundance of cetaceans along the US west coast: 1991-2001. SWFSC-NMFS Admin Report LJ-03-03. 33 pp.

Barlow, J. 1988. Harbor Porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: I. Ship Surveys. *Fishery Bulletin* 86(3):417-432.

Barlow, J and KA Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. *Fishery Bulletin* 105(4): 509-526.

Benoit-Bird, KJ, B Wursig and CJ McFadden. 2004. Dusky dolphin (*Lagenorhynchus obscurus*) foraging in two different habitats: active acoustic detection of dolphins and their prey. *Marine Mammal Science* 20(2): 215-231.

Berrow and Rogan, 1996.

Blanco C and JA Raga. 2000. Cephalopod prey of two *Ziphius cavirostris* (Cetacea) stranded on the western Mediterranean coast. *Journal of the Marine Biological Association of the United Kingdom* 80 (2): 381-382

Blix, AS. and LP Folkow. 1995. Daily energy expenditure in free living minke whales. *Acta Physiologica Scandinavica* 153(1): 61-6.

Bluhm, B, KO Coyle, B Konar and R Highsmith. 2007. High gray whale relative abundances associated with an oceanographic front in the south-central Chukchi Sea. *Deep Sea Research Part II: Topical Studies in Oceanography* 54(23-26):2919-2933. 2007. Effects of Climate Variability on Sub-Arctic Marine Ecosystems - A GLOBEC Symposium, GLOBEC-ESSAS Symposium.

Bonnell, ML and CE Bowlby. 1992. Pinniped distribution and abundance off Oregon and Washington, 1989-1990 In: JJ Brueggeman (ed) Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.

Calambokidis, J, EA Falcone, TJ Quinn, AM Burdin, PJ Clapham, JKB Ford, CM Gabriele, R LeDuc, D Mattila, L Rojas-Bracho, JM Straley, BL Taylor, J Urbán R, D Weller, BH Witteveen, M Yamaguchi, A Bendlin, D Camacho, K Flynn, A Havron, J Huggins and N Maloney. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the north Pacific. Final Report for Contract AB133F-03-RP-00078 by Cascadia Research, Olympia, WA for US Department of Commerce. 57 pp.

Call, KA, BS Fadely, A Grieg and MJ Rehberg. 2007. At-sea and on-shore cycles of juvenile Steller sea lions (*Eumetopias jubatus*) derived from satellite dive recorders: a comparison between declining and increasing populations. *Deep-Sea Research II* 54: 298-300.

Canadas, A, R Sagarminaga and S Garcia-Tiscar. 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep-Sea Research I* 49: 2053-2073.

Cipriano, F., 2002. Atlantic white-sided dolphin. pp. 49-51In: Encyclopedia of marine mammals (Perrin WF, Würsig B, Thewissen JGM, eds.) Academic Press, San Diego.

Carretta, JV, KA Forney, MS Lowry, J Barlow, J Baker, D Johnston, B Hanson, MM Muto, D Lynch and L Carswell. 2009. U.S. Pacific Marine Mammal Stock Assessments: 2008. NOAA-TM-NMFS-SWFSC-434. Available from http://swfsc.noaa.gov.

Carretta, JV, BL Taylor and SJ Chivers. 2001. Abundance and depth distribution of harbor porpoise (*Phocoena phocoena*) in northern California determined from a 1995 ship survey. *Fishery Bulletin* 99: 29-39.

Clapham, PJ. 2002. Humpback whale. Pp. 589-592 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Clarke, JT and SE Moore. 2002. A note on observations of gray whales in the southern Chukchi and northern Bering Seas, August-November, 1980-89. *J. Cetacean Res. Manage*. 4(3): 283-288.

Clarke, JT, SE Moore and DK Ljungblad. 1989. Observations on gray whale (*Eschrichtius robustus*) utilization patterns in the northeastern Chukchi Sea, July-October 1982-87. *Canadian Journal of Zoology* 67: 2646-2654.

Clarke, MR. 1986. Cephalopods in the diet of odontocetes. Pp. 281-321 In: MM Bryden and RJ Harrison (eds), *Research on Dolphins*. Oxford University Press: Oxford.

Clarke, MR and TK Kristensen. 1980. Cephalopod beaks from the stomachs of two northern bottlenosed whales (*Hyperoodon ampullatus*). *Journal of the Marine Biological Association of the United Kingdom* 60(1):151-156.

Clarke, M and R Young. 1998. Description and analysis of cephalopod beaks from stomachs of six species of odontocete cetaceans stranded on Hawaiian shores. *Journal of the Marine Biological Association of the United Kingdom* 78: 623-641.

Crocker, DE, BJ LeBoeuf, Y Naito, T Asaga and DP Costa. 1994. Swim speed and dive function in a female northern elephant seal. Chapter 18 In: *Elephant seals: population ecology, behavior, and physiology*, BJ LeBoeuf and RM Laws (eds). University of California Press: Berkeley. 414 pp.

Dahlheim, ME, A York, R Towell, JM Waite and J Breiwick. 2000. Harbor Porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. *Marine Mammal Science* 16:28-45.

Croll DA, A Acevedo-Gutierrez, BR Tershy and J Urban-Ramirez. 2001. The diving behavior of blue and fin whales: is dive duration shorter than expected based on oxygen stores? *Comparative Biochemistry and Physiology a-Molecular and Integrative Physiology* 129:797-809.

Davis, RW, N Jaquet, D Gendron, U Markaida, G Bazzino and W Gillly. 2007. Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. *Marine Progress Series* 333: 291-302.

Davis RW, LA Fuiman, TM Williams and BJ Le Boeuf. 2001. Three-dimensional movements and swimming activity of a northern elephant seal. *Comparative Biochemistry and Physiology Part A Molecular & Integrative Physiology* 129A:759-770.

Department of the Navy. 2006. Marine Resources Assessment for the Gulf of Alaska Operating Area. Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, HI. Contract # N62470-02-D-9997, CTO 0029. Prepared by Geo-Marine, Inc., Plano, TX.

Dietz, R, J Teilmann, MP Heide Jorgensen and MK Jensen. 2002. Satellite tracking of humpback whales in West Greenland. National Environmental Research Institute, Ministry of the Environment, Denmark. NERI Technical Report 411.

Dohl, TP, RC Guess, ML Duman and RC Helm. 1983. Cetaceans of central and northern California, 1980-83: Status, abundance, and distribution. Report prepared for U.S. Minerals Management Service, contract #14-12-0001-29090. Available from National Marine Mammal Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115.

Dolphin, WF. 1988. Foraging dive patterns of humpback whales, *Megaptera novaeangliae*, in southeast Alaska: a cost-benefit analysis. *Canadian Journal of Zoology* 66: 2432-2441.

Dolphin, WF. 1987. Dive behavior and estimated energy expenditures of foraging humpback whales in Southeast Alaska. *Canadian J. Zoology* 65: 354-362.

Drouot, V, A Gannier, and JC Goold. 2004. Diving and feeding behaviour of sperm whales (*Physeter macrocephalus*) in the northwestern Mediterranean Sea. *Aquatic Mammals* 30(3): 419-426.

Dunham, JS and DA Duffus. 2002. Diet of gray whales (*Eschrichtius robustus*) in Clayoquot Sound, British Columbia, Canada. *Marine Mammal Science* 18(2): 419-437.

Estes, J. A., M.T. Tinker, T.M. Williams, and D. F. Doa. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. Science 282, 473-476.

Ferguson, MC and J Barlow. 2001. Spatial distribution and density of cetaceans in the Eastern Tropical Pacific ocean based on summer/fall research vessel surveys in 1986-96. NMFS-SWFSC Administrative Report LJ-01-04.

Ferguson, MC. and J Barlow. 2003. Addendum: Spatial Distribution and Density of Cetaceans in the Eastern Tropical Pacific Ocean Based on Summer/Fall Research Vessel Surveys in 1986-96. Southwest Fisheries Science Center Administrative Report LJ-01-04 (Addendum).

Ford, JKB. 2002. Killer whale. Pp. 669-676 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Ford, JKB, GM Ellis, LG Barrett-Lennard, AB Morton, RS Palm and KC Balcomb III. 1998. Dietary specialization in two sympatric populations of killer whale (*Orcinus orca*) in coastal British Columbia and adjacent waters. *Canadian Journal of Zoology* 76: 1456-1471.

Forney, KA. 2007. Preliminary estimates of cetacean abundance along the US west coast and within four National Marine Sanctuaries during 2005. NOAA-TM-NMFS-406.

Frost, KJ, MA Simpkins, and LF Lowry. 2001. Diving behavior of subadult and adult harbor seals in Prince William Sound, Alaska. *Marine Mammal Science* 17:813-834.

Gentry, RL. 2002. Northern fur seal. Pp 813-817 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Gentry, RL, GL Kooyman and ME Goebel. 1986. Feeding and diving behavior of northern fur seals. Pp 61-78 In RL Gentry and GL Kooyman (eds) Fur *Seals: Maternal Strategies on Land and at Set*. Princeton University Press, Princeton, New Jersey.

Goldbogen, JA, J Calambokidis, RE Shadwick, EM Oleson, MA McDonald and JA Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209(7):1231-1244.

Gowans, S. 2002. Bottlenose whales. Pages 128-129 *in* W. F. Perrin, B. Würsig and J. G. M. Thewissen, eds. Encyclopedia of Marine Mammals. Academic Press, San Diego.

Hain, JHW, SL Ellis, RD Kenney, PJ Clapham, BK Gray, MT Weinrich and IG Babb. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. *Marine Mammal Science* 11(4): 464-479.

Hamilton, PK, GS Stone and SM Martin. 1997. Note on a deep humpback whale *Megaptera novaeangliae* dive near Bermuda. *Bulletin of Marine Science* 61(2): 491-494.

Hanson, MB and RW Baird. 1998. Dall's porpoise reactions to tagging attempts using a remotely-deployed suction cup tag. *MTS Journal* 32(2): 18-23.

Harvey, JT and BR Mate. 1984. Dive characteristics and movements of radio-tagged gray whales in San Ignacio Lagoon, Baja California Sur, Mexico. Chapter 24. In: ML Jones, SL Swartz and S Leatherwood (eds*), The Gray Whale*. Academic Press, Inc: Orlando, FL. 600 pp.

Hassrick, JL, DE Crocker, RL Zeno, SB Blackwell, DP Costa and BJ Le Boeuf. 2007. Swimming speed and foraging strategies of northern elephant seals. *Deep-Sea Research II* 54: 369-383.

Haug, T, U Lindstrom and KT Nilssen. 2002. Variations in minke whale diet and body condition in response to ecosystem changes in the Barents Sea. *Sarsia* 87: 409-422.

Haug, T, U Lindstrom, KT Nilssen, I Rottingen and HJ Skaug. 1996. Diet and food availability for northeast Atlantic minke whales. *Report of the International Whaling Commission* 46: 371-382.

Haug, T, H Gjosaeter, U Lindstrom and KT Nilssen. 1995. Diet and food availability for northeast Atlantic minke whales during summer 1992. *ICES Journal of Marine Science* 52: 77-86.

Helweg, DA and LM Herman. 1994. Diurnal patterns of behaviour and group membership of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Ethology* 98: 298-311.

Heyning, JE. 2002. Cuvier's beaked whale. Pp 305-307 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Hindell, MA. 2002. Elephant seals. Pp 370-373 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Hoelzel, A, EM Dorsey and J Stern. 1989. The foraging specializations of individual minke whales. *Animal Behavior 38*: 786-794.

Hooker, SK and RW Baird. 1999. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacean: Ziphiidae). *Proceedings of the Royal Society, London B* 266: 671-676.

Insley, SJ, BW Robson, T Yack, RR Ream and WC Burgess. 2008. Acoustic determination of activity and flipper stroke rate in foraging northern fur seal females. *Endangered Species Research* 4: 147-155.

Jacquet, N, S Dawson and E Slooten. 2000. Seasonal distribution and diving behavior of male sperm whales off Kaikoura: foraging implications. *Canadian Journal of Zoology:* 78: 407-419.

Jahoda, M, C Almirante, A Azzellino, S Panigada, M Zanardelli and S Canese. 1999. 3D-tracking as a tool for studying behavior in Mediterranean fin whales (*Balaenoptera physalus*). 13th Biennial Conference on the Biology of Marine Mammals. The Society of Marine Mammalogy, Hawaii.

Jefferson, TA. 2002. Dall's porpoise. Pp. 308-310 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Jefferson, TA, S Leatherwood and MA Webber. 1993. *Marine mammals of the world*. FAO Species Identification Guide. United Nations Environment Programme, Food and Agriculture Organization of the United Nations.

Johnson, M, PT Madsen, WMX Zimmer, N Aguilar de Soto, and PL Tyack. 2004. Beaked whales echolocate on prey. *Proceedings of the Royal Society, London B* (Suppl.) 271: S383-S386.

Johnston, DW, LH Thorne and AJ Read. 2005. Fin whales and minke whales exploit a tidally driven island wake ecosystem in the Bay of Fundy. *Marine Ecology Progress Series* 305: 287-295.

Jones, ML and SL Swartz. 2002. Gray whale *Eschrichtius robustus*. Pp 524-536 in *Encyclopedia of Marine Mammals*, WF Perrin, B Wursig and JGM Thewissen (eds). Academic Press, London. 1414 pp.

Kasuya, T., 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. Sci Rep Whales Res Inst, Tokyo 37: 61-83.

Kasuya, T., 2002. Giant beaked whales. pp. 519-522. In: Encyclopedia of marine mammals (Perrin WF, Würsig B, Thewissen JGM, eds.) Academic Press, San Diego.

Kinze, C.C., 2002. White-beaked dolphin. pp. 1032-1034. In: Encyclopedia of marine mammals (Perrin WF, Würsig B, Thewissen JGM, eds.) Academic Press, San Diego.

Konishi, K and T Tamura. 2007. Occurrence of the minimal armhook squids *Berryteuthis anonychus* (Cephalopoda: Gonatidae) in the stomachs of common minke whales *Balaenoptera acutorostrata* in the western North Pacific. *Fisheries Science* (Tokyo) 73(5):1208-1210.

Kooyman, GL and ME Goebel. 1986. Feeding and diving behavior of northern fur seals. Pp 61-78 In RL Gentry and GL Kooyman (eds) *Fur Seals: Maternal Strategies on Land and at Sea*. Princeton University Press, Princeton, New Jersey.

Laerm, J, F Wenzel, JE Craddock, D Weinand, J McGurk, MJ Harris, GA Early, JG Mead, CW Potter and NB Barros. 1997. New prey species for northwestern Atlantic humpback whales. *Marine Mammal Science* 13(4): 705-711.

Laidre, KL, KEW Shelden, DJ Rugh and B Mahoney. 2000. Beluga distribution and survey effort in the Gulf of Alaska. *Marine Fishery Review* 62(3): 27-36.

LeBoeuf, BJ. 1994. Variation in the diving pattern of northern elephant seals with age, mass, sex, and reproductive condition. Chapter 13 In: *Elephant seals: population ecology, behavior, and physiology*, BJ LeBoeuf and RM Laws (eds). University of California Press: Berkeley. 414 pp.

LeBoeuf, BJ, DE Crocker, DB Costa, SB Blackwell et al. 2000. Foraging ecology of northern elephant seals. *Ecological Monographs* 70(3): 353-382.

LeBoeuf, BJ, DE Crocker, SB Blackwell, PA Morris and PH Thorson. 1993. Sex differences in diving and foraging behavior of northern elephant seals. *Symp. Zool. Soc. London* 66: 149-178.

LeBoeuf, BJ, DP Costa, AC Huntley and SD Feldkamp. 1988. Continuous deep diving in female northern elephant seals, Ma. *Canadian Journal of Zoology* 66: 446-458.

LeBoeuf, B, DP Costa, AC Huntley, GL Kooyman and RW Davis. 1986. Pattern and depth of dives in northern elephant seals, Ma. *Journal of Zoology Ser*. A 208: 1-7.

Lindstrom, U and T Haug. 2001. Feeding strategy and prey selection in minke whales foraging in the southern Barents Sea during early summer. *J. Cetacean Research and Management* 3: 239-249.

Loughlin, TR. 2002. Steller's sea lion. Pp. 1181-1185 In: WF Perrin, B Wursig and JGM Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Loughlin TR, JT Sterling, RL Merrick, JL Sease and AE York. 2003. Diving behavior of immature Steller sea lions (*Eumetopias jubatus*). *Fishery Bulletin* (Seattle) 101:566-582.

Lowry, LF, KJ Frost, JM Ver Hoef, and RA DeLong. 2001. Movements of satellite-tagged subadult and adult harbor seals in Prince William Sound, Alaska. *Marine Mammal Science* 17(4): 835-861.

Malcolm, CD and DA Duffus. 2000. Comparison of subjective and statistical methods of dive classification using data from a time-depth recorder attached to a gray whale (*Eschrichtius robustus*). *J. Cetacean Res. Manage*. 2(3): 177-182.

Malcolm, CD, DA Duffus and SG Wischniowski. 1995/6. Small scale behavior of large scale subjects: diving behaviour of a gray whale (*Eschrichtius robustus*). *Western Geography* 5/6: 35-44.

Maniscalco, JM, K Wynne, KW Pitcher, MB Hanson, SR Melin and S Atkinson. 2004. The occurrence of California sea lions (*Zalophus californianus*) in Alaska. *Aquatic Mammals* 30(3): 427-433.

Mate, BR and JT Harvey. 1984. Ocean movements of radio-tagged gray whales. Chapter 25. In: ML Jones, SL Swartz and S Leatherwood (eds), *The Gray Whale*. Academic Press, Inc: Orlando, FL. 600 pp.

Mate, BR and J Urban Ramirez. 2003. A note on the route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag. *Journal of Cetacean Research and Management* 5(2): 155-157.

Mate, BR, KM Stafford, R Nawojchik and JL Dunn. 1994. Movements and dive behavior of a satellite monitored Atlantic white-side dolphin (*Lagenorhycnus acutus*) in the Gulf of Maine. *Marine Mammal Science* 10(1): 116-121.

Mellinger, DK, KM Stafford and CG Fox. 2004a. Seasonal occurrence of sperm whale (Pm) sounds in the Gulf of Alaska, 1999-2001. *Marine Mammal Science* 20(1): 48-62.

Mellinger, DK, KM Stafford, SE Moore, L Munger and CG Fox. 2004b. Detection of north Pacific right whale (Ej) calls in the Gulf of Alaska. *Marine Mammal Science* 20(4): 872-879.

Merrick, R.L., T.R. Loughlin, G.A. Antonelis, and R. Hill, 1994. "Use of satellite-linked telemetry to study Steller sea lion and northern fur seal foraging. Polar Research 13:105-114.

Merrick, RL and TR Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. *Canadian Journal of Zoology* 75: 776-786.

Mizroch, SA, DW Rice, D Zwiefelhofer, J Waite and WL Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. Mammal Review 39(3): 193-227.

Moore, SE, KM Wynne, JC Kinney and JM Grebmeier. 2007. Gray whale occurrence and forage southeast of Kodiak Island, Alaska. *Marine Mammal Science* 23(2): xx.

Moore, SE, KM Stafford, DK Mellinger and JA Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. *BioScience* 56(1): 49-55.

Moore, SE, JM Grebmeier and JR Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. *Canadian Journal of Zoology* 81: 734-742.

Moore, SE, KM Stafford, ME Dahlheim, CG Fox, HW Braham, JJ Polovina, and DE Bain. 1998. Seasonal variation in reception of fin whale calls at five geographic in the North Pacific. *Marine Mammal Science* 14:217-225.

Morton, Alexandra, 2000. "Occurrence, photo-identification and prey of Pacific white-sided dolphins (Lagenorhynchus obliquidens) in the Broughton Archipelago," Canada 1984-1998. Marine Mammal Science 16(1): 80-93.

Murase, H, T Tamura, H Kiwada, Y Fujise, H Watanabe, H Ohizumi, S Yonezaki, H Okamura and S Kawahura. 2007. Prey selection of common minke (*Balaenoptera acutorostrata*) and Bryde's (*Balaenoptera edeni*) whales in the western North Pacific in 2000 and 2001. *Fisheries Oceanography* 16(2): 186-201.

Nationa4l Marine Fisheries Service. 2006. Draft conservation plan for the eastern Pacific stock of northern fur seal (*Callorhinus ursinus*). National Marine Fisheries Service, Juneau.

National Marine Fisheries Service. 2007. Cook Inlet Beluga Whale Proposed Rule. *Federal Register*, Vol. 72, No. 76, Friday, April 12, 2007, 19854-189862.

Notarbartolo-di-Sciara, G, M Zanardelli, M Jahoda, S Panigada and S Airoldi. 2003. The fin whale *Balaenoptera physalus* (Linnaeus 1758) in the Mediterranean Sea. *Mammal Review* 33(2): 105-150.

O'Corry-Crowe, G, W Lucey, C Bonin, E Henniger and R Hobbs. 2006. The ecology, status and stock identity of beluga whales, *Delphinapterus leucas*, in Yakutat Bay, Alaska. Report on Year 1, 2005 to the US Marine Mammal Commission.

Ohizumi, H, T Isoda, T Kishiro and H Kato. 2003. Feeding habits of Baird's beaked whale *Berardius bairdii*, in the western North Pacific and Sea of Okhotsk off Japan. *Fisheries Science* 69: 11-20.

Palka, D. and M Johnson, eds. 2007. Cooperative research to study dive patterns of sperm whales in the Atlantic Ocean. OCS Study MMS 2007-033. New Orleans, Louisiana: Gulf of Mexico Region, Minerals Management Service.

Panigada, S, G Notarbartolo di Sciara and MZ Panigada. 2006. Fin whales summering in the Pelagos Sanctuary (Mediterranean Sea): Overview of studies on habitat use and diving behaviour. *Chemistry and Ecology* 22(Supp.1):S255-S263.

Panigada, S, G Pesante, M Zanardelli and S Oehen. 2003. Day and night-time behaviour of fin whales in the western Ligurian Sea. Proceedings of the Conference Oceans 2003, September 22-26, 2003, San Diego, CA. Pp 466-471.

Panigada, S, M Zanardelli, S Canese and M Jahoda. 1999. How deep can baleen whales dive? *Marine Ecology Progress Series* 187: 309-311.

Papastavrou V, SC Smit and H Whitehead H. 1989. Diving behavior of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands [Ecuador]. *Canadian Journal of Zoology* 67:839-846.

Perrin, WF and RL Brownell, Jr. 2002. Minke whales. Pp. 750-754 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Ponganis, PJ, RL Gentry, EP Ponganis and KV Ponganis. 1992. Analysis of swim velocities during deep and shallow dives to two northern fur seals, *Callorhinus ursinus*. *Marine Mammal Science* 8(1): 69-75.

Raum-Suryan, K.L., M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, T.S. Gelatt, 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (*Eumetopias jubatus*) in Alaska. Marine Mammal Science Vol. 20, no. 4, pp. 823-850.

Ream, RR, JT Sterling and TR Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. *Deep-Sea Research II*: 823-843.

Reeves, RR, BS Stewart, PJ Clapham, and JA Powell. 2002. *National Audubon Society Guide to Marine Mammals of the World*. Alfred A Knopf: New York.

Rehberg, M and RJ Small. 2001. Dive behavior, haulout patterns, and movements of harbor seal pups in the Kodiak Archipelago, 1997-2000. Pp 209-238 In: Harbor seal investigations in Alaska, Annual Report, NOAA Grant NA87FX0300. Alaska Department of Fish and Game, Division of Wildlife Conservation.

Roberts, SM. 2003. Examination of the stomach contents from a Mediterranean sperm whale found south of Crete, Greece. *Journal of the Marine Biological Association of the United Kingdom* 83: 667-670.

Rone, BK, AB Douglas, P Clapham, A Martinez, LJ Morse, AN Zerbini and J Calambokidis. 2009. Final Report for the April 2009 Gulf of Alaska Line-Transect Survey (GOALS) in the Navy Training Exercise Area. Prepared by NOAA and Cascadia Research Collective. 28 pp. Available from: http://www.cascadiaresearch.org.

Santos, RA and M Haimovici. 2001. Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21-34S). *Fisheries Research* 52(1-2): 99-112.

Santos, MB, GJ Pierce, J Herman, A Lopez, A Guerra, E Mente and MR Clarke. 2001. Feeding ecology of Cuvier's beaked whale (*Ziphius cavirostris*): a review with new information on the diet of this species. *Journal of the Marine Biological Association of the United Kingdom* 81: 687-694.

Saulitis, E, C Matkin, L Barrett-Lennard, K Heise and G Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. *Marine Mammal Science* 16(1): 94-109.

Shelden, KEW, SE Moore, JM Waite, PR Wade and DJ Rugh. 2005. Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. *Mammal Review* 35(2): 129-155.

Simmons, S.E., Crocker, D.E., Kudela, R.M., Costa, D.P. 2007. Linking Foraging Behaviour of the Northern Elephant seal with Oceanography and Bathymetry at Mesoscales. Marine Ecology Progress Series: 346:265-275.

Smith, SC and H Whitehead. 2000. The diet of Galapagos sperm whales *Physeter macrocephalus* as indicated by fecal sample analysis. *Marine Mammal Science* 16(2): 315-325.

Soto, NA, M Johnson, PT Madsen, PL Tyack, A Bocconcelli and JF Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science* 22(3): 690-699.

Stafford, KM. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. *Marine Mammal Science* 19(4): 682-693.

Sterling, JT and RR Ream. 2004. At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*). *Canadian Journal of Zoology* 82: 1621-1637.

Stewart, BS and RL DeLong. 1995. Double migrations of the northern elephant seal *Mirounga angustirostris*. *Journal of Mammalogy* 76(1): 196-205.

Stewart, BS and RL DeLong. 1994. Postbreeding foraging migrations of northern elephant seals. Chapter 16 In: *Elephant seals: population ecology, behavior, and physiology*, BJ LeBoeuf and RM Laws (eds). University of California Press: Berkeley. 414 pp.

Stewart, BS and RL DeLong. 1993. Seasonal dispersion and habitat use of foraging northern elephant seals. *Symp. Zool. Soc. London* 66: 179-194.

Swain, U G. 1996. Foraging behaviour of female Steller sea lions in Southeast Alaska and the eastern Gulf of Alaska. Pages 135-166 in: Steller sea lion recovery investigations in Alaska, 1992-1994. Rep from AK. Dep. Fish and Game, Juneau, AK to NOAA, Wildlife Technical Bulletin 13, May 1996.

Swartz, SL, BL Taylor and DJ Rugh. 2006. Gray whale *Eschrichtius robustus* population and stock identity. *Mammal Review* 36(1):66-84.

Teloni, V, MP Johnson, PJO Miller, and PT Madsen. 2007. Shallow food for deep divers: Dynamic foraging behavior of male sperm whales in a high latitude habitat. *Journal of Experimental Marine Biology and Ecology* 354(1):119-131.

Tiemann, CO, SW Martin and JR Mobley, Jr. 2006. Aerial and acoustic marine mammal detection and localization on Navy ranges. IEEE *Journal of Oceanic Engineering* 31(1): 107-119.

Trites, A.W., D.CG. Calkins and A.J. Winship, 2007. Diets of Steller sea lions (Eumetopias jubatus) in Southest Alaska, 1993 to 1999. Fishery Bulletin 105:234-248.

Tyack, PL, M Johnson, N Aguilar Soto, A Sturlese and PT Madsen. 2006. Extreme diving of beaked whales. *Journal of Experimental Biology* 209(21):4238-4253.

Van Waarebeek, K and B Wursig. 2002. Pacific white-sided dolphin and dusky dolphin. Pp. 859-861 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Wade, PR and T Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Report of the International Whaling Commission* 43:477-493.

Wahlberg, M. 2002. The acoustic behaviour of diving sperm whales observed with a hydrophone array. *Journal of Experimental Marine Biology and Ecology* 281: 53-62.

Waite, J. 2003. Cetacean Assessment and Ecology Program: Cetacean Survey. *AFSC Quarterly Research Reports* July-Sept 2003.

Walker, WA, JG Mead and RL Brownell. 2002. Diets of Baird's beaked whales, *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific coast of Honshu, Japan. *Marine Mammal Science* 18(4): 902-919.

Watkins, WA and WE Schevill. 1979. Aerial observations of feeding behavior in four baleen whales: *Eubalaena glacialis, Balaenoptera borealis, Megaptera novaeangliae* and *Balaenoptera physalus*. *Journal of Mammalogy* 60(1): 155-163.

Watkins, WA, MA Daher, NA DiMarzio, A Samuels, D Wartzok, KM Fristrup, PW Howey and RR Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. *Marine Mammal Science* 18(1): 55-68.

Watkins, WA, MA Daher, KM Fristrup, TJ Howald and G Notarbartolo di Sciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. *Marine Mammal Science* 9: 55-67.

Watwood, SL, PJO Miller, M Johnson, PT Madsen and PL Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). *Journal of Ecology* 75: 814-825.

Whitehead, H. 2002. Sperm whale. Pp. 1165-1172 In: WF Perrin, B Wursig and JGM Thewissen (eds) *Encyclopedia of Marine Mammals*. Academic Press: San Diego. 1414 pp.

Yazvenko, S. B., McDonald, T. L., Blokhin, S. A., Johnson, H.R. Melton, M.W. Newcomer, R. Nielson, and P.W. Wainwright, 2007. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environmental Monitoring and Assessment*, 134; 93-106.

Zerbini, AN, JM Waite, JW Durban, R LeDuc, ME Dahlheim and PR Wade. 2007. Estimating abundance of killer whales in the nearshore waters of the Gulf of Alaska and Aleutian Islands using line-transect sampling. *Marine Biology* (BERLIN) 150(5):1033-1045.

Zerbini, AN, JM Waite, JL Laake and PR Wade. 2006. Abundance, trends and distribution of baleen whales off Western Alaska and the central Aleutian Islands. *Deep Sea Research Part I: Oceanographic Research Papers* 53(11):1772-1790.

Table E-6. Summary of Marine Mammal Depth and Diving Information for Species Found in the TMAA

NOTE: some species that are not endemic to GOA are included in this appendix because data on their depth and diving preferences were extrapolated to GOA species.

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
MYSTICETES - Baleen whales									
Fin whale	Planktonic crustaceans, including *Thyanoessa* sp and *Calanus* sp, as well as scholling fishes such as capelin (*Mallotus*), herring (*Clupea*) and mackerel (*Scomber*)	Pelagic with some occurrence over continental shelf areas, including in island wake areas of Bay of Fundy	Aguilar (2002); Croll et al. (2001); Acevado et al. (2002): Notarbartolo-di-Sciara et al. (2003); Bannister (2002); Johnston et al. (2005); Watkins and Schevill (1979)	Feeding at depth	Northeast Pacific (Mexico, California)	Mean depth 98 +- 33 m; mean dive time 6.3+- 1.5 min		Fifteen whales/ April-October/Time-depth-recorder	Croll et al. (2001)
Fin whale				Non-feeding	Northeast Pacific (Mexico, California)	Mean depth 59 +-30 m; mean dive time 4.2 +- 1.7 min; most dives to ~ 30 m with occasional deeper V-shaped dives to >90 m		Fifteen whales/ April-October/Time-depth-recorder	Croll et al. (2001)
Fin whale				Feeding	Mediterranean (Ligurian Sea)	Shallow dives (mean 26-33 m, with all <100m) until late afternoon; then dives in excess of 400 m (perhaps to 540 m); in one case a whale showed deep diving in midday; deeper dives probably were to feed on specific prey (*Meganyctiphanes norvegica*) that undergo diel vertical migration		Three whales/ Summer/ Velocity-time-depth-recorder	Panigada et al. (1999); Panigada et al. (2003); Panigada et al. (2006)
Fin whale				Traveling	Mediterranean (Ligurian Sea)	Shallow dives (mean 9.8 +- 5.3 m, with max 20 m) , shorter dive times and slower swimming speed indicate travel mode; deep dives (mean 181.3 +- 195.4 m, max 474 m), longer dive times and faster swimming speeds indicate feeding mode		One whale/ Summer/ Velocity-time-depth-recorder	Jahoda et al. (1999)
Fin whale				Feeding	Northeast Pacific (Southern California Bight)	Mean dive depth 248+-18 m; total dive duration mean 7.0+-1.0 min with mean descent of 1.7+-0.4 min and mean ascet of 1.4+-0.3 min; 60% (i.e., 7.0 min) of total time spent diving with 40% (i.e., 4.7 min) total time spent near sea surface (<50m)	44% in 0-49m (includes surface time plus descent and ascent to 49 m); 23% in 50-225 m (includes descent and ascent times taken from Table 1 minus time spent descending and ascending through 0-49 m); 33% at >225 m (total dive duration minus surface, descent and ascent times)	Seven whales/ August/ Bioacoustic probe	Goldbogen et al. (2006)
Fin whale				Feeding	Northeast Pacific (Southern California Bight)	Distribution of foraging dives mirrored distribution of krill in water collumn, with peaks at 75 and 200-250 m.		Two whales/ September-October/ Time-depth-recorder	Croll et al. (2001)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Minke whale	Regionally dependent; can include euphausiids, copepods, small fish and squids; Japanese anchovy preferred in western North Pacific, capelin and krill in the Barents Sea; armhook squids in North Pacific	Coastal, inshore and offshore; known to concentrate in areas of highest prey density, including during flood tides	Perrin and Brownell (2002); Jefferson et al. (1993); Murase et al. (2007); Bannister (2002); Lindstrom and Haug (2001); Johnston et al. (2005); Hoelzel et al. (1989); Haug et al. (2002); Haug et al. (1995); Haug et al. (1996); Konishi and Tamura (2007); Clarke (1986)	Feeding, Searching	North Atlantic (Norway)	Searching for capelin at less than 20 m, then lunge-feeding at depths from 15 to 55 m, then searching again at shallower depths	Based on time series in Figure 2, 47% of time was spent foraging from 21-55 m; 53% of time was spent searching for food from 0-20 m	One whale/ August/ Dive-depth-transmitters	Blix and Folkow (1995)
Minke whale				Feeding	North Pacific (San Juan Islands)	80% of feeding occurred over depths of 20-100m; two types of feeding observed both near surface - lunge feeding and bird association		23 whales/ June-September/ behavioral observations	Hoelzel et al. (1989)
Humpback whale	Pelagic schooling euphausiids and small fish including capelin, herring, mackerel, croaker, spot, and weakfish	Coastal, inshore, near islands and reefs, migration through pelagic waters	Clapham (2002); Hain et al. (1995); Laerm et al. (1997); Bannister (2002); Watkins and Schevill (1979)	Feeding	North Atlantic (Stellwagen Bank)	Depths <40 m		Several whales/ August/ Visual Observations	Hain et al. (1995)
Humpback whale				Feeding (possible)	Tropical Atlantic (Bermuda)	Dives to 240 m		One whale/ April/ VHF tag	Hamilton et al. (1997)
Humpback whale				Feeding (in breeding area)	Tropical Atlantic (Samana Bay - winter breeding area)	Not provided; lunge feeding with bubblenet		One whale/ January/ Visual observations	Baraff et al. (1991)
Humpback whale				Breeding	North Pacific (Hawaii)	Depths in excess of 170 m recorded; some depths to bottom, others to mid- or surface waters; dive duration was not necessarily related to dive depth; whales resting in morning with peak in aerial displays at noon	40% in 0-10 m, 27% in 11-20 m, 12% in 21-30 m, 4% in 31-40 m, 3% in 41-50 m, 2% in 51-60 m, 2% in 61-70 m, 2% in 71-80 m, 2% in 81-90 m, 2% in 91-100 m, 3% in >100 m (from Table 3)	Ten Males/ February-April/ Time-depth-recorder	Baird et al. (2000); Helweg and Herman (1994)
Humpback whale				Feeding	Northeast Atlantic (Greenland)	Dive data was catalogued for time spent in upper 8 m as well as maximum dive depth; diving did not extend to the bottom (~1000 m) with most time in upper 4 m of depth with few dives in excess of 400 m	37% of time in <4 m, 25% of time in 4-20 m, 7% of time in 21-35m, 4% of time in 36-50 m, 6% of time in 51-100 m, 7% of time in 101-150 m, 8% of time in 151-200 m, 6% of time in 201-300 m, and <1% in >300 m	Four whales/ June-July/ Satellite transmitters	Dietz et al. (2002)
Humpback whale				Feeding	North Pacific (Southeast Alaska)	Dives were short (<4 min) and shallow (<60 m); deepest dive to 148m; percent of time at surface increased with increased dive depth and with dives exceeding 60 m; dives related to position of prey patches		Several whales/ July-September/ Passive sonar	Dolphin (1987); Dolphin (1988)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Gray whale	Amphipods, including *Ampelisca* sp, and other organisms living in the sea floor; also occasionally surface skim and engulfing; dependent on location; euphausiids along frontal systems may also be important	Continental shelf, 4-120 m depth	Dunham and Duffus (2002); Jones and Swartz (2002); Bannister (2002); Yazvenko et al. (2007); Bluhm et al. (2007)	Migrating	Northeast Pacific (coastal Baja California to northern California)	30 of 36 locations in depths <100m deep (mean 39 m); consistent speed indicating directed movement		One whale/ February/ Satellite tag	Mate and Urban Ramirez (2003)
Gray whale				Feeding	Bering and Chukchi Seas	Depths at feeding locations from 5-51 m depth		Several whales/ July-November/ Aerial surveys and benthic sampling	Clarke et al. (1989); Clarke and Moore (2002); Moore et al. (2003)
Gray whale				Feeding	Northeast Pacific (Kodiak Island)	Feeding on cumacean invertebrates		Several whales/ Year-round/ Aerial surveys	Moore et al. (2007)
Gray whale				Feeding	Northeast Pacific (Vancouver Island)	Majority of time was spent near the surface on interventilation dives (<3 m depth) and near the bottom (extremely nearshore in a protected bay with mean dive depth of 18 m, range 14-22 m depth; little time spent in the water column between surface and bottom.	40% of time at <4 m (surface and interventilation dives), 38% of time at 3-18 m (active migration), 22% of time at >18 m (foraging).	One whale/ August/ Time-depth recorder	Malcolm et al. (1995/96); Malcolm and Duffus (2000)
ODONTOCETES - Toothed whales									
Sperm whale	Squids and other cephalopods, demersal and mesopelagic fish; varies according to region	Deep waters, areas of upwelling	Whitehead (2002); Roberts (2003); Clarke (1986)	Feeding	Mediterranean Sea	Overall dive cycle duration mean = 54.78 min, with 9.14 min (17% of time) at the surface between dives; no measurement of depth of dive		16 whales/ July-August/ visual observations and click recordings	Drouot et al. (2004)
Sperm whale				Feeding	South Pacific (Kaikoura, New Zealand)	83% of time spent underwater; no change in abundance between summer and winter but prey likely changed between seasons		>100 whales/ Year-round/ visual observations	Jacquet et al. (2000)
Sperm whale				Feeding	Equatorial Pacific (Galapagos)	Fecal sampling indicated four species of cephalopods predominated diet, but is likely biased against very small and very large cephalopods; samples showed variation over time and place		Several whales/ January-June/ fecal sampling	Smith and Whitehead (2000)
Sperm whale				Feeding	Equatorial Pacific (Galapagos)	Dives were not to ocean floor (2000-4000 m) but were to mean 382 m in one year and mean of 314 in another year; no diurnal patterns noted; general pattern was 10 min at surface followed by dive of 40 min; clicks (indicating feeding) started usually after descent to few hundred meters		Several whales/ January-June/ acoustic sampling	Papastavrou et al. (1989)
Sperm whale				Feeding	North Pacific (Baja California)	Deep dives (>100m) accounted for 26% of all dives; average depth 418 +- 216 m; most (91%) deep dives were to 100-500 m; deepest dives were 1250-1500m; average dive duration was 27 min; average surface time was 8.0; whale dives closely correlated with depth of squid (200-400 m) during day; nighttime squid were shallower but whales still dove to same depths	74% in <100 m; 24% in 100-500 m; 2% in >500m	Five whales/ October-November/ Satellite-linked dive recorder	Davis et al. (2007)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Sperm whale				Resting/ socializing	North Pacific (Baja California)	Most dives (74%) shallow (8-100 m) and short duration; likely resting and/or socializing		Five whales/ October-November/ Satellite-linked dive recorder	Davis et al. (2007)
Sperm whale				Feeding	North Atlantic (Norway)	Maximum dive depths near sea floor and beyond scattering layer		Unknown # male whales/ July/ hydrophone array	Wahlberg (2002)
Sperm whale				Feeding	North Pacific (Southeast Alaska)	Maximum dive depth if 340 m when fishing activity was absent; max dive depth during fishing activity was 105 m		Two whales/ May/ acoustic monitoring	Tiemann et al. (2006)
Sperm whale				Feeding	Northwest Atlantic (Georges Bank)	Dives somewhat more U-shaped than observed elsewhere; animals made both shallow and deep dives; average of 27% of time at surface; deepest dive of 1186 m while deepest depths in area were 1500-3000 m so foraging was mid-water column; surface interval averaged 7.1 min		Nine Whales/ July 2003/ DTAG	Palka and Johnson (2007)
Sperm whale				Feeding	Northwest Atlantic (Georges Bank)	37% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	48% in <10 m; 3% in 10-100 m; 7% in 101-300 m; 7% in 301-500 m; 4% in 501-636 m; 31% in >636 m	Six females or immatures/ September-October/ DTAG	Watwood et al. (2006)
Sperm whale				Feeding	Mediterranean Sea	20% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	35% in <10 m; 4% in 10-100 m; 9% in 101-300 m; 9% in 301-500 m; 5% in 501-623 m; 38% in >636 m	Eleven females or immatures/ July/ DTAG	Watwood et al. (2006)
Sperm whale				Feeding	Gulf of Mexico	28% of total time was spent near surface (0-10m); foraging dive statistics provided in Table 1 and used to calculate percentages of time in depth categories, adjusted for total time at surface	41% in <10 m; 4% in 10-100 m; 8% in 101-300 m; 7% in 301-468 m; 40% >468 m	20 females or immatures/ June-September/ DTAG	Watwood et al. (2006)
Sperm whale				Feeding/ Resting	North Pacific (Japan)	Dives to 400-1200 m; active bursts in velocity at bottom of dive suggesting search-and-pursue strategy for feeding; 14% of total time was spent at surface not feeding or diving at all, with 86% of time spent actively feeding; used numbers from Table 1 to determine percentages of time in each depth category during feeding then adjusted by total time at surface	31% in <10 m (surface time); 8% in 10-200 m; 9% in 201-400 m; 9% in 401-600 m; 9% in 601-800m; 34% in >800 m	One female/ June/ Time-depth-recorder	Amano and Yoshioka (2003)
Sperm whale				Feeding	North Pacific (Japan)	Diel differences in diving in one location offshore Japan, with deeper dives (mean 853 m) and faster swimming during the day than at night (mean 469 m); other location along Japan's coast showed no difference between day and night dives; most time (74%) spent on dives exceeding 200 m; surface periods of 2.9 h at least once per day; max depth recorded 1304 m		Ten whales/ May-June, October/ depth data loggers and VHF radio transmitters	Aoki et al. (2007)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Sperm whale				Feeding/ Resting	North Atlantic (Caribbean)	Whales within 5 km of shore during day but moved offshore at night; calves remained mostly at surface with one or more adults; night time tracking more difficult due to increased biological noise from scattering layer; both whales spent long periods of time (>2hr) at surface during diving periods		Two whales/ October/ Acoustic transponder	Watkins et al. (1993)
Sperm whale					North Atlantic (Caribbean)	Dives did not approach bottom of ocean (usually >200 m shallower than bottom depth); day dives deeper than night dives but not significantly; 63% of total time in deep dives with 37% of time near surface or shallow dives (within 100 m of surface)		One whale/ April/ Time-depth tag	Watkins et al. (2002)
Sperm whale				Feeding	Northern Pacific (Hawaii)	Cephalopods of several genera recovered		Two animals/ unknown/ stomach contents	Clarke and Young (1998)
Sperm whale				Occurrence	Mediterranean Sea (Alborian Sea south of Spain)	Preferred waters >700m		Vessel transects	Canadas et al. (2002)
Sperm whale				Feeding	Arctic Ocean (Norway)	Dives from 14-1860 m with median of 175 m; clicking (searching for prey) began at 14-218 m and stopped at 1-1114 m, and whale spent 91% of overall dives emitting clicks; shallower dives were apparently to target more sparse prey while deep dives led to frequent prey capture attempts and were likely within denser food layers		Four adult males/ July/ DTAG	Teloni et al. (2007)
Cuvier's beaked whale	Meso-pelagic or deep water benthic organisms, particularly squid (Cephalapoda: Teuthoidea); may have larger range of prey species than other deep divers; likely suction feeders based on lack of teeth and enlarged hyoid bone and tongue muscles	Offshore, deep waters of continental slope (200-2000 m) or deeper	Heyning (2002); Santos et al. (2001); Blanco and Raga (2000); Clarke (1986)	Feeding	Northeast Pacific (Hawaii)	Max dive depth = 1450 m; identified at least three dive categories including inter-ventilation (<4 m, parabolic shape), long duration (>1000m, U-shaped but with inflections in bottom depth), and intermediate duration (292-568 m, U-shaped); dive cycle usually included one long duration per 2 hours; one dive interval at surface of >65 min; mean depth at taggin was 2131 m so feeding occurred at mid-depths; no difference between day and night diving		Two whales/September-November/Time-depth recorders	Baird et al. (2006a); Baird et al. (2005a)
Cuvier's beaked whale				Feeding	Mediterranean (Ligurian Sea)	Two types of dive, U-shaped deep foraging dives (>500 m, mean 1070 m) and shallower non-foraging dives (<500 m, mean 221 m); depth distribution taken from information in Table 2	27% in <2 m (surface); 29% in 2-220 m; 4% in 221-400 m; 4% in 401-600 m; 4% in 601-800 m; 5% in 801-1070; 27% in >1070 m	Seven whales/ June/ DTAGs	Tyack et al. (2006)
Cuvier's beaked whale				Feeding	Mediterranean (Ligurian Sea)	Deep dives broken into three phases: silent descent, vocal-foraging and silent ascent; vocalizations not detected <200m depth; detected when whales were as deep as 1267 m; vocalizations ceased when whale started ascending from dive; clicks ultrasonic with no significant energy below 20 kHz		Two whales/ September/ DTAGs	Johnson et al. (2004); Soto et al. (2006)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Baird's beaked whale	Benthic fishes and cephalopods, also pelagic fish including mackerel and sardine; primarily squid off northern coast of Hokkaido and deep sea fish off Pacific coast of Japan	Deep waters over continental slope	Kasuya (2002); Kasuya (1986); Walker et al. (2002); Clarke (1986)	Feeding	Northwest Atlantic (Japan)	Whales caught at depths of ~1000 m; stomach contents included prey species normally found from 1100-1300 m; likely feeding at or near bottom		Several whales/ August-September/ Stomach contents	Ohizumi et al. (2003)
Northern bottlenose whale	Squid of genus *Gonatus* and *Taonius* and occasionally fish and benthic invertebrates	Deep waters >500 m; can dive to >1400 m	Gowans (2002); Kasuya (2002); Clarke and Kristensen (1980); Clarke (1986)	Feeding	Northeast Atlantic (Nova Scotia "Gully")	Most (62-70%, average = 66%) of the time was spent diving (deeper than 40 m); most dives somewhat V-shaped; shallow dives (<400 m) and deep dives (>800 m); whales spent 24-30% (therefore, average of 27%) of dives at 85% maximum depth indicating they feed near the bottom; deepest dive 1453 m; depth distribution taken from info in Table 1	34% at 0-40 m, 39% at 41-800 m, 27% at >800 m	Two whales/ June-August/ Time-depth recorders	Hooker and Baird (1999)
Killer whale	Diet includes fish (salmon, herring, cod, tuna) and cephalopods, as well as other marine mammals (pinnipeds, dolphins, mustelids, whales) and sea birds; most populations show marked dietary specialization	Widely distributed but more commonly seen in coastal temperate waters of high productivity	Ford (2002); Estes et al. (1998); Ford et al. (1998); Saulitis et al. (2000); Baird et al. (2006b)	Feeding	North Pacific (Puget Sound)	Resident-type (fish-eater) whales; maximum dive depth recorded 264 m with maximum depth in study area of 330 m; population appeared to use primarily near-surface waters most likely because prey was available there; some difference between day and night patterns and between males and femalesl depth distribution info from Table 5 in Baird et al. (2003)	96% at 0-30 m; 4% at >30 m	Eight whales/ Summer-fall/ Time-depth recorders	Baird et al. (2005b); Baird et al. (2003)
Killer whale				Feeding	Southwest Atlantic (Brazil)	Small to medium-sized cephalopods, both offshore and coastal		Unknown animals/ unknown/ stomach contents	Santos and Haimovici (2001)
Killer whale				Feeding	North Pacific	Offshore type whales, likely fish eaters based on behavioral observations and stomach content analysis		Several/ Year round/ Observations and stomach contents	Dahlheim et al. (2008)
Pacific white-sided dolphin	Lanternfish, anchovies, hake and squid; also herring, salmon, cod, shrimp and capelin	Mostly pelagic and temperate; may syncrhonize movements with anchovy and other prey	van Waerebeek and Wursig (2002); Clarke (1986)	Feeding	Northeast Pacific (British Columbia inland waters)	Prey collected included herring, capelin, Pacific sardine and possibly eulachon		Unknown/ year round/ dipnet collection of prey	Morton (2000)
Atlantic white-sided dolphin	Herring, small mackerel, gadid fishes, smelts, hake, sand lances, squid; likely change from season to season	Continental shelf and slope from deep oceanic areas to occasionally coastal waters	Cipriano (2002); Clarke (1986)		North Atlantic (Gulf of Maine)	Most (89%) of time spent submerged; most (76%) dives were <1 min duration and none were for longer that 4 minute duration		One animal/ February/ satellite-monitored radio tag	Mate et al. (1994)
Atlantic white-sided dolphin				Feeding	North Atlantic (Ireland)	Most frequent prey were mackerel and silvery pout		Four animals/ year round/ stomach contents	Berrow and Rogan (1996)
White-beaked dolphin	Mesopelagic fish, especially cod, whiting and other gadids, and squid		Kinze (2002); Clarke (1986)	Feeding	North Atlantic (Ireland)	Stomach contained Gadoid fish and scad remains		One animal/ year round/ stomach contents	Berrow and Rogan (1996)
Dall's porpoise	Small schooling and mesopelagic fish and cephalopods	Deep offshore as well as deeper near shore waters; diurnal as well as nocturnal feeders to take advantage of prey availability	Jefferson (2002), Amano et al. (1998); Clarke (1986)	Travelling	North Pacific (Puget Sound)	Feasibility study to determine if Dall's could be successfully tagged with suction cup tag; depth distribution info from Table 2 and excludes initial dive data when animal responded to tag event	39% at <1 m, 8% at 1-10 m, 45% at 11-40 m and 8% at >40 m	One animal/ August/ time-depth recorder	Hanson and Baird (1998)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
PINNIPEDS									
Northern fur seal	Small fish and squid in deep water and along the shelf break; Pacific herring, squid and walleye pollock dominated in the Gulf of Alaska, British Columbia, Washington and Oregon; northern anchovy and squid primary in Oregon, Washington and California	Deep dives occur on the shelf and feeding probably occurs near the bottom	Gentry (2002); Ream et al. (2005)			Maximum dive depth 256 m		Two females/ July/ time-depth recorders	Ponganis et al. (1992)
Northern fur seal				Feeding	North Pacific (Bering Sea)	Mean dive depth 68 m (range 32-150 m); mean maximum depth 168 m (range 86-207 m); two types of dives, shallow (<75 m; mean = 30 m; occur at night) and deep (>75 m; mean = 130 m; occur during day and night); total activity budget during feeding trips was 57% active at surface, 26% diving and 17% resting; depth distribution info from Gentry and others	Daytime: 74% at <2 m, 24% at 2-260 m; night time: 74% at <2 m, 24% at 2-75 m	Seven females/ July/ time-depth recorders	Gentry et al. (1986)
Northern fur seal				Feeding	North Pacific (Bering Sea)	Mean dive depth of 17.5 m, with a maximum depth of 175 m; diving deeper in the daytime than during nighttime, perhaps reflecting the different distribution of prey (especially juvenile pollock) that undertake night time vertical migrations, and also differed between inner-shelf, mid-shelf, outer-shelf and off-shelf locations; deeper diving tended to occur on-shelf, with shallower diving off-shelf.		19 juvenile males/ July-September/ satellite transmitters	Sterling and Ream (2004)
Northern fur seal				Feeding	North Pacific (Bering Sea to California)	Higher dive rates during night time hours compared with daytime; variation in mean dive depth between migratory travelling and destination area (eastern North Pacific coast) where mean dive depth was <25 m; night time mean dive depths were greater during full moon than during new moon		Three females/ November-May/ satellite transmitters	Ream et al. (2005)
Northern fur seal				Feeding	North Pacific (Bering Sea)	Activity budgets of lactating females of 44% locomoting, 23% diving and 33% resting at the surface		Four females/ August/ platform terminal transmitters	Insley et al. (2008)
Northern fur seal				Migrating	North Pacific (Bering Sea to Gulf of Alaska)	Diving behavior consistent regardless of habitat (pelagic or continental shelf); diving largely at night and in evening and morning with little diving during day suggesting feeding on vertically migrating prey	71% at <2 m, 14% at 2-5 m, 5% at 6-10 m, 6% at 11-25 m and 3% at 26-50 m	20 post-weaning pups/ November-May/ satellite-linked time-depth recorders	Baker (2007)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Steller sea lion	Fish, including walleye pollock, Pacific herring, sand lance, salmon, flounder, rockfish and cephalopods	Diets and feeding patterns change with seasons; population levels are related to prey with increasing populations correlated with diverse diets and decreasing populations correlated with diets of primarily one prey item; females feed mostly at night during breeding season; feeding occurs throughout the day during non-breeding season	Trites et al. (2007); Loughlin (2002); Merrick et al. (1994)	Feeding	North Pacific (southeast Alaska)	Characterized by relatively brief trips to sea that represent about on-half of total time, and by fairly frequent, short and shallow dives that occur mostly at night. Maximum depth recorded was 424 m; mean depth was 26.4 m, and 49% of all dives were <10 m.		13 females/ May-June, January/ satellite-linked time-depth recorders	Swain (1996)
Steller sea lion				Feeding	North Pacific (Gulf of Alaska)	Adult females forage close to land in summer (<20 km) and make brief trips (<2 days) and shallow dives (<30 m); in winter, divers are longer in distance (up to 300 km), time (up to several months) and deeper (>250 m), Average dive depth of 36.5 and 42.9 m		Two females/ unknown/ satellite-linked time-depth recorder	Merrick et al. (1994)
Steller sea lion					North Pacific (Gulf of Alaska)	Adult females capable of foraging throughout GOA and Bering Sea, while young-of-year have smaller ranges and shallower dives; females in winter dove deepest (median 24 m, maximum >250 m, while young-of-year were shallowest (median 9 m, max 72 m); depth distribution taken from Figure 4 and represent averaging of all age/season classes	60% at 0-10 m, 22% at 11-20 m, 12% at 21-50 m, 5% at 51-100 m and 1% at >100 m.	15 animals/ June-July, November-March/ satellite-linked time-depth recorders and VHF transmitters	Merrick and Loughlin (1997)
Steller sea lion					North Pacific (Gulf of Alaska)	Young of year dove for shorter periods and shallower depths than yearlings; maximum dive depth was 288 m; long-range transits began at >10 months of age; depth distribution taken from Figure 2	78% in 0-10 m, 13% in 11-20 m, 7% in 21-50 m, and 2% in > 51 m	18 animals/ October-June/ satellite-linked time-depth recorders	Loughlin et al. (2003)
Steller sea lion					North Pacific (Washington)	Maximum dive depth was 328 m; depth distribution taken from Figure 2	28% in 0-10 m, 30% in 11-20 m, 18% in 21-50 m, 14% in 51-100 m and 10% in >100 m	Seven animals/ October-June/ satellite-linked time-depth recorders	Loughlin et al. (2003)
Steller sea lion					North Pacific (Gulf of Alaska)	Juveniles from western Alaska rookeries left on foraging trips at dusk and returned at dawn (taking advantage of polluck that vertically migrates and hauling out during the day), while juveniles from eastern Alaska rookeries left on foraging trips throughout the day and night, likely feeding on prey other than vertical migrants		129 animals/ August-November, January-May/ satellite dive recorders	Call et al. 2007)
Steller sea lion					North Pacific (Gulf of Alaska)	Round trip distance and duration of pups and juveniles increased with age, trip distance was greater for western rookeries than for eastern rookeries, trip duration was greater for females than males; 90% of trips were <=15 km from haul-outs; dispersals >500 km were undertaken only by males although dispersals of >120 km were common.		103 animals/ year round/ satellite dive recorders	Raum-Suryan et al. (2004)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Northern elephant seal	Feed on deep-water squid and fish, and likely spend about 80% of their annual cycle at sea feeding; feed in meso-pelagic zone on vertically migrating squid	Deeper waters (>1000 m); males farther north than females	Hindell (2002); Stewart and DeLong (1993; 1995); LeBoeuf et al. (1988); Asaga et al. (1994); LeBoeuf (1994)	Feeding	North Pacific	Dive continuously for 8-10 months/year; dispersion and migratory patterns related to oceanographic features and areas of biological productivity; primarily squid eaters; males travel farther than females; females submerged 91% and males submerged 88% of time at sea; dive continuously; average depth for females was 479 m (post-moult) and 518 m (post-breeding) and for males 364 m (post-breeding) and 366 m (post-moult)		36 adults (both sexes)/ February-August/ dive and location recorders	Stewart and Delong (1993)
Northern elephant seal				Feeding	North Pacific	seals use same foraging areas during post-breeding and post-moulting periods; sexes are segregated geographically		36 adults (both sexes)/ January-February; May; July/ geographic location time depth recorders	Stewart and DeLong (1995)
Northern elephant seal				Feeding	North Pacific	little time at depths <200 m or >800 m; post-breeding migration is directed northward and quick until feeding areas are obtained; dives in transit are shallower than those on foraging grounds		14 adults (both sexes)/ February-July/ geographic location time depth recorders	Stewart and DeLong (1994)
Northern elephant seal				Feeding	North Pacific	Sea surface temperature appears to influence female forage area choice; foraging occurred in near shore areas of Gulf of Alaska, offshore Gulf of Alaska, near shore off Washington and Oregon and offshore between 40 and 50 N		12 adult females/ year round/ time depth recorders	Simmins et al. (2007)
Northern elephant seal				Feeding	North Pacific	Post-lactation monitoring; 86% of time at-sea spent submerged; maximum dive of 894 m, but dives >700 m were rare; modal dive depths between 350 and 650 m; continuous deep diving while at-sea; night dives were more numerous, shallower and of shorter duration; most dives types D (deep and u-shaped)		Seven adult females/ February-March/ time-depth recorders	LeBoeuf et al. (1988)
Northern elephant seal				Feeding	North Pacific	Mean depth of dive 333 m; maximum dive 630 m; 6% of all dives <200 m		One adult female/ February/ time-depth recorder	LeBoeuf et al. (1986)
Northern elephant seal				Feeding	North Pacific	Differences in foraging locations and behavior between males and females; females exhibited pelagic diving with varying dive depths depending on prey location in deep scattering layer; males exhibited pelagic diving as well as flat-bottom benthic dives near continental margins; males migrated to northern Gulf of Alaska and eastern Aleutians with females distributed west to 150 W between 44 and 52 N		32 adults (both sexes)/ March-July/ radio-telemetry	LeBoeuf et al. (1993)
Northern elephant seal				Transiting	North Pacific	90% of time submerged; mean depth 289 m; directed swimming even while submerged used prolonged gliding during dive descents which reduces cost of transport and can increase the duration of the dive		One adult female/ April/ video and satellite telemetry	Davis et al. (2001)

	GENERAL INFORMATION			DEPTH SPECIFIC INFORMATION					
Common Name	**Food Preference**	**Depth or Oceanic Preference**	**References**	**Behavioral State**	**Geographic Region**	**Depth Information**	**Depth Distribution**	**Sample Size/ Time of Year/Method**	**References**
Northern elephant seal				Feeding	North Pacific	Type D (foraging) dives account for 75-80% of all dives; type A (transit dives) rarely occurred in series; type C dives were shallowest; depth distribution information from table 17.3, type D dives which are foraging dives as they are the most common	9% at <2 m, 11% at 2-100 m, 11% at 101-200 m, 11% at 201-300 m, 11% at 301-400 m, 11% at 401-500 m and 36% at >500 m.	Two adult females/ February-May/ time-depth recorders	Asaga et al. (1994)
Northern elephant seal				Feeding	North Pacific	Transit dives in males cover large horizontal distances and are shallower than pelagic dive depths; transit dives in females and juveniles are both for transiting and search for prey patches; foraging dives have steeper angles than transit dives in females, but angles are not noticeably different in juveniles; swim speeds were similar across age and sex		16 animals (various ages)/ April-May/ time-depth recorders and platform terminal transmitters	Hassrick et al. (2007)
Northern elephant seal				Feeding	North Pacific	Males feed primarily from coastal Oregon to western Aleutian Islands, along continental margin and feed primarily on benthic organisms, migration is direct to forage areas across Pacific; females have wider foraging area from 38-60 N and from the coast to 172 E, and forage on pelagic prey in the water column, migration is more variable to take advantage of prey patches		47 adults (both sexes)/ March-June, September-December/ time-depth swim speed recorders	LeBoeuf et al. (2000)
Northern elephant seal				Feeding, Transiting	North Pacific	Different types of dives serve three general functions: type AB dives are transit dives (covering great horizontal distance and with shallow ascent and descent angles); type C dives are "processing" dives for internal processes such as digestions (slower swimming speed and short horizontal distance; type DE dives are foraging (both chasing prey pelagically and benthic foraging)		unknown	Crocker et al. (1994)

Appendix F

Cetacean Stranding Report

TABLE OF CONTENTS

F CETACEAN STRANDING REPORT F-1

F.1 CETACEAN STRANDINGS AND THREATS F-1
F.1.1 WHAT IS A STRANDED MARINE MAMMAL? F-1
F.1.2 UNITED STATES STRANDING RESPONSE ORGANIZATION F-2
F.1.3 UNUSUAL MORTALITY EVENTS (UMES) F-3
F.1.4 THREATS TO MARINE MAMMALS AND POTENTIAL CAUSES FOR STRANDING F-5
F.1.4.1 Natural Stranding Causes F-6
F.1.4.2 Anthropogenic Stranding Causes and Potential Risks F-10
F.1.5 STRANDING EVENTS ASSOCIATED WITH NAVY SONAR F-16
F.1.6 STRANDING ANALYSIS F-19
F.1.6.1 Naval Association F-19
F.1.6.2 Other Global Stranding Discussions F-24
F.1.6.3 Causal Associations for Stranding Events F-32
F.1.7 STRANDING SECTION CONCLUSIONS F-32
F.2 REFERENCES F-33

LIST OF FIGURES

FIGURE F-1. ANIMAL MORTALITIES FROM HARMFUL ALGAL BLOOMS WITHIN THE U.S., 1997-2006 ..... F-8
FIGURE F-2. HUMAN THREATS TO WORLD WIDE SMALL CETACEAN POPULATIONS F-10
FIGURE F-3. NORTHWEST REGION HARBOR PORPOISE STRANDINGS 1990 – 2006 ..... F-26

LIST OF TABLES

TABLE F-1. DOCUMENTED UMES IN THE PACIFIC. F-4
TABLE F-2. ALASKA REGION MARINE MAMMAL STRANDINGS F-5
TABLE F-3. MOST COMMONLY REPORTED SPECIES OF CETACEANS FOUND STRANDED IN THE GULF OF ALASKA 1975 – 1987 ..... F-5

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F CETACEAN STRANDING REPORT

F.1 CETACEAN STRANDINGS AND THREATS

Strandings can involve a single animal or several to hundreds of animals. An event where animals are found out of their normal habitat may be considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 "Hanalei Mass Stranding Event"; Southall et al., 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete echolocation, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as individual animals. This may be due to their unfamiliarity with the coastal area. By contrast, pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings, 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors - including bathymetry (i.e. steep drop offs), narrow channels (less than 35 nm), environmental conditions (e.g. surface ducting), and multiple sonar ships (see Section on Stranding Events Associated with Navy Sonar) - were compared among the different stranding events.

F.1.1 What is a Stranded Marine Mammal?

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding within the U.S. is that "a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance." (16 United States Code [U.S.C.] section 1421h).

The majority of animals that strand are dead or moribund (NMFS, 2007). For animals that strand alive, human intervention through medical aid and/or guidance seaward may be required for the animal to return to the sea. If unable to return to sea, rehabilitation at an appropriate facility may be determined as the best opportunity for animal survival. An event where animals are found out of their normal habitat may be considered a stranding depending on circumstances even though the animals do not necessarily end up beaching (Southall, 2006).

Three general categories can be used to describe strandings: single, mass, and unusual mortality events. The most frequent type of stranding involves only one animal (or a mother/calf pair) (NMFS, 2007).

Mass stranding involves two or more marine mammals of the same species other than a mother/calf pair (Wilkinson, 1991), and may span one or more days and range over several miles (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Walsh et al., 2001; Freitas, 2004). In North America, only a few species typically strand in large groups of 15 or more and include sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white-beaked dolphins, and rough-toothed dolphins (Odell 1987, Walsh et al. 2001). Some species, such as pilot whales, false-killer whales, and melon-headed whales occasionally strand in groups of 50 to 150 or more (Geraci et al. 1999). All of these normally pelagic off-shore species are highly sociable and infrequently encountered in coastal waters. Species that commonly strand in smaller numbers include pygmy killer whales, common dolphins, bottlenose dolphins, Pacific white-sided dolphin Frasier's dolphins, gray whale and humpback whale (West Coast only), harbor porpoise, Cuvier's

beaked whales, California sea lions, and harbor seals (Mazzuca et al. 1999, Norman et al. 2004, Geraci and Lounsbury 2005).

Unusual mortality events (UMEs) can be a series of single strandings or mass strandings, or unexpected mortalities (i.e., die-offs) that occur under unusual circumstances (Dierauf and Gulland, 2001; Harwood, 2002; Gulland, 2006; NMFS, 2007). These events may be interrelated: for instance, at-sea die-offs lead to increased stranding frequency over a short period of time, generally within one to two months. As published by the NMFS, revised criteria for defining a UME include (71 FR 75234, 2006):

(1) A marked increase in the magnitude or a marked change in the nature of morbidity, mortality, or strandings when compared with prior records.

(2) A temporal change in morbidity, mortality or strandings is occurring.

(3) A spatial change in morbidity, mortality or strandings is occurring.

(4) The species, age, or sex composition of the affected animals is different than that of animals that are normally affected.

(5) Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g., blubber thickness).

(6) Potentially significant morbidity, mortality, or stranding is observed in species, stocks or populations that are particularly vulnerable (e.g., listed as depleted, threatened or endangered or declining). For example, stranding of three or four right whales may be cause for great concern whereas stranding of a similar number of fin whales may not.

(7) Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species.

UMEs are usually unexpected, infrequent, and may involve a significant number of marine mammal mortalities. As discussed below, unusual environmental conditions are probably responsible for most UMEs and marine mammal die-offs (Vidal and Gallo-Reynoso, 1996; Geraci et al., 1999; Walsh et al., 2001; Gulland and Hall, 2005).

F.1.2 United States Stranding Response Organization

Stranding events provide scientists and resource managers information not available from limited at-sea surveys, and may be the only way to learn key biological information about certain species such as distribution, seasonal occurrence, and health (Rankin, 1953; Moore et al., 2004; Geraci and Lounsbury, 2005). Necropsies are useful in attempting to determine a reason for the stranding, and are performed on stranded animals when the situation and resources allow.

In 1992, Congress amended the MMPA to establish the Marine Mammal Health and Stranding Response Program (MMHSRP) under authority of the NMFS. The MMHSRP was created out of concern started in the 1980s for marine mammal mortalities, to formalize the response process, and to focus efforts being initiated by numerous local stranding organizations and as a result of public concern.

Major elements of the MMHSRP include (NMFS, 2007):

- National Marine Mammal Stranding Network
- Marine Mammal UME Program

- National Marine Mammal Tissue Bank (NMMTB) and Quality Assurance Program
- Marine Mammal Health Biomonitoring, Research, and Development
- Marine Mammal Disentanglement Network
- John H. Prescott Marine Mammal Rescue Assistance Grant Program (a.k.a. the Prescott Grant Program)
- Information Management and Dissemination.

The United States has a well-organized network in coastal states to respond to marine mammal strandings. Overseen by the NMFS, the National Marine Mammal Stranding Network is comprised of smaller organizations manned by professionals and volunteers from nonprofit organizations, aquaria, universities, and state and local governments trained in stranding response animal health, and diseased investigation. Currently, 141 organizations are authorized by NMFS to respond to marine mammal strandings (National Marine Fisheries Service, 2007o). Through a National Coordinator and six regional coordinators, NMFS authorizes and oversees stranding response activities and provides specialized training for the network.

NMFS Regions and Associated States and Territories

NMFS Northeast Region- ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, VA

NMFS Southeast Region- NC, SC, GA, FL, AL, MS, LA, TX, PR, VI

NMFS Southwest Region- CA

NMFS Northwest Region- OR, WA

NMFS Alaska Region- AK

NMFS Pacific Islands Region- HI, Guam, American Samoa, Commonwealth of the Northern Mariana Islands (CNMI)

Stranding reporting and response efforts over time have been inconsistent, although effort and data quality within the U.S. have been improving within the last 20 years (NMFS, 2007). Given the historical inconsistency in response and reporting, however, interpretation of long-term trends in marine mammal stranding is difficult (NMFS, 2007). Nationwide, between 1995-2004, there were approximately 700-1500 cetacean strandings per year and between 2000-4600 pinniped strandings per year (NMFS, 2007). In Alaska from 2001-2004, there were 45-165 cetacean strandings per year and 58-125 pinniped strandings per year (NMFS, 2007). Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

F.1.3 Unusual Mortality Events (UMEs)

From 1991 to the present, there have been 45 formally recognized UMEs in the U.S. The UMEs have either involved single or multiple species and dozens to hundreds of individual marine mammals per event (NOAA Fisheries, Office of Protected Resources 2008). Table F-1 contains a list of documented UMEs in and along the Pacific coast of the U.S.

Table F-1. Documented UMEs in the Pacific.

Year	Composition	Determination
2007	Guadeloupe fur seals in the Northwest	Cause not determined
2007	Large whales in California	Human Interaction
2007	Cetaceans in California	Cause not determined
2006	Harbor porpoises in the Pacific Northwest	Cause not determined
2006	Sea otters in Alaska	Cause not determined
2003	Sea otters in California	Ecological Factors
2002	Multiple species (common dolphins, California sea lion, sea otters) in California	Biotoxin
2001-2002	Hawaiian monk seals in the Northwest Hawaiian Islands	Ecological Factors
2000	Harbor seals in California	Infectious disease
2000	California sea lions in California	Biotoxin
1999/2000	Gray whales in California, Oregon and Washington	Cause not determined
1998	California sea lions in California	Harmful algal bloom; Domoic acid
1997	Harbor seals in California	Unknown infectious respiratory disease
1994	Common dolphins in California	Cause not determined
1993	Harbor seals, Steller sea lions, and California sea lions on the central Washington coast	Human Interaction
1992-1993	Pinnipeds in California	Ecological Factors
1991	California sea lions in California	Infectious disease

Source: NOAA Fisheries, Office of Protected Resources 2008

Stranding of cetaceans and pinnipeds reported to NMFS Alaska Region from 1998-2007 are summarized in Table F-2. The southcentral area includes the area from Cape Suckling to Cape Douglas and the Kodiak area follows the boundaries of the Kodiak Borough.

Strandings constituting this record were reported by fishermen, hunters, fishery observers, and other members of the public and include animals found dead (floating and beach-cast) and reports of live stranded, mass stranded, abandoned, sick or injured animals. Strandings where the animal(s) could not be examined are included in the numbers as long as the animal was at least identified as either cetacean or pinniped. Human interactions like ship strike/collisions, fishery interactions and entanglements are also included. Known subsistence takes are not included, but suspected subsistence animals are in some cases included (e.g., animals reported shot). Fishery observer reports are not included unless the animal was observed outside of statistical reporting protocols (and thus would not be included by the observer program as part of their watch data set). (NMFS, Alaska Region, Protected Resources, 2008).

Both unconfirmed and confirmed reports are included. (NMFS, Alaska Region, Protected Resources, 2008). This practice differs somewhat from strandings tabulated in the official record for other regions (such as for the Northwest Region), where a field investigation must confirm the reported stranding, however, Alaska's size, weather conditions, geography, and remote coastlines do not always allow for a field investigation/ confirmation to be a reasonable use of resources.

While the Alaska records could potentially be argued to constitute a variable record based on opportunistic reports, this data collection (sampling) method has been consistent for a decade and therefore constitutes a record that can be compared across reporting years. It is recognized that controls

were not established for other important variables influencing the occurrence of strandings and/or the reporting of strandings (e.g, weather, seismic events, changes in fisheries).

Table F-2. Alaska Region Marine Mammal Strandings

Year	Cetacea – All Areas	Beaked Whales – All Areas	Cetacea – Southcentral and Kodiak Areas	Pinnipedia – All Areas	Pinnipedia – Southcentral and Kodiak Areas
1998 – 2002*	110	8	74	50	25
2003	166	1	131	81	14
2004	62	8	33	59	12
2005	63	2	30	54	20
2006	92	1	34	57	26
2007	63	0	30	54	20

Source: NMFS, Alaska Region, Protected Resources 2004; 2005; 2006; 2007; 2008

Records gathered by Zimmerman (1991) for the period between 1975 and 1987 indicate that 325 stranded cetaceans were reported for the entire state of Alaska. Prior to 1985, a centralized Federal stranding network had not been established, which limited the number of stranding reports recorded. Table F-3 details the most commonly stranded cetaceans in the Gulf of Alaska for that period.

Table F-3. Most Commonly Reported Species of Cetaceans Found Stranded in the Gulf of Alaska 1975 – 1987

Species	Number Stranded
Gray Whale	7
Beluga Whale	20
Stejneger's Beaked Whale	5
Killer Whale	6
Cuvier's Beaked Whale	5
Minke Whale	10
Bowhead Whale	0
Humpback Whale	9
Sperm Whale	4
Baird's Beaked Whale	1
Fin Whale	3
Total	70

Source: Zimmerman, 1991

F.1.4 Threats to Marine Mammals and Potential Causes for Stranding

Reports of marine mammal strandings can be traced back to ancient Greece (Walsh et al., 2001). Like any wildlife population, there are normal background mortality rates that influence marine mammal population dynamics, including starvation, predation, aging, reproductive success, and disease (Geraci et al. 1999; Carretta et al. 2007). Strandings in and of themselves may be reflective of this natural cycle or, more recently, may be the result of anthropogenic sources (i.e., human impacts). Current science suggests that multiple factors, both natural and man-made, may be acting alone or in combination to cause a marine mammal to strand (Geraci et al., 1999; Culik, 2002; Perrin and Geraci, 2002; Hoelzel, 2003; Geraci and Lounsbury, 2005; NRC, 2006). While post-stranding data collection and necropsies of dead animals are attempted in an effort to find a possible cause for the stranding, it is often difficult to pinpoint exactly one factor that can be blamed for any given stranding. An animal suffering from one ailment

becomes susceptible to various other influences because of its weakened condition, making it difficult to determine a primary cause. In many stranding cases, scientists never learn the exact reason for the stranding.

Specific potential stranding causes can include both natural and human influenced (anthropogenic) causes listed below and described in the following sections:

Natural Stranding Causes
- Disease
- Natural toxins
- Weather and climatic influences
- Navigation errors
- Social cohesion
- Predation

Human Influenced (Anthropogenic) Stranding Causes
- Fisheries interaction
- Vessel strike
- Pollution and ingestion
- Noise

F.1.4.1 Natural Stranding Causes

Significant natural causes of mortality, die-offs, and stranding discussed below include disease and parasitism; marine neurotoxins from algae; navigation errors that lead to inadvertent stranding; and climatic influences that impact the distribution and abundance of potential food resources (i.e., starvation). Other natural mortality not discussed in detail includes predation by other species such as sharks (Cockcroft et al., 1989; Heithaus, 2001), killer whales (Constantine et al. 1998; Guinet et al. 2000; Pitman et al. 2001), and some species of pinniped (Hiruki et al. 1999; Robinson et al. 1999).

Disease

Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, parasitic, and fungal origin (Visser et al. 1991; Dunn et al. 2001; Harwood 2002). Gulland and Hall (2005) provide a more detailed summary of individual and population effects of marine mammal diseases.

Microparasites such as bacteria, viruses, and other microorganisms are commonly found in marine mammal habitats and usually pose little threat to a healthy animal (Geraci et al. 1999). For example, long-finned pilot whales that inhabit the waters off of the northeastern coast of the U.S. are carriers of the morbillivirus, yet have grown resistant to its usually lethal effects (Geraci et al. 1999). Since the 1980s, however, virus infections have been strongly associated with marine mammal die-offs (Domingo et al., 1992; Geraci and Lounsbury, 2005). Morbillivirus is the most significant marine mammal virus and suppresses a host's immune system, increasing risk of secondary infection (Harwood 2002). A bottlenose dolphin UME in 1993 and 1994 was caused by infectious disease. Die-offs ranged from northwestern Florida to Texas, with an increased number of deaths as it spread (NMFS 2007c). A 2004 UME in Florida was also associated with dolphin morbillivirus (NMFS 2004). Influenza A was responsible for the first reported mass mortality in the U.S., occurring along the coast of New England in 1979-1980 (Geraci et al. 1999; Harwood 2002). Canine distemper virus (a type of morbillivirus) has been responsible for large scale pinniped mortalities and die-offs (Grachev et al. 1989; Kennedy et al., 2000; Gulland and Hall, 2005), while a bacteria, *Leptospira pomona*, is responsible for periodic die-offs in California sea lions about every four years (Gulland et al. 1996; Gulland and Hall 2005). It is difficult to determine whether microparasites commonly act as a primary pathogen, or whether they show up as a secondary infection in

an already weakened animal (Geraci et al. 1999). Most marine mammal die-offs from infectious disease in the last 25 years, however, have had viruses associated with them (Simmonds and Mayer 1997; Geraci et al. 1999; Harwood 2002).

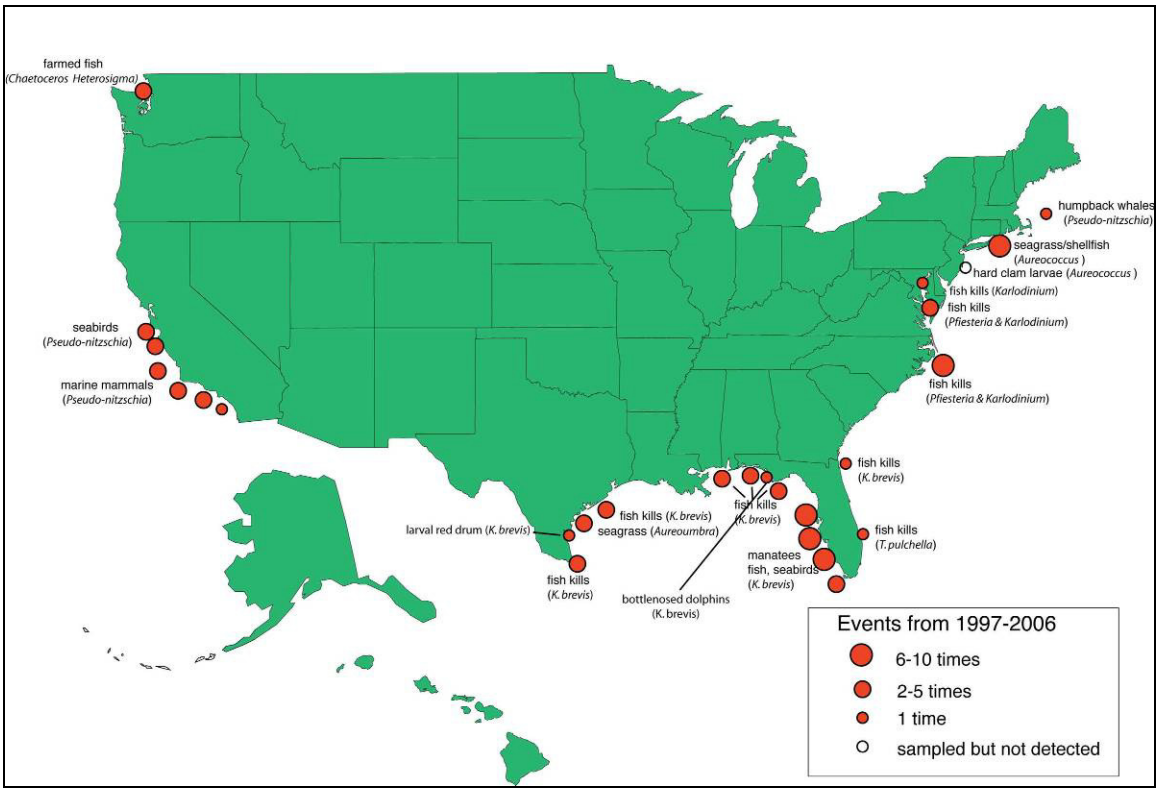
Macroparasites are usually large parasitic organisms and include lungworms, trematodes (parasitic flatworms), and protozoans (Geraci and St. Aubin 1987; Geraci et al. 1999). Marine mammals can carry many different types, and have shown a robust tolerance for sizeable infestation unless compromised by illness, injury, or starvation (Morimitsu et al. 1987; Dailey et al. 1991; Geraci et al., 1999). Nasitrema, a usually benign trematode found in the head sinuses of cetaceans (Geraci et al. 1999), can cause brain damage if it migrates (Ridgway and Dailey 1972). As a result, this worm is one of the few directly linked to stranding in the cetaceans (Dailey and Walker 1978; Geraci et al. 1999).

Non-infectious disease, such as congenital bone pathology of the vertebral column (osteomyelitis, spondylosis deformans, and ankylosing spondylitis [AS]), has been described in several species of cetacean (Paterson 1984; Alexander et al. 1989; Kompanje 1995; Sweeny et al. 2005). In humans, bone pathology such as AS, can impair mobility and increase vulnerability to further spinal trauma (Resnick and Niwayama 2002). Bone pathology has been found in cases of single strandings (Paterson 1984; Kompanje 1995), and also in cetaceans prone to mass stranding (Sweeny et al. 2005), possibly acting as a contributing or causal influence in both types of events.

Naturally Occurring Marine Neurotoxins

Some single cell marine algae common in coastal waters, such as dinoflagellates and diatoms, produce toxic compounds that can accumulate (termed bioaccumulation) in the flesh and organs of fish and invertebrates (Geraci et al. 1999; Harwood 2002). Marine mammals become exposed to these compounds when they eat prey contaminated by these naturally produced toxins although exposure can also occur through inhalation and skin contact (Van Dolah 2005). Figure F-1 shows U.S. animal mortalities from 1997-2006 resulting from toxins produced during harmful algal blooms.

In the Gulf of Mexico and mid- to southern Atlantic states, “red tides,” a form of harmful algal bloom, are created by a dinoflagellate (*Karenia brevis*). *K. brevis* is found throughout the Gulf of Mexico and sometimes along the Atlantic coast (Van Dolah 2005; NMFS 2007). It produces a neurotoxin known as brevetoxin. Brevetoxin has been associated with several marine mammal UMEs within this area (Geraci 1989; Van Dolah et al. 2003; NMFS 2004; Flewelling et al. 2005; Van Dolah 2005; NMFS 2007). On the U.S. West Coast and in the northeast Atlantic, several species of diatoms produce a toxin called domoic acid which has also been linked to marine mammal strandings (Geraci et al. 1999; Van Dolah et al. 2003; Greig et al. 2005; Van Dolah 2005; Brodie et al. 2006; NMFS 2007; Bargu et al. 2008; Goldstein et al. 2008). Other algal toxins associated with marine mammal strandings include saxitoxins and ciguatoxins and are summarized by Van Dolah (2005).



Source: Woods Hole Oceanographic Institute (WHO) http://www.whoi.edu/redtide/HABdistribution/HABmap.html

Figure F-1. Animal Mortalities from Harmful Algal Blooms within the U.S., 1997-2006.

Weather events and climate influences

Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to localized marine mammal strandings (Geraci et al., 1999; Walsh et al. 2001). Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais' beaked whales in North Carolina (Mignucci-Giannoni et al. 2000; Norman and Mead 2001). Storms in 1982-1983 along the California coast led to deaths of 2,000 northern elephant seal pups (Le Boeuf and Reiter 1991). Ice movement along southern Newfoundland has forced groups of blue whales and white-beaked dolphins ashore (Sergeant 1982). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al. 2005).

The effect of large scale climatic changes to the world's oceans and how these changes impact marine mammals and influence strandings is difficult to quantify given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore 2005; Learmonth et al. 2006). The most immediate, although indirect, effect is decreased prey availability during unusual conditions. This, in turn, results in increased search effort required by marine mammals (Crocker et al. 2006), potential starvation if not successful, and corresponding stranding due directly to starvation or succumbing to disease or predation while in a more weakened, stressed state (Selzer and Payne 1988; Geraci et al. 1999; Moore 2005; Learmonth et al. 2006; Weise et al. 2006).

Two recent papers examined potential influences of climate fluctuation on stranding events in southern Australia, including Tasmania, an area with a history of more than 20 mass stranding since the 1920s (Evans et al., 2005; Bradshaw et al. 2006). These authors note that patterns in animal migration, survival, fecundity, population size, and strandings will revolve around the availability and distribution of food

resources. In southern Australia, movement of nutrient-rich waters pushed closer to shore by periodic meridinal winds (occurring about every 12 to 14 years) may be responsible for bringing marine mammals closer to land, thus increasing the probability of stranding (Bradshaw et al. 2006). The papers conclude, however, that while an overarching model can be helpful for providing insight into the prediction of strandings, the particular reasons for each one are likely to be quite varied.

Navigation Error

Geomagnetism - It has been hypothesized that, like some land animals, marine mammals may be able to orient to the Earth's magnetic field as a navigational cue, and that areas of local magnetic anomalies may influence strandings (Bauer et al. 1985; Klinowska 1985; Kirschvink et al. 1986; Klinowska, 1986; Walker et al. 1992; Wartzok and Ketten 1999). In a plot of live stranding positions in Great Britain with magnetic field maps, Klinowska (1985; 1986) observed an association between live stranding positions and magnetic field levels. In all cases, live strandings occurred at locations where magnetic minima, or lows in the magnetic fields, intersect the coastline. Kirschvink et al. (1986) plotted stranding locations on a map of magnetic data for the East Coast of the U.S., and were able to develop associations between stranding sites and locations where magnetic minima intersected the coast. The authors concluded that there were highly significant tendencies for cetaceans to beach themselves near these magnetic minima and coastal intersections. The results supported the hypothesis that cetaceans may have a magnetic sensory system similar to other migratory animals, and that marine magnetic topography and patterns may influence long-distance movements (Kirschvink et al. 1986). Walker et al. (1992) examined fin whale swim patterns off the northeastern U.S. continental shelf, and reported that migrating animals aligned with lows in the geometric gradient or intensity. While a similar pattern between magnetic features and marine mammal strandings at New Zealand stranding sites was not seen (Brabyn and Frew, 1994), mass strandings in Hawaii typically were found to occur within a narrow range of magnetic anomalies (Mazzuca et al. 1999).

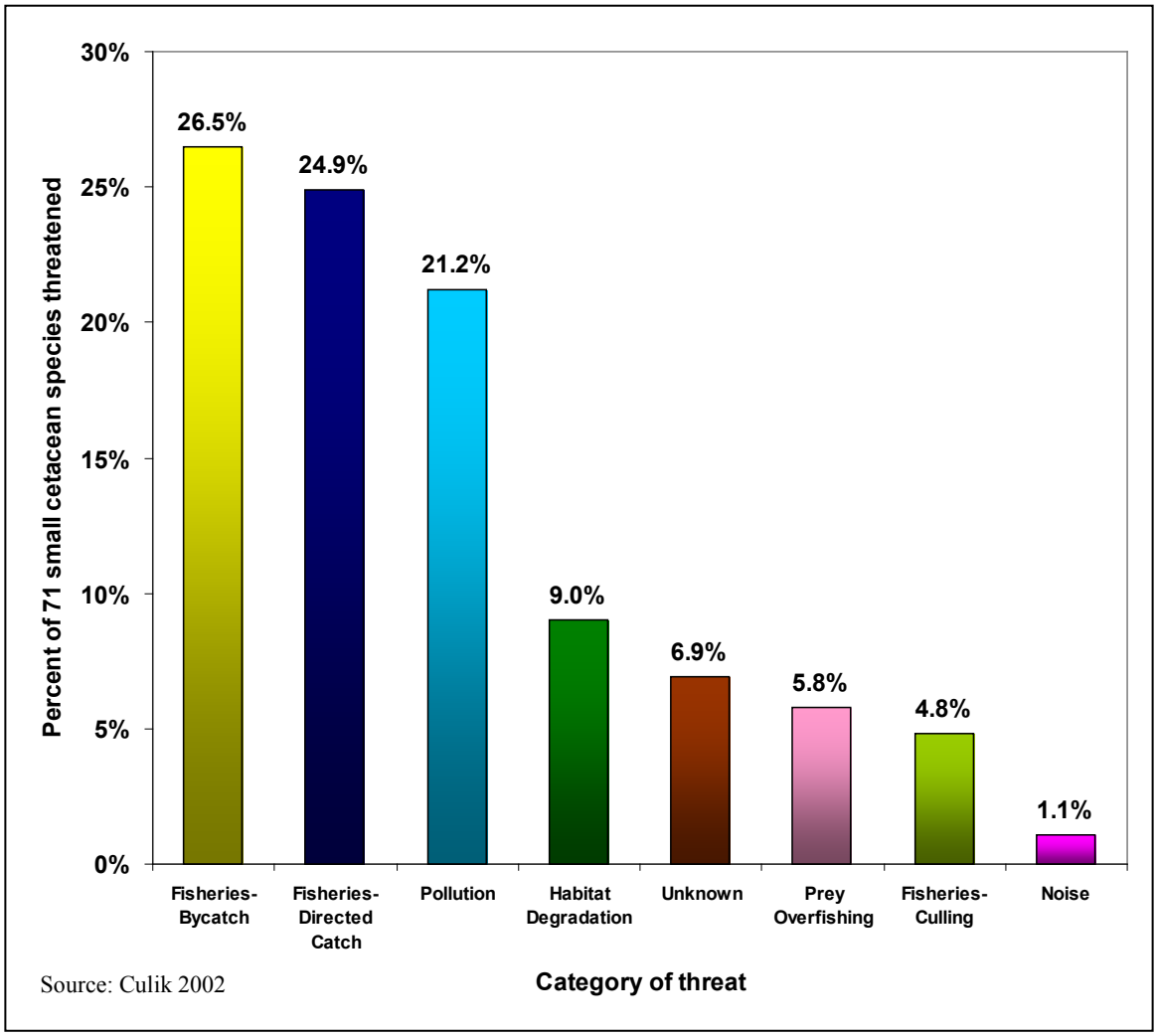
Echolocation Disruption in Shallow Water - Some researchers believe stranding may result from reductions in the effectiveness of echolocation within shallow water, especially with the pelagic species of odontocetes that may be less familiar with coastline (Dudok van Heel 1966; Chambers and James 2005). For an odontocete, echoes from echolocation signals contain important information on the location and identity of underwater objects and the shoreline. The authors postulate that the gradual slope of a beach may present difficulties to the navigational systems of some cetaceans, since it is common for live strandings to occur along beaches with shallow, sandy gradients (Brabyn and McLean, 1992; Mazzuca et al., 1999; Maldini et al., 2005; Walker et al., 2005). A contributing factor to echolocation interference in turbulent, shallow water is the presence of microbubbles from the interaction of wind, breaking waves, and currents. Additionally, ocean water near the shoreline can have an increased turbidity (e.g., floating sand or silt, particulate plant matter, etc.) due to the run-off of fresh water into the ocean, either from rainfall or from freshwater outflows (e.g., rivers and creeks). Collectively, these factors can reduce and scatter the sound energy within echolocation signals and reduce the perceptibility of returning echoes of interest.

Social Cohesion

Many pelagic species such as sperm whale, pilot whales, melon-head whales, and false killer whales, and some dolphins occur in large groups with strong social bonds between individuals. When one or more animals strand due to any number of causative events, then the entire pod may follow suit out of social cohesion (Geraci et al. 1999; Conner 2000; Perrin and Geraci 2002; NMFS 2007).

F.1.4.2 Anthropogenic Stranding Causes and Potential Risks

With the exception of historic whaling in the 19th and early part of the 20th century, over the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al. 1999; NMFS 2007). These include fisheries interactions (bycatch and directed catch), pollution (marine debris, toxic compounds), habitat modification (degradation, prey reduction), direct trauma (vessel strikes, gunshots), and noise. Figure F-2 shows potential worldwide risk to small toothed cetaceans by source.



Source: Culik 2002

Figure F-2. Human Threats to World Wide Small Cetacean Populations

Fisheries Interaction: By-Catch, Directed Catch, and Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al.,1999; Baird 2002; Culik 2002; Carretta et al. 2004; Geraci and Lounsbury 2005; NMFS 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al. 1999; Nieri et al. 1999; Geraci and Lounsbury 2005; Read et al. 2006; Zeeber et al. 2006). For instance, baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded out at sea (Geraci et al. 1999; Campagna et al. 2007).

Bycatch - Bycatch is the catching of non-target species within a given fishing operation and can include non-commercially used invertebrates, fish, sea turtles, birds, and marine mammals (NRC 2006). Read et al. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Data on marine mammal bycatch within the United States was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks, and was then extrapolated to estimate global bycatch by using the ratio of U.S. fishing vessels to the total number of vessels within the world's fleet (Read et al., 2006). Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals, with a standard error of +/- 448 (Read et al., 2006). Eight-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al., 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, which was significantly lower from 1995-1999 than it was from 1990-1994 (Read et al., 2006). Read et al., (2006) suggests that this is primarily due to effective conservation measures that were implemented during this period.

Read et al. (2006) then extrapolated this data for the same time period and calculated an annual estimate of 653,365 of marine mammals globally, with most of the world's bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries is the single greatest threat to many marine mammal populations around the world (Read et al., 2006).

Entanglement - Entanglement in active fishing gear is a major cause of death or severe injury among the endangered whales in the action area. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, manage to be set free either of their own accord, or are set free by fishermen. Many large whales carry off gear after becoming entangled (Read et al., 2006). Many times when a marine mammal swims off with gear attached, the end result can be fatal. The gear may be become too cumbersome for the animal or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies, and the cause of death for many stranded marine mammals is often attributed to such interactions (Baird and Gorgone, 2005). Because marine mammals that die or are injured in fisheries may not wash ashore and because not all animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimate fishery-related mortality and serious injury (NMFS 2005a)

From 1993 through 2003, 1,105 harbor porpoises were reported stranded from Maine to North Carolina, many of which had cuts and body damage suggestive of net entanglement (NMFS 2005e). In 1999 it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions, with one additional animal having been mutilated (right flipper and fluke cut off) (NMFS 2005e). In 2000, one stranded porpoise was found with monofilament line wrapped around its body (NMFS 2005e). In 2003, nine stranded harbor porpoises were attributed to fishery interactions, with an additional three mutilated animals (NMFS 2005e). An estimated 78 baleen whales were killed annually in the offshore Southern California/Oregon drift gillnet fishery during the 1980s (Heyning and Lewis 1990). From 1998-2005, based on observer records, five fin whales (CA/OR/WA stock), 12 humpback whales (ENP stock), and six sperm whales (CA/OR/WA stock) were either seriously injured or killed in fisheries off the mainland West Coast of the U.S. (California Marine Mammal Stranding Network Database 2006).

Ship Strike

Vessel strikes to marine mammals are another cause of mortality and stranding (Laist et al., 2001; Geraci and Lounsbury 2005; de Stephanis and Urquiola, 2006). An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart, 2007).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus, 2001; Laist et al., 2001, Jensen and Silber, 2003; Vanderlaan and Taggart, 2007). In assessing records in which vessel speed was known, Laist et al. (2001) found a direct relationship between the occurrence of a whale strike and the speed of the vessel involved in the collision. The authors concluded that most deaths occurred when a vessel was traveling in excess of 13 knots although most vessels do travel greater than 15 knots. Jensen and Silber (2003) detailed 292 records of known or probable ship strikes of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67 percent) resulted in serious injury or death (19 or 33 percent resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 or 35% resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79 percent) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 percent to 75 % as vessel speed increased from 10 to 14 knots, and exceeded 90% at 17 knots. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne, 1999; Knowlton et al., 1995).

The growth in civilian commercial ports and associated commercial vessel traffic is a result in the globalization of trade. The Final Report of the NOAA International Symposium on "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology" stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to more than 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). Between 1950 and 1998, the U.S. flagged fleet declined from approximately 25,000 to fewer than 15,000 and currently represents only a small portion of the world fleet. From 1985 to 1999, world seaborne trade doubled to 5 billion tons and currently includes 90 percent of the total world trade, with container shipping movements representing the largest volume of seaborne trade. It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall 2005).

While there are reports and statistics of whales struck by vessels in U.S. waters, the magnitude of the risks of commercial ship traffic poses to marine mammal populations is difficult to quantify or estimate. In addition, there is limited information on vessel strike interactions between ships and marine mammals outside of U.S. waters (de Stephanis and Urquiola 2006). Laist et al. (2001) concluded that ship collisions may have a negligible effect on most marine mammal populations in general, except for regional based small populations where the significance of low numbers of collisions would be greater given smaller populations or populations segments.

U.S. Navy vessel traffic is a small fraction of the overall U.S. commercial and fishing vessel traffic. While U.S. Navy vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the U.S. Navy, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of U.S. Navy ships and marine mammals and sea turtles, such as maneuvering to keep away from any observed marine mammal and sea turtle are part of existing

at-sea protocols and standard operating procedures. Navy ships have up to three or more dedicated and trained lookouts as well as two to three bridge watchstanders during at-sea movements who would be searching for any whales, sea turtles, or other obstacles on the water surface. Such lookouts are expected to further reduce the chances of a collision.

Commercial and Private Marine Mammal Viewing

In addition to vessel operations, private and commercial vessels engaged in marine mammal watching also have the potential to impact marine mammals in Southern California. NMFS has promulgated regulations at 50 CFR 224.103, which provide specific prohibitions regarding wildlife viewing activities. In addition, NMFS launched an education and outreach campaign to provide commercial operators and the general public with responsible marine mammal viewing guidelines. In January 2002, NMFS also published an official policy on human interactions with wild marine mammals which states: "NOAA Fisheries cannot support, condone, approve or authorize activities that involve closely approaching, interacting or attempting to interact with whales, dolphins, porpoises, seals, or sea lions in the wild. This includes attempting to swim, pet, touch or elicit a reaction from the animals."

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational, and scientific benefits, marine mammal watching is not without potential negative impacts. One concern is that animals become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. A whale's behavioral response to whale watching vessels depends on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels (Amaral and Carlson 2005; Au and Green 2000; Cockeron 1995; Erbe 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Schedat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale's responses changed with these different variables and, in some circumstances, the whales did not respond to the vessels, but in other circumstances, whales changed their vocalizations surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. In addition to the information on whale watching, there is also direct evidence of pinniped haul out site (Pacific harbor seals) abandonment because of human disturbance at Strawberry Spit in San Francisco Bay (Allen 1991).

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure

For many marine mammals, debris in the marine environment is a great hazard and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS, 2007g). U.S. Navy vessels have a zero-plastic discharge policy and return all plastic waste to appropriate disposition on shore.

There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al. 1999). From 1990 through October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic Coast from New York through the Florida Keys (NMFS 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals (NMFS 2005a). During the same period, 46 dwarf sperm whale strandings occurred along the U.S. Atlantic coastline between Massachusetts and the Florida Keys (NMFS 2005d). In 1987 a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS 2005d). One hundred twenty-five pygmy sperm whales were reported stranded from 1999 to 2003 between Maine and Puerto Rico; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS 2005a).

Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans et al. 2003; Whitehead 2003). While this has led to mortality, the scale to which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time.

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal bio-monitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Contaminants such as organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS, 2007c). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (NMFS, 2007c). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can be toxic causing effects such as reproductive impairment and immunosuppression (NMFS, 2007c).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (NMFS 2005b). For U.S. East Coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification (NMFS 2005b). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (NMFS 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (NMFS 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (NMFS, 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (NMFS 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (NMFS 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, and cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (NMFS 2005b). Population effects resulting from such high contamination levels are currently unknown (NMFS 2005b).

Habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by man have direct and obvious effects on marine mammals, such as oil spills (Geraci et al. 1999). But in most cases, effects of contamination will more than likely be indirect in nature, such as effects on prey species availability, or by increasing disease susceptibility (Geraci et al. 1999).

U.S. Navy vessel operation between ports and exercise locations has the potential for release of small amounts of pollutant discharges into the water column. U.S. Navy vessels are not a typical source, however, of either pathogens or other contaminants with bioaccumulation potential such as pesticides and

PCBs. Furthermore, any vessel discharges such as bilge water and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality.

Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather, are the primary causes of deep-water ambient noise. The ambient noise frequency spectrum can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For example, for frequencies between 100 and 500 Hz, Urick (1983) estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, marine animals (Urick 1983). At any give time and place, the ambient noise is a mixture of all of these noise variables. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sounds levels tend to be higher, than when the bottom is absorptive.

Noise from Aircraft and Vessel Movement

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans and may contribute to over 75 percent of all human sound in the sea (Simmonds and Hutchinson 1996, ICES 2005b). Ross (1976) has estimated that between 1950 and 1975, shipping had caused a rise in ambient noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The National Resource Council (1997) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships. Michel et al. (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with ships.

Sound from a low-flying helicopter or airplane may be heard by marine mammals and turtles while at the surface or underwater. Due to the transient nature of sounds from aircraft involved in at-sea operations, such sounds would not likely cause physical effects but have the potential to affect behaviors. Responses by mammals and turtles could include hasty dives or turns, or decreased foraging (Soto et al., 2006). Whales may also slap the water with flukes or flippers or swim away from the aircraft track.

Sound emitted from large vessels, particularly in the course of transit, is the principal source of noise in the ocean today, primarily due to the properties of sound emitted by civilian cargo vessels (Richardson et al., 1995; Arveson and Vendittis, 2000). Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions contribute to a large vessels' noise emission into the marine environment. Propeller-driven vessels also generate noise through cavitation, which accounts for much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment. Noise emitted by large vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity and length (Richardson et al. 1995; Arveson and Vendittis, 2000). Vessels ranging from 135 to 337 meters generate peak source sound levels from 169

to 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds.

Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away. Unfortunately, it is not always possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a vessel transit through an area.

Vessel noise primarily raises concerns for masking of environmental and conspecific cues. However, exposure to vessel noise of sufficient intensity and/or duration can also result in temporary or permanent loss of sensitivity at a given frequency range, referred to as temporary or permanent threshold shifts (TTS or PTS). Threshold shifts are assumed to be possible in marine mammal species as a result of prolonged exposure to large vessel traffic noise due to its intensity, broad geographic range of effectiveness, and constancy.

Collectively, significant cumulative exposure to individuals, groups, or populations can occur if they exhibit site fidelity to a particular area; for example, whales that seasonally travel to a regular area to forage or breed may be more vulnerable to noise from large vessels compared to transiting whales. Any permanent threshold shift in a marine animal's hearing capability, especially at particular frequencies for which it can normally hear best, can impair its ability to perceive threats, including ships. Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. It is not possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel.

Most observations of behavioral responses of marine mammals to human generated sounds have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Nowacek et al. (2007) provide a detailed summary of cetacean response to underwater noise.

Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers away (Ross, 1976 in Polefka, 2004). U.S. Navy vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (compared to a similarly sized vessel) in order to reduce their vulnerability to detection by enemy passive acoustics (Southall, 2005). Therefore, the potential for TTS or PTS from U.S. Navy vessel and aircraft movement is extremely low given that the exercises and training events are transitory in time, with vessels moving over large area of the ocean. A marine mammal or sea turtle is unlikely to be exposed long enough at high levels for TTS or PTS to occur. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a U.S. Navy vessel transiting through an area. If behavioral disruptions result from the presence of aircraft or vessels, it is expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors without any threat to their survival or reproduction. However, if an animal is aware of a vessel and dives or swims away, it may successfully avoid being struck.

F.1.5 Stranding Events Associated with Navy Sonar

There are two classes of sonars employed by the U.S. Navy: active sonars and passive sonars. Most active military sonars operate in a limited number of areas, and are most likely not a significant contributor to a comprehensive global ocean noise budget (ICES, 2005b).

The effects of mid-frequency active naval sonar on marine wildlife have not been studied as extensively as the effects of air-guns used in seismic surveys (Madsen et al., 2006; Stone and Tasker, 2006; Wilson et al., 2006; Palka and Johnson, 2007; Parente et al., 2007). Maybaum (1989, 1993) observed changes in behavior of humpbacks during playback tapes of the M-1002 system (using 203 dB re 1 µPa-m for study); specifically, a decrease in respiration, submergence, and aerial behavior rates; and an increase in speed of travel and track linearity. Direct comparison of Maybaum's results, however, with U.S Navy mid-frequency active sonar are difficult to make. Maybaum's signal source, the commercial M-1002, operated differently from naval mid-frequency sonar. In addition, behavioral responses were observed during playbacks of a control tape, (i.e. a tape with no sound signal) so interpretation of Maybaum's results are inconclusive.

Research by Nowacek, et al. (2004) on North Atlantic right whales using a whale alerting signal designed to alert whales to human presence suggests that received sound levels of only 133 to 148 pressure level (decibel [dB] re 1 microPascals [µPa]) for the duration of the sound exposure may disrupt feeding behavior. The authors did note, however, that within minutes of cessation of the source, a return to normal behavior would be expected. Direct comparison of the Nowacek et al. (2004) sound source to MFA sonar, however, is not possible given the radically different nature of the two sources. Nowacek et al.'s source was a series of non-sonar like sounds designed to purposely alert the whale, lasting several minutes, and covering a broad frequency band. Direct differences between Nowacek et al. (2004) and MFA sonar is summarized below from Nowacek et al. (2004) and Nowacek et al. (2007):

(1) Signal duration: Time difference between the two signals is significant, 18-minute signal used by Nowacek et al. versus < 1 sec for MFA sonar.

(2) Frequency modulation: Nowacek et al. contained three distinct signals containing frequency modulated sounds:

1st - alternating 1-sec pure tone at 500 and 850 Hz

2nd - 2-sec logarithmic down-sweep from 4500 to 500 Hz

3rd - pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz

(3) Signal-to-noise ratio: Nowacek et al.'s signal maximized signal-to noise-ratio so that it would be distinct from ambient noise and resist masking.

(4) Signal acoustic characteristics: Nowacek et al.'s signal comprised of disharmonic signals spanning northern right whales' estimated hearing range.

Given these differences, therefore, the exact cause of apparent right whale behavior noted by the authors can not be attributed to any one component since the source was such a mix of signal types.

The effects of naval sonars on marine wildlife have not been studied as extensively as have the effects of airguns used in seismic surveys (Nowacek et al., 2007). In the Caribbean, sperm whales were observed to interrupt their activities by stopping echolocation and leaving the area in the presence of underwater sounds surmised to have originated from submarine sonar signals (Watkins and Schevill, 1975; Watkins et al., 1985). The authors did not report receive levels from these exposures, and also got a similar reaction from artificial noise they generated by banging on their boat hull. It was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Madsen et al. (2006) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm (4 to 13 km) away from the whales and based on multipath propagation RLs were as high as 162 dB re 1 uPa with energy content greatest between 0.3

and 3.0 kHz. Sperm whales engaged in foraging dives continued the foraging dives throughout exposures to these seismic pulses. In the Caribbean Sea, sperm whales avoided exposure to mid-frequency submarine sonar pulses, in the range 1000 Hz to 10,000 Hz (IWC 2005). Sperm whales have also moved out of areas after the start of air gun seismic testing (Davis et al. 1995). In contrast, during playback experiments off the Canary Islands, André et al. (1997) reported that foraging sperm whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions.

The Navy sponsored tests of the effects of low-frequency active (LFA) sonar source, between 100 Hz and 1000 Hz, on blue, fin, and humpback whales. The tests demonstrated that whales exposed to sound levels up to 155 dB did not exhibit significant disturbance reactions, though there was evidence that humpback whales altered their vocalization patterns in reaction to the noise. Given that the source level of the Navy's LFA is reported to be in excess of 215 dB, the possibility exists that animals in the wild may be exposed to sound levels much higher than 155 dB.

Acoustic exposures have been demonstrated to kill marine mammals and result in physical trauma, and injury (Ketten 2005). Animals in or near an intense noise source can die from profound injuries related to shock wave or blast effects. Acoustic exposures can also result in noise induced hearing loss that is a function of the interactions of three factors: sensitivity, intensity, and frequency. Loss of sensitivity is referred to as a threshold shift; the extent and duration of a threshold shift depends on a combination of several acoustic features and is specific to particular species (TTS or PTS, depending on how the frequency, intensity and duration of the exposure combine to produce damage). In addition to direct physiological effects, noise exposures can impair an animal's sensory abilities (masking) or result in behavioral responses such as aversion or attraction (see Section 3.19).

Acoustic exposures can also result in the death of an animal by impairing its foraging, ability to detect predators or communicate, or by increasing stress, and disrupting important physiological events. Whales have moved away from their feeding and mating grounds (Bryant *et al*., 1984; Morton and Symnods, 2002; Weller et al., 2002), moved away from their migration route (Richardson et al., 1995), and have changed their calls due to noise (Miller et al., 2000). Acoustic exposures such as MFA sonar tend to be infrequent and temporary in nature. In situations such as the alteration of gray whale migration routes in response to shipping and whale watching boats, those acoustic exposures were chronic over several years (Moore and Clarke 2002). This was also true of the effect of seismic survey airguns (daily for 39 days) on the use of feeding areas by gray whales in the western North Pacific although whales began returning to the feeding area within one day of the end of the exposure (Weller et al. 2002).

Below are evaluations of the general information available on the variety of ways in which cetaceans and pinnipeds have been reported to respond to sound, generally, and mid-frequency sonar, in particular.

The Navy is very concerned and coordinates with NMFS as they thoroughly investigate each marine mammal stranding potentially associated with Navy activities to better understand the events surrounding strandings (Norman 2006). Strandings can involve a single animal or several to hundreds. An event where animals are found out of their normal habitat may be considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 "Hanalei Mass Stranding Event"; Southall et al., 2006). Several hypotheses have been given for the mass strandings which include the impact of shallow beach slopes on odontocete sonar, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and human actions. Generally, inshore species do not strand in large numbers but generally just as a single animal. This may be due to their familiarity with the coastal area whereas pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings, 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors, including

bathymetry (i.e., steep drop offs), narrow channels (less than 35 nm), environmental conditions (e.g., surface ducting), and multiple sonar ships were compared between the different stranding events.

When a marine mammal swims or floats onto shore and becomes "beached" or stuck in shallow water, it is considered a "stranding" (MMPA section 410 (16 USC section 1421g); NMFS, 2007a). NMFS explains that "a cetacean is considered stranded when it is on the beach, dead or alive, or in need of medical attention while free-swimming in U.S. waters. A pinniped is considered to be stranded either when dead or when in distress on the beach and not displaying normal haul-out behavior" (NMFS, 2007b).

Over the past three decades, several "mass stranding" events [strandings involving two or more individuals of the same species (excluding a single cow-calf pair) and at times, individuals from different species] that have occurred have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment (Canary Islands, Greece, Vieques, U.S. Virgin Islands, Madeira Islands, Haro Strait, Washington State, Alaska, Hawaii, North Carolina).

Information was collected on mass stranding events (events in which two or more cetaceans stranded) that have occurred and for which reports are available, from the past 40 years. Any causal agents that have been associated with those stranding events were also identified. Major range events undergo name changes over the years, however, the equivalent of COMPTUEX and JTFEX have been conducted in southern California since 1934. Training involving sonar has been conducted since World War II and sonar systems described in the SOCAL EIS/OEIS since the 1970's (Jane's 2005).

F.1.6 Stranding Analysis

Over the past two decades, several mass stranding events involving beaked whales have been documented. While beaked whale strandings have been reported since the 1800s (Geraci and Lounsbury, 1993; Cox et al., 2006; Podesta et al., 2006), several mass strandings since have been associated with naval operations that may have included mid-frequency sonar (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Jepson et al., 2003; Cox et al., 2006). As Cox et al. (2006) concludes, the state of science can not yet determine if a sound source such as mid-frequency sonar alone causes beaked whale strandings, or if other factors (acoustic, biological, or environmental) must co-occur in conjunction with a sound source.

A review of historical data (mostly anecdotal) maintained by the Marine Mammal Program in the National Museum of Natural History, Smithsonian Institution reports 49 beaked whale mass stranding events between 1838 and 1999. The largest beaked whale mass stranding occurred in the 1870s in New Zealand when 28 Gray's beaked whales (*Mesoplodon grayi*) stranded. Blainsville's beaked whale (*Mesoplodon densirostris*) strandings are rare, and records show that they were involved in one mass stranding in 1989 in the Canary Islands. Cuvier's beaked whales (*Ziphius cavirostris*) are the most frequently reported beaked whale to strand, with at least 19 stranding events from 1804 through 2000 (DoC and DoN, 2001; Smithsonian Institution, 2000).

The discussion below centers on those worldwide stranding events that may have some association with naval operations, and global strandings that the U.S. Navy feels are either inconclusive or can not be associated with naval operations.

F.1.6.1 Naval Association

In the following sections, specific stranding events that have been putatively linked to potential sonar operations are discussed. Of note, these events represent a small number of animals over an 11-year period (40 animals), and not all worldwide beaked whale strandings can be linked to naval activity (ICES

2005a; 2005b; Podesta et al., 2006). Four of the five events occurred during NATO exercises or events where U.S. Navy presence was limited (Greece, Portugal, Spain). One of the five events involved only U.S. Navy ships (Bahamas).

Beaked whale stranding events associated with potential naval operations.

1996 May	Greece (NATO)
2000 March	Bahamas (US)
2000 May	Portugal, Madeira Islands (NATO/US)
2002 September	Spain, Canary Islands (NATO/US)
2006 January	Spain, Mediterranean Sea coast (NATO/US)

Case Studies of Stranding Events (coincidental with or implicated with naval sonar)

1996 Greece Beaked Whale Mass Stranding (May 12 – 13, 1996)

Description: Twelve Cuvier's beaked whales (*Ziphius cavirostris*) stranded along a 38.2-kilometer strand of the coast of the Kyparissiakos Gulf on May 12 and 13, 1996 (Frantzis, 1998). From May 11 through May 15, the NATO research vessel Alliance was conducting sonar tests with signals of 600 Hz and 3 kHz and root-mean-squared (rms) sound pressure levels (SPL) of 228 and 226 dB re: 1µPa, respectively (D'Amico and Verboom, 1998; D'Spain et al., 2006). The timing and the location of the testing encompassed the time and location of the whale strandings (Frantzis, 1998).

Findings: Partial necropsies of eight of the animals were performed, including external assessments and the sampling of stomach contents. No abnormalities attributable to acoustic exposure were observed, but the stomach contents indicated that the whales were feeding on cephalopods soon before the stranding event. No unusual environmental events before or during the stranding event could be identified (Frantzis, 1998).

Conclusions: The timing and spatial characteristics of this stranding event were atypical of stranding in Cuvier's beaked whale, particularly in this region of the world. No natural phenomenon that might contribute to the stranding event coincided in time with the mass stranding. Because of the rarity of mass strandings in the Greek Ionian Sea, the probability that the sonar tests and stranding coincided in time and location, while being independent of each other, was estimated as being extremely low (Frantzis, 1998). However, because information for the necropsies was incomplete and inconclusive, the cause of the stranding cannot be precisely determined.

2000 Bahamas Marine Mammal Mass Stranding (March 15-16, 2000)

Description: Seventeen marine mammals - Cuvier's beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), minke whale (*Balaenoptera acutorostrata*), and one spotted dolphin (*Stenella frontalis*), stranded along the Northeast and Northwest Providence Channels of the Bahamas Islands on March 15-16, 2000 (Evans and England, 2001). The strandings occurred over a 36-hour period and coincided with U.S. Navy use of mid-frequency active sonar within the channel. Navy ships were involved in tactical sonar exercises for approximately 16 hours on March 15. The ships, which operated the AN/SQS-53C and AN/SQS-56, moved through the channel while emitting sonar pings approximately every 24 seconds. The timing of pings was staggered between ships and average source levels of pings varied from a nominal 235 dB SPL (AN/SQS-53C) to 223 dB SPL (AN/SQS-56). The center frequency of pings was 3.3 kHz and 6.8 to 8.2 kHz, respectively.

Seven of the animals that stranded died, while ten animals were returned to the water alive. The animals known to have died included five Cuvier's beaked whales, one Blainville's beaked whale, and the single spotted dolphin. Six necropsies were performed and three of the six necropsied animals (one Cuvier's beaked whale, one Blainville's beaked whale, and the spotted dolphin) were fresh enough to permit identification of pathologies by computerized tomography (CT). Tissues from the remaining three animals were in a state of advanced decomposition at the time of inspection.

Findings: The spotted dolphin demonstrated poor body condition and evidence of a systemic debilitating disease. In addition, since the dolphin stranding site was isolated from the acoustic activities of Navy ships, it was determined that the dolphin stranding was unrelated to the presence of Navy active sonar.

All five necropsied beaked whales were in good body condition and did not show any signs of external trauma or disease. In the two best preserved whale specimens, hemorrhage was associated with the brain and hearing structures. Specifically, subarachnoid hemorrhage within the temporal region of the brain and intracochlear hemorrhages were noted. Similar findings of bloody effusions around the ears of two other moderately decomposed whales were consistent with the same observations in the freshest animals. In addition, three of the whales had small hemorrhages in their acoustic fats, which are fat bodies used in sound production and reception (i.e., fats of the lower jaw and the melon). The best-preserved whale demonstrated acute hemorrhage within the kidney, inflammation of the lung and lymph nodes, and congestion and mild hemorrhage in multiple other organs. Other findings were consistent with stresses and injuries associated with the stranding process. These consisted of external scrapes, pulmonary edema and congestion.

Conclusions: The post-mortem analyses of stranded beaked whales lead to the conclusion that the immediate cause of death resulted from overheating, cardiovascular collapse and stresses associated with being stranded on land. However, subarachnoid and intracochlear hemorrhages were believed to have occurred prior to stranding and were hypothesized as being related to an acoustic event. Passive acoustic monitoring records demonstrated that no large scale acoustic activity besides the Navy sonar exercise occurred in the times surrounding the stranding event. The mechanism by which sonar could have caused the observed traumas or caused the animals to strand was undetermined. The spotted dolphin was in overall poor condition for examination, but showed indications of long-term disease. No analysis of baleen whales (minke whale) was conducted. Baleen whale stranding events have not been associated with either low-frequency or mid-frequency sonar use (ICES 2005a, 2005b).

2000 Madeira Island, Portugal Beaked Whale Strandings (May 10 – 14, 2000)

Description: Three Cuvier's beaked whales stranded on two islands in the Madeira Archipelago, Portugal, from May 10 to 14, 2000 (Cox et al., 2006). A joint NATO amphibious training exercise, named "Linked Seas 2000," which involved participants from 17 countries, took place in Portugal during May 2 to 15, 2000. The timing and location of the exercises overlapped with that of the stranding incident.

Findings: Two of the three whales were necropsied. Two heads were taken to be examined. One head was intact and examined grossly and by CT; the other was only grossly examined because it was partially flensed and had been seared from an attempt to dispose of the whale by fire (Ketten, 2005).

No blunt trauma was observed in any of the whales. Consistent with prior CT scans of beaked whales stranded in the Bahamas 2000 incident, one whale demonstrated subarachnoid and peribullar hemorrhage and blood within one of the brain ventricles. Post-cranially, the freshest whale demonstrated renal congestion and hemorrhage, which was also consistent with findings in the freshest specimens in the Bahamas incident.

Conclusions: The pattern of injury to the brain and auditory system were similar to those observed in the Bahamas strandings, as were the kidney lesions and hemorrhage and congestion in the lungs (Ketten, 2005). The similarities in pathology and stranding patterns between these two events suggested a similar causative mechanism. Although the details about whether or how sonar was used during "Linked Seas 2000" is unknown, the presence of naval activity within the region at the time of the strandings suggested a possible relationship to Navy activity.

2002 Canary Islands Beaked Whale Mass Stranding (September 24, 2002)

Description: On September 24, 2002, 14 beaked whales stranded on Fuerteventura and Lanzaote Islands in the Canary Islands (Jepson et al., 2003). Seven of the 14 whales died on the beach and the 7 were returned to the ocean. Four beaked whales were found stranded dead over the next three days either on the coast or floating offshore (Fernández et al., 2005). At the time of the strandings, an international naval exercise (Neo-Tapon 2002) that involved numerous surface warships and several submarines was being conducted off the coast of the Canary Islands. Tactical mid-frequency active sonar was utilized during the exercises, and strandings began within hours of the onset of the use of mid-frequency sonar (Fernández et al., 2005).

Findings: Eight Cuvier's beaked whales, one Blainville's beaked whale, and on Gervais' beaked whale were necropsied; six of them within 12 hours of stranding (Fernández et al. 2005). The stomachs of the whales contained fresh and undigested prey contents. No pathogenic bacteria were isolated from the whales, although parasites were found in the kidneys of all of the animals. The head and neck lymph nodes were congested and hemorrhages were noted in multiple tissues and organs, including the kidney, brain, ears, and jaws. Widespread fat emboli were found throughout the carcasses, but no evidence of blunt trauma was observed in the whales. In addition, the parenchyma of several organs contained macroscopic intravascular bubbles and lesions, putatively associated with nitrogen off-gassing.

Conclusions: The association of NATO mid-frequency sonar use close in space and time to the beaked whale strandings, and the similarity between this stranding event and previous beaked whale mass strandings coincident with sonar use, suggests that a similar scenario and causative mechanism of stranding may be shared between the events. Beaked whales stranded in this event demonstrated brain and auditory system injuries, hemorrhages, and congestion in multiple organs, similar to the pathological findings of the Bahamas and Madeira stranding events. In addition, the necropsy results of the Canary Islands stranding event lead to the hypothesis that the presence of disseminated and widespread gas bubbles and fat emboli were indicative of nitrogen bubble formation, similar to what might be expected in decompression sickness (Jepson et al., 2003; Fernández et al., 2005). Whereas gas emboli would develop from the nitrogen gas, fat emboli would enter the blood stream from ruptured fat cells (presumably where nitrogen bubble formation occurs) or through the coalescence of lipid bodies within the blood stream.

The possibility that the gas and fat emboli found by Fernández et al. (2005) was due to nitrogen bubble formation has been hypothesized to be related to either direct activation of the bubble by sonar signals or to a behavioral response in which the beaked whales flee to the surface following sonar exposure. The first hypothesis is related to rectified diffusion (Crum and Mao, 1996), the process of increasing the size of a bubble by exposing it to a sound field. This process is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard, 1979). Deeper and longer dives of some marine mammals, such as those conducted by beaked whales, are theoretically predicted to induce greater levels of supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness. It is unlikely that the brief duration of

sonar pings would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable bubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario the marine mammal would need to be in a gas-supersaturated state long enough for bubbles to become of a problematic size. The second hypothesis speculates that rapid ascent to the surface following exposure to a startling sound might produce tissue gas saturation sufficient for the evolution of nitrogen bubbles (Jepson et al. 2003; Fernández et al. 2005). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation. Tyack et al. (2006) showed that beaked whales often make rapid ascents from deep dives suggesting that it is unlikely that beaked whales would suffer from decompression sickness. Zimmer and Tyack (2007) speculated that if repetitive shallow dives that are used by beaked whales to avoid a predator or a sound source, they could accumulate high levels of nitrogen because they would be above the depth of lung collapse (above about 210 feet) and could lead to decompression sickness. There is no evidence that beaked whales dive in this manner in response to predators or sound sources and other marine mammals such as Antarctic and Galapagos fur seals, and pantropical spotted dolphins make repetitive shallow dives with no apparent decompression sickness (Kooyman and Trillmich, 1984; Kooyman et al., 1984; Baird et al., 2001).

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann, 2004). Sound exposure levels predicted to cause in vivo bubble formation within diving cetaceans have not been evaluated and are suspected as needing to be very high (Evans, 2002; Crum et al., 2005). Moore and Early (2004) reported that in analysis of sperm whale bones spanning 111 years, gas embolism symptoms were observed indicating that sperm whales may be susceptible to decompression sickness due to natural diving behavior. Further, although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Jepson et al. 2003), there is no conclusive evidence supporting this hypothesis and there is concern that at least some of the pathological findings (e.g., bubble emboli) are artifacts of the necropsy. Currently, stranding networks in the United States have agreed to adopt a set of necropsy guidelines to determine, in part, the possibility and frequency with which bubble emboli can be introduced into marine mammals during necropsy procedures (Arruda et al., 2007).

2006 Spain, Gulf of Vera Beaked Whale Mass Stranding (26-27 January 2006)

Description: The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26 to 28, 2006, on the southeast coast of Spain near Mojacar (Gulf of Vera) in the Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of January 27, a few kilometers north of the first three animals.

From January 25-26, 2006, a NATO surface ship group (seven ships including one U.S. ship under NATO operational command) conducted active sonar training against a Spanish submarine within 50 nm of the stranding site.

Findings: Veterinary pathologists necropsied the two male and two female beaked whales (*Z. cavirostris*).

Conclusions: According to the pathologists, a likely cause of this type of beaked whale mass stranding event may have been anthropogenic acoustic activities. However, no detailed pathological results

confirming this supposition have been published to date, and no positive acoustic link was established as a direct cause of the stranding.

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas, 2004):

- Operations were conducted in areas of at least 1000 meters in depth near a shoreline where there is a rapid change in bathymetry on the order of 1000 to 6000 meters occurring a cross a relatively short horizontal distance (Freitas, 2004).

- Multiple ships, in this instance, five MFA sonar equipped vessels, were operating in the same area over extended periods (20 hours) in close proximity.

- Exercises took place in an area surrounded by landmasses, or in an embayment. Operations involving multiple ships employing mid-frequency active sonar near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas, 2004).

F.1.6.2 Other Global Stranding Discussions

In the following sections, stranding events that have been linked to U.S. Navy activity in popular press are presented. As detailed in the individual case study conclusions, the U.S. Navy believes there is enough evidence available to refute allegations of impacts from mid-frequency sonar, or at least indicate a substantial degree of uncertainty in time and space that precludes a meaningful scientific conclusion.

Case Studies of Stranding Events

2003 Washington State Harbor Porpoise Strandings (May 2 – June 2 2003)

Description: At 1040 hours on May 5, 2003, the USS SHOUP began the use of mid-frequency tactical active sonar as part of a naval exercise. At 1420, the USS SHOUP entered the Haro Strait and terminated active sonar use at 1438, thus limiting active sonar use within the strait to less than 20 minutes. Between May 2 and June 2, 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and one Dall's porpoise (*Phocoenoides dalli*) were reported to the Northwest Marine Mammal Stranding Network. A comprehensive review of all strandings and the events involving USS SHOUP on May 5, 2003 were presented in U.S. Department of Navy (2004). Given that the USS SHOUP was known to have operated sonar in the strait on May 5, and that supposed behavioral reactions of killer whales (*Orcinus orca*) had been putatively linked to these sonar operations (NMFS Office of Protected Resources, 2005), NMFS undertook an analysis of whether sonar caused the strandings of the harbor porpoises.

Whole carcasses of ten harbor porpoises and the head of an additional porpoise were collected for analysis. Necropsies were performed on ten of the porpoises and six whole carcasses, and two heads were selected for CT imaging. Gross examination, histopathology, age determination, blubber analysis, and various other analyses were conducted on each of the carcasses (Norman et al., 2004).

Findings: Post-mortem findings and analysis details are found in Norman et al. (2004). All of the carcasses suffered from some degree of freeze-thaw artifact that hampered gross and histological evaluations. At the time of necropsy, three of the porpoises were moderately fresh, whereas the remainder of the carcasses was considered to have moderate to advanced decomposition. None of the 11 harbor porpoises demonstrated signs of acoustic trauma. In contrast, a putative cause of death was determined for five of the porpoises; two animals had blunt trauma injuries and three animals had indication of disease processes (fibrous peritonitis, salmonellosis, and necrotizing pneumonia). A cause of death could not be determined in the remaining animals, which is consistent with expected percentage of marine mammal

necropsies conducted within the Northwest region. It is important to note, however, that these determinations were based only on the evidence from the necropsy to avoid bias with regard to determinations of the potential presence or absence of acoustic trauma. The result was that other potential causal factors, such as one animal (Specimen 33NWR05005) found tangled in a fishing net, was unknown to the investigators in their determination regarding the likely cause of death.

Conclusions: NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al., 2004). In this regard, it is important to note that the number of strandings in the May-June timeframe in 2003 was also higher for the outer coast indicating a much wider phenomena than use of sonar by USS SHOUP in Puget Sound for one day in May. The conclusion by NMFS that the number of strandings in 2003 was higher is also different from that of The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne, 2003). According to The Whale Museum, the number of strandings as of May 15, 2003, was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992 the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997 there were 12 strandings in the San Juan Islands with more than 30 strandings throughout the general Puget Sound area. Disregarding the discrepancy in the historical rate of porpoise strandings and its relation to the USS SHOUP, NMFS acknowledged that the intense level of media attention focused on the strandings likely resulted in an increased reporting effort by the public over that which is normally observed (Norman et al., 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings."

Seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on May 5, 2003. Of these seven, one, discovered on May 5, 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined, most likely, to be salmonella septicemia. Another porpoise, discovered at Port Angeles on May 6, 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS SHOUP's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered one to three weeks after the USS SHOUP's May 5 transit of the Haro Strait, making it difficult to causally link the sonar activities of the USS SHOUP to the timing of the strandings. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al. 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

Additionally, it has become clear that the number of harbor porpoise strandings in the Northwest increased beginning in 2003 and through 2006. Figure F-3 shows the number of strandings documented in the Northwest for harbor porpoises. On November 3, 2006, a UME in the Pacific Northwest was declared. In 2006, a total of 66 harbor porpoise strandings were reported in the Outer Coast of Oregon and Washington and Inland waters of Washington (NOAA Fisheries, 2006; NOAA Fisheries, Northwest Region, 2006a).

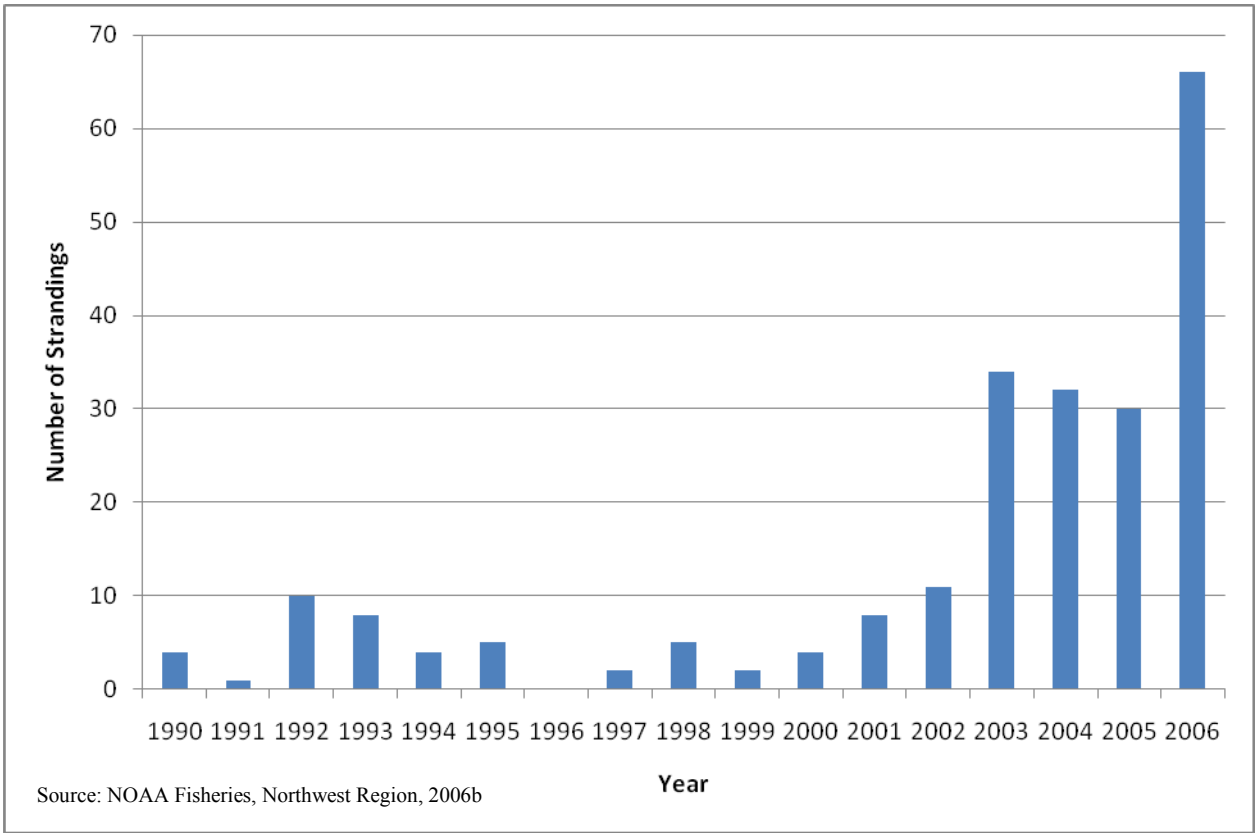


Figure F-3. Northwest Region Harbor Porpoise Strandings 1990 – 2006

The speculative association of the harbor porpoise strandings to the use of sonar by the USS SHOUP is inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events, the stranding of whales occurred over a short period of time (less than 36 hours), stranded individuals were spatially co-located, traumas in stranded animals were consistent between events, and active sonar was known or suspected to be in use. Although mid-frequency active sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that mid-frequency active sonar was a cause of harbor porpoise strandings. Rather, a complete lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, further supports the conclusion that harbor porpoise strandings were unrelated to the sonar activities of the USS SHOUP.

Additional allegations regarding USS SHOUP use of sonar having caused behavioral effects to Dall's porpoise, orca, and a minke whale also arose in association with this event (see U.S. Department of Navy 2004 for a complete discussion).

Dall's porpoise: Information regarding the observation of Dall's porpoise on May 5, 2003 came from the operator of a whale watch boat at an unspecified location. This operator reported the Dall's porpoise were seen "going north" when the SHOUP was estimated by him to be 10 miles away. Potential reasons for the Dall's movement include the pursuit of prey, the presence of harassing resident orca or predatory transient orca, vessel disturbance from one of many whale watch vessels, or multiple other unknowable reasons including the use of sonar by SHOUP. In short, there was nothing unusual in the observed behavior of the Dall's porpoise on May 5, 2003 and no way to assess if the otherwise normal behavior was in reaction to the use of sonar by USS SHOUP, any other potential causal factor or a combination of factors.

Orca: Observer opinions regarding orca J-Pod behaviors on 5 May 2003 were inconsistent, ranging from the orca being "at ease with the sound" or "resting" to their being "annoyed." One witness reported observing "low rates of surface active behavior" on behalf of the orca J-Pod, which is in conflict with that of another observer who reported variable surface activity, tail slapping and spyhopping. Witnesses also expressed the opinion that the behaviors displayed by the orca on 5 May 2003 were "extremely unusual," although those same behaviors are observed and reported regularly on the Orca Network Website, are behaviors listed in general references as being part of the normal repertoire of orca behaviors. Given the contradictory nature of the reports on the observed behavior of the J-Pod orca, there is no way to assess if any unusual behaviors were present or if present they were in reaction to vessel disturbance from one of many nearby whale watch vessels, use of sonar by SHOUP, any other potential causal factor, or a combination of factors.

Minke whale: A minke whale was reported porpoising in Haro Strait on May 5, 2003, which is a rarely observed behavior. The cause of this behavior is indeterminate given multiple potential causal factors including but not limited to the presence of predatory Transient orca, possible interaction with whale watch boats, other vessels, or SHOUP's use of sonar. Given the existing information, there is no way to be certain if the unusual behavior observed was in reaction to the use of sonar by SHOUP, any other potential causal factor or a combination of factors.

2004 Alaska Beaked Whale Strandings (Northern Edge Exercise, 7-16 June 2004)

Description: Between 27 June and 19 July 2004, five beaked whales were discovered at various locations along 1,600 miles of the Alaskan coastline and one was found floating (dead) at sea. These whales included three Baird's beaked whales and two Cuvier's beaked whales. Questions and comments posed on previous Navy environmental documents have alleged that sonar use may have been the cause of these strandings in association with the Navy Alaska Shield/Northern Edge exercise, which occurred June 7 to June 16, 2004 (within the approximate timeframe of these strandings).

Findings: Information regarding the strandings is incomplete as the whales had been dead for some time before they were discovered. The stranded beaked whales were in moderate to advanced states of decomposition and necropsies were not performed. Additionally, prior to the Navy conducting the Alaska Shield/Northern Edge exercise, two Cuvier's beaked whales were discovered stranded at two separate locations along the Alaskan coastline (February 26 at Yakutat and June 1 at Nuka Bay).

Zimmerman (1991) reported that between 1975 and 1987, 11 species of cetaceans were found stranded in Alaska seven or more times, including 29 Stejneger's beaked whales, 19 Cuvier's beaked whales, and 8 Baird's beaked whales. Cuvier's beaked whales have been found stranded from the eastern Gulf of Alaska to the western Aleutians. Baird's beaked whales were found stranded as far north as the area between Cape Pierce and Cape Newenham, east near Kodiak, and along the Aleutian Islands. (Zimmerman, 1991). In short, however, the stranding of beaked whales in Alaska is a relatively uncommon occurrence (as compared to other species).

Conclusions: The at-sea portion of the Alaska Shield/Northern Edge 2004 exercise consisted mainly surface ships and aircraft tracking a vessel of interest followed by a vessel boarding search and seizure event. There was no ASW component to the exercise, no use of mid-frequency sonar, and no use of explosives in the water. There were no events in the Alaska Shield/Northern Edge exercise that could have caused or been related to any of the strandings over this 33 day period along 1,600 miles of coastline.

2004 Hawai'i Melon-Headed Whale Unusual Milling Event (July 3-4 2004)

Description: The majority of the following information is taken from the NMFS report (which referred to the event as a "mass stranding event"; Southall et al., 2006) but includes additional and new information not presented in the NMFS report. On the morning of July 3, 2004, between 150 and 200 melon-headed whales (*Peponocephala electra*) entered Hanalei Bay, Kauai. Individuals attending a canoe blessing ceremony observed the animals entering the bay at approximately 7:00 a.m. The whales were reported entering the bay in a "wave as if they were chasing fish" (Braun 2006). At 6:45 a.m. on July 3, 2004, approximately 25 nm north of Hanalei Bay, active sonar was tested briefly prior to the start of an anti-submarine warfare exercise.

The whales stopped in the southwest portion of the bay, grouping tightly, and displayed spy-hopping and tail-slapping behavior. As people went into the water among the whales, the pod separated into as many as four groups, with individual animals moving among the clusters. This continued through most of the day, with the animals slowly moving south and then southeast within the bay. By about 3 p.m., police arrived and kept people from interacting with the animals. The Navy believes that the abnormal behavior by the whales during this time is likely the result of people and boats in the water with the whales rather than the result of sonar activities taking place 25 or more miles off the coast. At 4:45 p.m. on July 3, 2004, the RIMPAC Battle Watch Captain received a call from a National Marine Fisheries representative in Honolulu, Hawaii, reporting the sighting of as many as 200 melon-headed whales in Hanalei Bay. At 4:47 p.m. the Battle Watch Captain directed all ships in the area to cease active sonar transmissions.

At 7:20 p.m. on July 3, 2004, the whales were observed in a tight single pod 75 yards from the southeast side of the bay. The pod was circling in a group and displayed frequent tail slapping and whistle vocalizations and some spy hopping. No predators were observed in the bay and no animals were reported as having fresh injuries. The pod stayed in the bay through the night of July 3, 2004. On the morning of July 4, 2004, the whales were observed to still be in the bay and collected in a tight group. A decision was made at that time to attempt to herd the animals out of the bay. A 700-to-800-foot rope was constructed by weaving together beach morning glory vines. This vine rope was tied between two canoes and with the assistance of 30 to 40 kayaks, was used to herd the animals out of the bay. By approximately 11:30 a.m. on July 4, 2004, the pod was coaxed out of the bay.

A single neonate melon-headed whale was observed in the bay on the afternoon of July 4, after the whale pod had left the bay. The following morning on July 5, 2004, the neonate was found stranded on Lumahai Beach. It was pushed back into the water but was found stranded dead between 9 and 10 a.m. near the Hanalei pier. NMFS collected the carcass and had it shipped to California for necropsy, tissue collection, and diagnostic imaging.

Following the unusual milling event, NMFS undertook an investigation of possible causative factors of the event. This analysis included available information on environmental factors, biological factors, and an analysis of the potential for sonar involvement. The latter analysis included vessels that utilized mid-frequency active sonar on the afternoon and evening of July 2. These vessels were to the southeast of Kauai, on the opposite side of the island from Hanalei Bay.

Findings: NMFS concluded from the acoustic analysis that the melon-headed whales would have had to have been on the southeast side of Kauai on July 2 to have been exposed to sonar from naval vessels on that day (Southall et al. 2006). There was no indication whether the animals were in that region or whether they were elsewhere on July 2. NMFS concluded that the animals would have had to swim from 1.4-4.0 m/s for 6.5 to 17.5 hours after sonar transmissions ceased to reach Hanalei Bay by 7:00 a.m. on July 3. Sound transmissions by ships to the north of Hanalei Bay on July 3 were produced as part of exercises between 6:45 a.m. and 4:47 p.m. Propagation analysis conducted by the 3rd Fleet estimated that

the level of sound from these transmissions at the mouth of Hanalei Bay could have ranged from 138-149 dB re: 1 μPa.

NMFS was unable to determine any environmental factors (e.g., harmful algal blooms, weather conditions) that may have contributed to the stranding. However, additional analysis by Navy investigators found that a full moon occurred the evening before the stranding and was coupled with a squid run (Mobley 2007). One of the first observations of the whales entering the bay reported the pod came into the bay in a line "as if chasing fish" (Braun, 2005). In addition, a group of 500 to700 melon-headed whales were observed to come close to shore and interact with humans in Sasanhaya Bay, Rota, on the same morning as the whales entered Hanalei Bay (Jefferson et al. 2006). Previous records further indicated that, though the entrance of melon-headed whales into the shallows is rare, it is not unprecedented. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to that which occurred at Hanalei Bay in 2004.

The necropsy of the melon-headed whale calf suggested that the animal died from a lack of nutrition, possibly following separation from its mother. The calf was estimated to be approximately one week old. Although the calf appeared not to have eaten for some time, it was not possible to determine whether the calf had ever nursed after it was born. The calf showed no signs of blunt trauma or viral disease and had no indications of acoustic injury.

Conclusions: Although it is not impossible, it is unlikely that the sound level from the sonar caused the melon-headed whales to enter Hanalei Bay. This conclusion is based on a number of factors:

1. The speculation that the whales may have been exposed to sonar the day before and then fled to the Hanalei Bay is not supported by reasonable expectation of animal behavior and swim speeds. The flight response of the animals would have had to persist for many hours following the cessation of sonar transmissions. Such responses have not been observed in marine mammals and no documentation exists that such persistent flight response after the cessation of a frightening stimulus has been observed in other mammals. The swim speeds, though feasible for the species, are highly unlikely to be maintained for the durations proposed, particularly since the pod was a mixed group containing both adults and neonates. Whereas adults may maintain a swim speed of 4.0 m/s for some time, it is improbable that a neonate could achieve the same for a period of many hours.

2. The area between the islands of Oahu and Kauai and the Pacific Missile Range Facility training range have been used in RIMPAC exercises for more than 30 years, and are used year-round for ASW training with mid frequency active sonar. Melon-headed whales inhabiting the waters around Kauai are likely not naive to the sound of sonar and there has never been another stranding event associated in time with ASW training at Kauai. Similarly, the waters surrounding Hawaii contain an abundance of marine mammals, many of which would have been exposed to the same sonar operations that were speculated to have affected the melon-headed whales. No other strandings were reported coincident with the RIMPAC exercises. This leaves it uncertain as to why melon-headed whales, and no other species of marine mammal, would respond to the sonar exposure by stranding.

3. At the nominal swim speed for melon-headed whales, the whales had to be within 1.5 to 2 nm of Hanalei Bay before sonar was activated on July 3. The whales were not in their open ocean habitat but had to be close to shore at 6:45 a.m. when the sonar was activated to have been observed inside Hanalei Bay from the beach by 7 a.m. (Hanalei Bay is very large area). This observation suggests that other potential factors could have caused the event (see below).

4. The simultaneous movement of 500 to 700 melon-headed whales and Risso's dolphins into Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the 2004 Hanalei stranding (Jefferson et al., 2006) suggests that there may be a common factor which prompted the melon-headed

whales to approach the shoreline. A full moon occurred the evening before the stranding and a run of squid was reported concomitant with the lunar activity (Mobley et al. 2007). Thus, it is possible that the melon-headed whales were capitalizing on a lunar event that provided an opportunity for relatively easy prey capture (Mobley et al. 2007). A report of a pod entering Hilo Bay in the 1870s indicates that on at least one other occasion, melon-headed whales entered a bay in a manner similar to the occurrence at Hanalei Bay in July 2004. Thus, although melon-headed whales entering shallow embayments may be an infrequent event, and every such event might be considered anomalous, there is precedent for the occurrence.

5. The received noise sound levels at the bay were estimated to range from roughly 95 to 149 dB re: 1 μPa. Received levels as a function of time of day have not been reported, so it is not possible to determine when the presumed highest levels would have occurred and for how long. However, received levels in the upper range would have been audible by human participants in the bay. The statement by one interviewee that he heard "pings" that lasted an hour and that they were loud enough to hurt his ears is unreliable. Received levels necessary to cause pain over the duration stated would have been observed by most individuals in the water with the animals. No other such reports were obtained from people interacting with the animals in the water.

Although NMFS concluded that sonar use was a "plausible, if not likely, contributing factor in what may have been a confluence of events (Southall et al. 2006)," this conclusion was based primarily on the basis that there was an absence of any other compelling explanation. The authors of the NMFS report on the incident were unaware, at the time of publication, of the simultaneous event in Rota. In light of the simultaneous Rota event, the Hanalei event does not appear as anomalous as initially presented and the speculation that sonar was a causative factor is weakened. The Hanalei Bay incident does not share the characteristics observed with other mass strandings of whales coincident with sonar activity (e.g., specific traumas, species composition, etc.). In addition, the inability to conclusively link or exclude the impact of other environmental factors makes a causal link between sonar and the melon-headed whale event highly speculative at best.

1980- 2004 Beaked Whale Strandings in Japan (Brownell et al. 2004)

Description: Brownell et al. (2004) compare the historical occurrence of beaked whale strandings in Japan (where there are U.S. Naval bases), with strandings in New Zealand (which lacks a U.S. Naval base) and concluded the higher number of strandings in Japan may be related to the presence of the US. Navy vessels using mid-frequency sonar. While the dates for the strandings were well documented, the authors of the study did not attempt to correlate the dates of any navy activities or exercises with those stranding dates.

To fully investigate the allegation made by Brownell et al. (2004), the Center for Naval Analysis (CNA) in an internal Navy report, looked at past U.S. Naval exercise schedules from 1980 to 2004 for the water around Japan in comparison to the dates for the strandings provided by Brownell et al. (2004). None of the strandings occurred during or soon (within weeks) after any U.S. Navy exercises. While the CNA analysis began by investigating the probabilistic nature of any co-occurrences, the strandings and sonar use were not correlated by time. Given that there was no instance of co-occurrence in over 20 years of stranding data, it can be reasonably postulated that sonar use in Japan waters by U.S. Navy vessels did not lead to any of the strandings documented by Brownell et al. (2004).

2005 North Carolina Marine Mammal Mass Stranding Event (January 15-16, 2005)

Description: On January 15 and 16, 2005, 36 marine mammals consisting of 33 short-finned pilot whales, one minke whale, and two dwarf sperm whales stranded alive on the beaches of North Carolina (Hohn et al., 2006a). The animals were scattered across a 111-km area from Cape Hatteras northward. Because of

the live stranding of multiple species, the event was classified as a UME. It is the only stranding on record for the region in which multiple offshore species were observed to strand within a two- to three-day period.

The U.S. Navy indicated that from January 12-14 some unit level training with mid-frequency active sonar was conducted by vessels that were 93 to 185 km from Oregon Inlet. An expeditionary strike group was also conducting exercises to the southeast, but the closest point of active sonar transmission to the inlet was 650 km away. The unit level operations were not unusual for the area or time of year and the vessels were not involved in antisubmarine warfare exercises. Marine mammal observers on board the vessels did not detect any marine mammals during the period of unit level training. No sonar transmissions were made on January 15-16.

The National Weather Service reported that a severe weather event moved through North Carolina on January 13 and 14. The event was caused by an intense cold front that moved into an unusually warm and moist air mass that had been persisting across the eastern United States for about a week. The weather caused flooding in the western part of the state, considerable wind damage in central regions of the state, and at least three tornadoes that were reported in the north central part of the state. Severe, sustained (one to four days) winter storms are common for this region.

Over a two-day period (January 16-17), two dwarf sperm whales, 27 pilot whales, and the minke whale were necropsied and tissue samples collected. Twenty-five of the stranded cetacean heads were examined; two pilot whale heads and the heads of the dwarf sperm whales were analyzed by CT.

Findings: The pilot whales and dwarf sperm whale were not emaciated, but the minke whale, which was believed to be a dependent calf, was emaciated. Many of the animals were on the beach for an extended period of time prior to necropsy and sampling, and many of the biochemical abnormalities noted in the animals were suspected of being related to the stranding and prolonged time on land. Lesions were observed in all of the organs, but there was no consistency across species. Musculoskeletal disease was observed in two pilot whales and cardiovascular disease was observed in one dwarf sperm whale and one pilot whale. Parasites were a common finding in the pilot whales and dwarf sperm whales but were considered consistent with the expected parasite load for wild odontocetes. None of the animals exhibited traumas similar to those observed in prior stranding events associated with mid-frequency sonar activity. Specifically, there was an absence of auditory system trauma and no evidence of distributed and widespread bubble lesions or fat emboli, as was previously observed (Fernández et al., 2005).

Sonar transmissions prior to the strandings were limited in nature and did not share the concentration identified in previous events associated with mid-frequency active sonar use (Evans and England, 2001). The operational/environmental conditions were also dissimilar (e.g., no constrictive channel and a limited number of ships and sonar transmissions). NMFS noted that environmental conditions were favorable for a shift from up-welling to down-welling conditions, which could have contributed to the event. However, other severe storm conditions existed in the days surrounding the strandings and the impact of these weather conditions on at-sea conditions is unknown. No harmful algal blooms were noted along the coastline.

Conclusions: All of the species involved in this stranding event are known to occasionally strand in this region. Although the cause of the stranding could not be determined, several whales had preexisting conditions that could have contributed to the stranding. Cause of death for many of the whales was likely due to the physiological stresses associated with being stranded. A consistent suite of injuries across species, which was consistent with prior strandings where sonar exposure is expected to be a causative mechanism, was not observed.

NMFS was unable to determine any causative role that sonar may have played in the stranding event. The acoustic modeling performed, as in the Hanalei Bay incident, was hampered by uncertainty regarding the location of the animals at the time of sonar transmissions. However, as in the Hanalei Bay incident, the response of the animals following the cessation of transmissions would imply a flight response that persisted for many hours after the sound source was no longer operational. In contrast, the presence of a severe weather event passing through North Carolina during January 13 and 14 is a possible, if not likely, contributing factor to the North Carolina UME of January 15. Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais' beaked whales in North Carolina (Mignucci-Giannoni et al. 2000; Norman and Mead 2001).

F.1.6.3 Causal Associations for Stranding Events

Several stranding events have been associated with Navy sonar activities but relatively few of the total stranding events that have been recorded occurred spatially or temporally with Navy sonar activities. While sonar may be a contributing factor under certain rare conditions, the presence of sonar it is not a necessary condition for stranding events to occur. In established range areas such as those in Hawaii and Southern California where sonar use has been routine for decades, there is no evidence of impacts from sonar use on marine mammals.

A review of past stranding events associated with sonar suggest that the potential factors that may contribute to a stranding event are steep bathymetry changes, narrow channels, multiple sonar ships, surface ducting and the presence of beaked whales that may be more susceptible to sonar exposures. The most important factors appear to be the presence of a narrow channel (e.g. Bahamas and Madeira Island, Portugal) that may prevent animals from avoiding sonar exposure and multiple sonar ships within that channel. There are no narrow channels (less than 35 nm wide and 10 nm in length) in the MAA and the ships would be spread out over a wider area allowing animals to move away from sonar activities if they choose. In addition, beaked whales may not be more susceptible to sonar but may favor habitats that are more conducive to sonar effects. There have been no mass strandings in GOA attributed to Navy sonar during any of the prior Northern Edge exercises or as the result of ay Navy sonar use.

F.1.7 Stranding Section Conclusions

Marine mammal strandings have been a historic and ongoing occurrence attributed to a variety of causes. Over the last 50 years, increased awareness and reporting has lead to more information about species effected and raised concerns about anthropogenic sources of stranding. While there has been some marine mammal mortalities potentially associated with mid-frequency sonar effects to a small number of species (primarily limited numbers of certain species of beaked whales), the significance and actual causative reason for any impacts is still subject to continued investigation.

By comparison and as described previously, potential impacts to all species of cetaceans worldwide from fishery related mortality can be orders of magnitude more significant (100,000s of animals versus tens of animals) (Culik, 2002; ICES, 2005b; Read et al., 2006). This does not negate the influence of any mortality or additional stressor to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distribution or migrations. ICES (2005a) noted, however, that taken in context of marine mammal populations in general, sonar is not a major threat, nor is it a significant portion of the overall ocean noise budget.

In conclusion, a constructive framework and continued research based on sound scientific principles is needed in order to avoid speculation as to stranding causes, and to further our understanding of potential effects or lack of effects from military mid-frequency sonar (Bradshaw et al., 2005; ICES, 2005b; Barlow and Gisiner, 2006; Cox et al., 2006).

F.2 REFERENCES

Alexander, J. W., M.A. Solangi, and L.S. Riegel. 1989. Vertebral osteomyelitis and suspected diskospondylitis in an Atlantic bottlenose dolphin (*Tursiops truncatus*). Journal of Wildife Diseases. 25:118-121.

André, M., M. Terada, and Y. Watanabe. 1997. Sperm Whale (*Physeter macrocephalus*) Behavioral Response after the Playback of Artificial Sounds. Reports of the International Whaling Commission. 47:499-504.

Arruda, J., A. Costidis, S.Cramer, D.R. Ketten, W. McLellan, E.W. Montie, M. Moore, and S. Rommel. 2007. Odontocete Salvage, Necropsy, Ear Extraction, and Imaging Protocols, edited by N.M. Young (Ocean Research, Conservation and Solutions (ORCAS) and ONR), 171 pp.

Arveson, P.T. and D.J. Vendittis. 2000. Radiated noise characteristics of a modern cargo ship. Journal of the Acoustic Society of America. 107:118-129.

Au, W.W.L. and M. Green, 2000. Acoustic interaction of humpback whales and whale-watching boats. Marine Environmental Research 49:469-481.

Baird, R.W. 2001. The status of the harbour seal *Phoca vitulina* in Canada. Canadian Field-Naturalist 115: 663-675.

Baird, R.W. and A.M. Gorgone. 2005. False Killer Whale Dorsal Fin Disfigurements as a Possible Indicator of Long-Line Fishery Interactions in Hawaiian Waters. Pacific Science. 59:593-601.

Bargu, S., C.L. Powell, Z. Wang, G.J. Doucette, and M.W. Silverc. 2008. Note on the occurrence of *Pseudo-nitzschia australis* and domoic acid in squid from Monterey Bay, CA (USA). Harmful Algae. 7:45-51.

Bauer, G.B., M. Fuller, A. Perry, J.R. Dunn, and J. Zoeger. 1985. Magnetoreception and biomineralization of magnetite in cetaceans. IN: J.L. Kirschvink, D.S. Jones and B.J. MacFadden, eds. Magnetite Biomineralization and Magnetoreception in Organisms. Plenum Press, New York. pp. 489-507.

Borell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. Marine Pollution Bulletin. 26:146-151.

Brabyn, M.W. and I.G. McLean. 1992. Oceanography and Coastal Topography of Herd-Stranding Sites for Whales in New Zealand. Journal of Mammalogy. 73:469-476.

Brabyn, M.W. and R.V.C. Frew. 1994. New Zealand Herd Stranding Sites Do Not Relate to Geomagnetic Topography. Marine Mammal Science. 10:195-207.

Bradshaw, C.J.A., K. Evans and M.A. Hindell. 2006. Mass Cetacean Strandings—a Plea for Empiricism. Conservation Biology. 20:584-586.

Braun, R. 2005. Robert Braun, DVM., description of the Hanalai Bay melon-headed whale unusual event on 4 July, 2004, sent to Robert Brownell, NOAA-NMFS.

Brownell, J., R.L., T. Yamada, J.G. Mead and A.L. van Helden. 2004. Mass Strandings of Cuvier's Beaked Whales in Japan: U.S. Naval Acoustic Link? Unpublished Report to the Scientific Committee of the International Whaling Commission. Sorrento, Italy. SC/56E37: 10 pp.

Campagna, C., V. Falabella and M. Lewis. 2007. Entanglement of southern elephant seals in squid fishing gear. Marine Mammal Science. 23:414-418.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, and M.M. Muto. 2007. U.S. Pacific Marine Mammal Stock Assessments: 2007. US Department of Commerce, NOAA Technical Memorandum, NMFS-SWFSC-414. 320 pp.

Chambers, S. and R.N. James. 2005. Sonar termination as a cause of mass cetacean strandings in Geographe Bay, south-western Australia. Acoustics 2005, Acoustics in a Changing Environment. Proceedings of the Annual Conference of the Australian Acoustical Society, November 9 - 11, 2005, Busselton, Western Australia.

Clyne, H. 1999. Computer simulations of interactions between the North Atlantic right whale (*Eubalaena glacialis*) and shipping.

Cockcroft, V.G., G. Cliff, and G.J.B. Ross. 1989. Shark predation on Indian Ocean bottlenose dolphins *Tursiops truncatus* off Natal, South Africa. South African Journal of Zoology. 24:305-310.

Constantine, R., I. Visser, D. Buurman, R. Buurman, and B. McFadden. 1998. Killer whale (*Orcinus orca*) predation on dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. Marine Mammal Science. 14:324-330.

Cox, T. M., T. J. Ragen, A. J. Read, E. Vos, R. W. Baird, K. C. Balcomb, J. Barlow, J. Caldwell, T. W. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. A. Hildebrand, D. Houser, T. Hullar, P. D. Jepson, D. R. Ketten, C. D. MacLeod, P. Miller, S. E. Moore, D. C. Mountain, D. L. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. L. Tyack, D. Wartzok, R. Gisiner, J. G. Mead and L. Benner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Management and Research. 7:177–187.

Crum, L.A., and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Journal of the Acoustical Society of America. 99:2898-2907.

Crum, L.A., M.R. Bailey, J. Guan, P.R. Hilmo, S.G. Kargl, T.J. Matula and O.A. Sapozhnikov. 2005. Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects. Acoustics Research Letters Online. 6:214-220.

D'Spain, G.L., A.D'Amico, and D.M. Fromm. 2006. Properties of the underwater sound fields during some well documented beaked whale mass stranding events. Journal of Cetacean Research and Management. 7:223-238.

Daily, M.D. and W.A. Walker. 1978. Parasitism as a factor. ?) in single strandings of southern California cetaceans. Journal of Parasitology 64:593-596.

Dailey, M., M. Walsh, D. Odell and T. Campbell. 1991. Evidence of prenatal infection in the bottlenose dolphin. *Tursiops truncatus*) with the lungworm. *Halocercus lagenorhynchi*. Nematoda: Pseudaliidae. Journal of Wildlife Diseases. 27:164-165.

De Stephanis, R. and E. Urquiola. 2006. Collisions between ships and cetaceans in Spain, Report to the Scientific Committee of the International Whaling Commission Annual Meeting St Kitts SC/58/BC5: 6 pp.

Department of Commerce and Department of the Navy. 2001. Joint Interim Report, Bahamas Marine Mammal Stranding Event of 15-16 March 2000. December.

Department of the Navy (DoN). 1997. Environmental Impact Statement for Shock Testing the Seawolf Submarine.

DoN. 1998. Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine. U.S. Department of the Navy, Southern Division, Naval Facilities ngineering Command, North Charleston, SC, 637 pp.

DoN. 1999. Environmental Assessment/Overseas Environmental Assessment of the SH-60R Helicopter/ALFS Test Program, October.

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

DoN. 2001b. Final Environmental Impact Statement for the North Pacific Acoustic Laboratory. Volumes I and II, Department of the Navy.

DoN. 2001c. Final Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Department of the Navy, Chief of Naval Operations. January 2001.

DoN. 2002a. Marine resource assessment for the Cherry Point Operating Area. Contract Number N62470-95-D-1160. Prepared for the Commander, U.S. Atlantic Fleet, Norfolk, Virginia by Geo-Marine, Inc., Plano, Texas.

Department of the Navy. 2002b. National Oceanic and Atmospheric Administration/National Marine Fisheries Service, Taking Marine Mammals Incidental to Navy Operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar; Final Rule. Federal Register: July 16, 2002 (Volume 67, Number 136, Page 46711-46789).

DoN. 2004. Department of the Navy, Commander U.S. Pacific Fleet. Report on the results of the inquiry into allegations of marine mammal impacts surrounding the use of active sonar by USS SHOUP (DDG 86) in the Haro Strait on or about 5 May 2003. 9 February 2004.

DoN. 2005a. Marine Resources Assessment for the Hawaiian Islands Operating Area, Draft Report, Department of the Navy, Commander. U.S. Pacific Fleet . July.

DoN. 2005b. Draft Overseas Environmental Impact Statement/Environmental Impact Statement (OEIS/EIS), Undersea Warfare Training Range. Department of the Navy, Commander, U.S. Atlantic Fleet.

DoN. 2006a. 2006 Supplement to the 2002 RIMPAC Programmatic Environmental Assessment. Department of the Navy, Commander, Third Fleet.

DoN. 2006b. Undersea Warfare Exercise (USWEX) EA/OEA. Department of the Navy, Commander, Third Fleet.

DoN. 2007. Department of the Navy, Chief of Naval Operations. Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. May 2007.

DoN. 2008. Department of the Navy, Chief of Naval Operations. Final Environmental Impact Statement/Overseas Environmental Impact Statement , Hawaii Range Complex. May 2008.

Department of Navy/Department of Commerce. 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 15-16 March 2000. D.L. Evans, U.S. Dept. of Commerce, Secretary; G.R. England, Secretary of the Navy. December, 2001.

Domingo, M., M. Vilafranca, J. Vista, N. Prats, A. Trudgett, and I. Visser. 1992. Pathologic and immunocytochemical studies of morbillivirus infection in striped dolphin. *Stenella coeruleoalba*. Veterinary Pathology 29:1-10.

Dudok van Heel, W.H. 1966. Navigation in Cetaceans. IN: K.S. Norris, eds. Whales, Dolphins, and Porpoises. University of California Press, Berkeley, CA. pp. 597-606.

Dunn, J.L., J.D. Buck, and T.R. Robeck. 2001. Bacterial diseases of cetaceans and pinnipeds. IN: L.A. Dierauf and F.M.D. Gulland, eds. CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton, FL.

Evans, K., R. Thresher, R.M. Warneke, C.J.A. Bradshaw, M. Pook, D. Thiele and M.A. Hindell. 2005. Periodic variability in cetacean strandings: links to large-scale climate events. Biology Letter. 1:147-150.

Fernández, A., J.F. Edwards, F. Rodreguez, A. Espinosa de los Monteros, P. Herreez, P. Castro, J. R. Jaber, V. Marten and M. Arbelo. 2005. Gas and Fat Embolic Syndrome Involving a Mass Stranding of Beaked Whales. Family Ziphiidae) Exposed to Anthropogenic Sonar Signals. Veterinary Pathology. 42:446-457.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature. 392:29.

Freitas, L. 2004. The stranding of three Cuvier's beaked whales *Ziphius caviostris* in Madeira archipelago- May 2000. European Cetacean Society Newsletter 42(Special Issue):28-32.

Geraci, J. R. 1989. Clinical investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. central and south Atlantic coast. Final report to the National Marine Fisheries Service, U. S. Navy, Office of Naval Research, and Marine Mammal Commission: 63.

Geraci, J.R. and V.J. Lounsbury. 1993. Marine Mammals Ashore: A Field Guide for Strandings. Texas A&M University Sea Grant College Program, Galveston, TX.

Geraci, J. R. and V.J. Lounsbury. 2005. Marine Mammals Ashore: A Field Guide for Strandings (Second Edition) National Aquarium in Baltimore, Baltimore, MD.

Geraci, J. R. and S. H. Ridgway. 1991. On disease transmission between cetaceans and humans. Marine Mammal Science. 7:191-194.

Geraci, J.R. and D.J. St. Aubin. 1987. Effects of parasites on marine mammals. International Journal of Parasitology. 17:407-414.

Geraci, J.R., J. Harwood and V.J. Lounsbury. 1999. Marine Mammal Die-offs: Causes, Investigations, and Issues. IN: J.R. Twiss and R.R. Reeves, eds., Conservation and Management of Marine Mammals. Washington, DC, Smithsonian Institution Press: 367-395.

Goldstein, T.2, J.A. K. Mazet, T.S. Zabka, G. Langlois, K.M. Colegrove, M. Silver, S. Bargu, F. Van Dolah, T. Leighfield, P.A. Conrad, J. Barakos, D.C. Williams, S. Dennison, M. Haulena, and F.M.D. Gulland. 2008. Novel symptomatology and changing epidemiology of domoic acid toxicosis in California sea lions (*Zalophus californianus*): an increasing risk to marine mammal health. Proceedings of the Royal Society B. 275:267–276.

Grachev, M.A. V.P. Kumarev, L.Mamaev, V.L. Zorin, L.V. Baranova, N.N. Denikina, S.I. Belikov, E.A. Petrov, V.S. Kolesnik, R.S. Kolesnik, V.M. Dorofeev, A.M.Beim, V.N. Kudelin, F.G. Nagieva, and V.N. Sidorov. 1989. Distemper virus in Baikal seals. Nature 338:209.

Greig, D. J., F. M. D. Gulland and C. Kreuder. 2005. A decade of live California sea lion. *Zalophus californianus*) strandings along the central California coast: Causes and trends, 1991-2000. Aquatic Mammals 31:11-22.

Gulland, F.M.D. 2006. Review of the Marine Mammal Unusual Mortality Event Response Program of the National Marine Fisheries Service. Report to the Office of Protected Resources, NOAA/National Marine Fisheries Service, Silver Springs, MD. 32 pp.

Gulland, F.M.D. and A.J. Hall. 2005. The Role of Infectious Disease in Influencing Status and Trends. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. Marine Mammal Research. John Hopkins University Press, Baltimore. pp. 47-61.

Harwood, J. 2002. Mass Die-offs. IN: W.F. Perrin, B. Würsig and J.G.M. Thewissen. Encyclopedia of Marine Mammals. Academic Press, San Diego: pp. 724-726.

Heithaus, M.R. 2001. Shark attacks on bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Western Australia: Attack rate, bite scar frequencies and attack seasonality. Marine Mammal Science. 17:526-539.

Heyning, J.E. and T.D. Lewis. 1990. Entanglements of baleen whales in fishing gear of southern California, Report to the International Whaling Commission. 40:427-431.

Hohn, A.A., D.S. Rotstein, C.A. Harms and B.L. Southall. 2006. Report on marine mammal unusual mortality event UMESE0501Sp: Multispecies mass stranding of pilot whales. *Globicephala macrorhynchus*), minke whale. B*alaenoptera acutorostrata*), and dwarf sperm whales. *Kogia sima*) in North Carolina on 15-16 January 2005: 222 pp.

Houser, D.S., R. Howard, and S. Ridgway. 2001. Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals? Journal of Theoretical Biology. 213, 183-195.

Houser, D.S., D.A. Helweg, and P.W.B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals. 27:82–91.

International Council for the Exploration of the Seas (ICES). 2005a. Ad-Hoc Group on the Impact of Sonar on Cetaceans- By Correspondence, International Council for the Exploration of the Seas. (ICES) CM 2006/ACE: 25 pp.

ICES. 2005b. Answer to DG Environment request on scientific information concerning impact of sonar activities on cetacean populations. International Council for the Exploration of the Sea. 5 pp.

Jefferson, T. A., S. K. Hung and P. K. S. Lam. 2006. Strandings, mortality and morbidity of Indo-Pacific humpback dolphins in Hong Kong, with emphasis on the role of organochlorine contaminants. Journal of Cetacean Management and Research. 8:181-193.

Jefferson, T.A., D. Fertl, M. Michael, and T.D. Fagin. 2006. An unusual encounter with a mixed school of melon-headed whales (*Peponocephala electra*) and rough-toothed dolphins (*Steno bredanesis*) at Rota, Northern Mariana Islands. Micronesica. 38:239-244.

Jensen, A.S. and G.K. Silber. 2004. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25, January 2004.

Jensen, A.S. and G.K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA National Marine Fisheries Service Technical Memorandum. NMFS-OPR-25. 37 pp.

Jepson, P. D., M. Arbelo, R.Deaville, I. A. P. Patterson, P. Castro, J. R. Bakers, E. Degollada, H. M. Ross, P. Herraez, A. M. Pocknell, F.Rodriguez, F. E. Howie, A. Espinsoa, R. J. Reid, J. R. Jaber, V.Martin, A. A. Cunningham and A. Fernandez. 2003. Gas-bubble lesions in stranded cetaceans. Nature. 425:575-576.

Jepson, P. D., R. Deaville, T. Patterson, J. R. Baker, H. R. Ross, A. Pocknell, F. Howie, R. J. Reid and A. A. Cunningham. 2003. Novel cetacean gas bubble injuries: acoustically induced decompression sickness? Marine Mammals and Sound: 17th Conference of the European Cetacean Society, Las Palmas de Gran Canaria, Gobierno De Canarias Consejeria De Politica Territorial Y Medio Ambiente Viceconsejería De Medio Ambiente Dirección General de Política Ambiental.

Kennedy, S., T. Kuiken, P.D. Jepson, R. Deaville, M. Forsyth, T. Barrett, M.W.G. vande Bildt, A.D.M.E. Osterhaus, T. Eybatov, C. Duck, A. Kydyrmanov, I. Mitrofanov, and S. Wilson. 2000. Mass die-off of Caspian seals caused by canine distemper virus. Emerging Infectious Diseases. 6:637-639.

Ketten, D. 2005. Beaked whale necropsy findings for strandings in the Bahamas, Puerto Rico, and Madeira, 1999-2002. Woods Hole Oceanographic Institution, Woods Hole, MA. Pp. 36.

Kirshvink, J.L., A.E. Dizon, and J.A. Westphal. 1986. Evidence from strandings for geomagnetic sensitivity in cetaceans. Journal of Experimental Biology. 120:1-24.

Klinowska, M. 1985. Cetacean Live Stranding Sites Relate to Geomagnetic Topography. Aquatic Mammals. 11:27-32.

Klinowska, M. 1986. Cetacean Live Stranding Dates Relate to Geomagnetic Disturbances. Aquatic Mammals. 11:109-119.

Knowlton, A.R., and Kraus, S.D. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. Journal of Cetacean Research and Management (Special Issue). 2:193-208.

Knowlton, A.R., F.T. Korsmeyer, J.E. Kerwin, H.Y.Wu, and B. Hynes. 1995. The hydrodynamic effects of large vessels on right whales. Final Report to NOAA Fisheries. NMFS Contract No. 40EANFF400534. 81 p.

Kompanje, E.J.O. 1995. On the occurrence of spondylosis deformans in white-beaked dolphins *Lagenorhynchus albirostris* (Gray, 1846) stranded on the Dutch coast. Zooligische Mededekingen Leiden. 69:231-250.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science. 17:35–75.

Le Boeuf, B.J. and J. Reiter. 1991. Biological effects associated with El Nino Southern Oscillation, 1982-83 on northern elephant seals breeding at Ano Nuevo, California. IN: F. Trillmich and K.A. Ono, eds. Pinnipeds and El Nino: Responses to Environmental Stress, Springer-Verlag, Berlin. Pp. 206-218.

Learmonth, J.A., C.D. MacLeod, M.B. Santos, G.J. Pierce, H.Q.P. Crick and R.A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology. 44:431-464.

Madsen, P.T., M.A. Johnson, P.J. Miller, A.N. Soto, J. Lynch, and P.L. Tyack. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustic Society of America. 120:2366-2379.

Magalhães, S.; Prieto, R.; Silva, M.A.; Gonçalves, J.; Afonso-Dias, M. & Santos, R.S. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. Aquatic Mammals, 28(3): 267-274.

Maldini, D., L. Mazzuca and S. Atkinson. 2005. Odontocete Stranding Patterns in the Main Hawaiian Islands. 19372002): How Do They Compare with Live Animal Surveys? Pacific Science. 59:55-67.

Maybaum, H.L. 1989. Effects of a 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae,* in Hawaiian waters. M.S. Thesis, University of Hawaii, Manoa. 112 pp.

Maybaum, H.L. 1993. Responses of humpback whales to sonar sounds. Journal of the Acoustical Society of America. 94:1848-1849.

Mignucci-Giannoni, A.A., Toyos-Gonzalez, G.M., Perez-Padilla, J., Rodriguez-Lopez, M.A., and Overing, J. 2000. Mass stranding of pygmy killer whales (*Feresa attenuata*) in the British Virgin Islands. Journal of the Marine Biology Association. U.K. 80:759-760.

Miller, P.J.O., N. Biassoni, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature. 405:903.

Mobley, J.R., S.W. Martin, D. Fromm, and P. Nachtigall. 2007. Lunar influences as possible causes for simultaneous aggregations of melon-headed whales in Hanalei Bay, Kauai and Sasanhaya Bay, Rota. Abstract for oral presentation at the Seventeeth Biennial Conference on the Biology of Marine Mammals. Cape Town, South Africa, 29 November -3 December 2007.

Moore, M.J., B. Rubinstein, S.A. Norman, and T. Lipscomb. 2004. A note on the most northerly record of Gervais' beaked whale from the western North Atlantic Ocean. Journal of Cetacean Research and Management. 6:279-281.

Moore, S.E. and J.T. Clarke. 2002. Potential impact of offshore human activities on gray whales. *Eschrichtius robustus*. Journal of Cetacean Research and Management. 4:19-25.

Moore, S. E. 2005. Long-term Environmental Change and Marine Mammals. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. Marine Mammal Research: Conservation Beyond Crisis. John Hopkins University Press, Baltimore. pp 137-147.

Morimitsu, T., T. Nagai, M. Ide, H. Kawano, A. Naichuu, M. Koono, and A. Ishii. 1987. Mass stranding of Odontoceti caused by parasitongenic eighth cranial neuropathy. Journal of Wildlife Diseases. 28:656-658.

Morton, A.B., and H.K. Symonds. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. ICES Journal of Marine Science. 59:71-80.

National Marine Fisheries Service (NMFS). 2004. Interim Report on the Bottlenose Dolphin. *Tursiops truncates*) Unusual Mortality Event Along the Panhandle of Florida March-April 2004. National Marine Fisheries Service. 36 pp.

National Marine Fisheries Service (NMFS)S. 2005. Assessment of Acoustic Exposures on Marine Mammals in Conjunction with *U.S.S. SHOUP* Active Sonar Transmissions in the Eastern Strait of Juan de Fuca and Haro Strait, Washington, 5 May 2003.

National Marine Fisheries Service (NMFS). 2005b. Pygmy Sperm Whale (*Kogia breviceps*): Western North Atlantic Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS). 2005d. False Killer Whale (*Pseudorca crassidens*): Northern Gulf of Mexico Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS). 2005e. Dwarf Sperm Whale (*Kogia sima*): Western North Atlantic Stock. Stock Assessment Report. December, 2005.

National Marine Fisheries Service (NMFS)S. 2006a. Final Rule, for Conducting the Precision Strike Weapon (PSW) Testing and Training by Eglin Air Force Base. Federal Register 71, No. 226, 67810-67824.

National Marine Fisheries Service (NMFS). 2006b. Notice; availability of new criteria for designation of marine mammal Unusual Mortality Events. UMEs. Federal Register 71 FR 75234 notice Dec. 14, 2006.

National Marine Fisheries Service (NMFS). 2006d. Hawaiian Melon-headed Whale (*Peponacephala electra*) Mass Stranding Event of July 3-4, 2004. NOAA Technical Memorandum NMFS-OPR-31, April, 2006.

National Marine Fisheries Service (NMFS). 2006e. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species- October 1, 2004 – September 30, 2006. Office of Protected Resources, National Marine Fisheries Service, Silver Springs, MD. 185 pp.

National Marine Fisheries Service (NMFS). 2007a. Biological Opinion on the U.S. Navy's proposed Composite Training Unit Exercises and Joint Task Force Exercises off Southern California from February 2007 to January 2009. National Marine Fisheries Service, Office of Protected Resources. 163 pp.

National Marine Fisheries Service (NMFS). 2007o, http://www.nmfs.noaa.gov/pr/health/. Accessed 1/30/07.

National Marine Fisheries Service (NMFS). 2008. Endangered Species Act Section 7 Consultation, Final Biological Opinion, Final regulations to authorize the U.S. Navy to "take" marine mammals incidental to the conduct of training exercises in the Hawaii Range Complex, December 2008 to December 2013. NMFS, Silver Spring, MD, dated 18 Dec, 2008, 316 pages.

National Research Council (NRC). 2003. Ocean Noise and Marine Mammals. Washington, DC, The National Academies Press, Ocean Studies Board, Division of Earth and Life Sciences, National Research Council of the National Academies.

National Research Council (NRC). 2006. Dynamic Changes in Marine Ecosystems: Fishing, Food Webs, and Future Options, Committee on Ecosystem Effects of Fishing: Phase II - Assessments of the Extent of Change and the Implications for Policy, National Research Council.

Nieri, M. E. Grau, B. Lamarch, A. Aguilar. 1999. Mass mortality of Atlantic spotted dolphin (*Stenella frontalis*) caused by a fishing interaction in Mauritania. Marine Mammal Science 15:847-854.

Norman, S.A. and J.G. Mead. 2001. *Mesoplodon europaeus*. Mammalian Species. 688:1-5.

Norman, S.A., Raverty, S., McLellan, B., Pabst, A., Ketten, D., Fleetwood, M., Gaydos, J.K., Norberg, B., Barre, L., Cox, T., Hanson, B., and Jeffries, S. 2004. Multidisciplinary investigation of stranded harbor porpoises (*Phocoena phocoena*) in Washington State with an assessment of acoustic trauma as a contributory factor (2 May – 2 June 2003). U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWR-34, 120 pp.

Norman, A. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer and J. Scordino. 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management. 6:87-99.

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

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack, 2007. "Responses of cetaceans to anthropogenic noise." Mammal Review, 37(2):81-115.

O'Shea, T.J. and R.L.J. Brownell. 1994. Organochlorine and metal contaminants in baleen whales: A review and evaluation of conservation implications. Science of the Total Environment. 154:179-200.

Odell, D.K. 1987. The mysteries of marine mammal strandings. Cetus 7:2.

Piantadosi, C.A. and E.D. Thalmann. 2004. Whales, sonar and decompression sickness arising from: Jepson, P.D. et al. Nature 425, 575-576. 2003. Nature. (15 April2004).

Podesta, M., A. D'Amico, G. Pavan, A. Drouga, A. Komnenou, and N. Portunato, 2006. A review of *Ziphius cavirostris* strandings in the Mediterranean Sea. Journal of Cetacean Research and Management. 7:251-261.

Read, A.J., P. Drinker and S. Northridge. 2006. Bycatch of Marine Mammals in U.S. and Global Fisheries. Conservation Biology. 20:163-169.

Richardson, W. J., C. R. J. Green, C. I. Malme and D. H. Thomson. 1995. Marine Mammals and Noise. San Diego, CA, Academic Press.

Richardson, W.J., C.R. Greene Jr., C.I. Malme and D.H. Thomson. 1991. Effects of Noise on Marine Mammals. Herndon, VA, U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region: 462.

Richter, C.F., S.M. Dawson, and E. Slooten. 2003. Sperm whale-watching off Kaikoura, New Zealand; effects of current activities on surfacing and vocalization patterns. Science for Conservation 219. Department of Conservation, Wellington, New Zealand, 78 pp.

Ridgway, S.H. and M.D. Dailey. 1972. Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. Journal of Wildlife Diseases. 8:33-43.

Ridgway, S.H., and R. Howard. 1979. Dolphin lung collapse and intramuscular circulation during free diving: evidence from nitrogen washout. Science. 206:1182–1183.

Rothschild, B. M., E. D. Mitchell, M. J. Moore and G. A. Early. 2005. What causes lesions in sperm whale bones? Science. 308: 631-632.

Rybitski, M. J., G. H. Balazs, R. C. Hale and J. A. Musick. 1994. Comparison of Organochlorine Contents in Atlantic Loggerheads. *Caretta caretta*) and Hawaiian Green Turtles. *Chelonia mydas*. Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, Jekyll Island, GA, NOAA Technical Memorandum NMFS-SEFSC-341.

Sergeant, D.E. 1982. Some biological correlates of environmental conditions around Newfoundland during 1970-1979: harp seals, blue whales and fulmar petrels. North Atlantic Fisheries Organization. NAFO. Scientific Council Studies. 5:107-110.

Simmonds, M.P. and S.J. Mayer. 1997. An evaluation of environmental and other factors in some recent marine mammal mortalities in Europe: implication for conservation and management. Environmental Review. 5:89-98.

Simmonds, M.P. and L.F. Lopez-Jurado. 1991. Whales and the military. Nature. 351(6326):448.

Soto, N.A., M.A. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli and J.F. Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales. *Ziphius cavirostris*)? Marine Mammal Science. 22:690-699.

Southall, B.L., 2005. Final Report of the National Oceanic and Atmospheric Administration (NOAA) International Symposium: Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology, 18-19 May 2004. Released 27 April 2005.

Southall, B.L., R. Braun, F.M. D. Gulland, A.D. Heard, R. Baird, S. Wilkin and T.K. Rowles. 2006. Hawaiian melon-headed whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004. NOAA Technical Memorandum NMFS-OPR-31. 73 pp.

Stone, S., United States. National Oceanic and Atmospheric Administration. and United States. National Marine Fisheries Service. Southwest Region. 1986. Annotated bibliography on impacts of gillnets on non-targeted species. [Terminal Island, Calif.?], U.S. Dept. of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service Southwest Region 1986.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan, and D.A. Pabst, 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Tyack, P.L., M.P. Johnson, W.M.X. Zimmer, P.T. Madsen, and M.A. de Soto. 2006. Acoustic behavior of beaked whales, with implications for acoustic monitoring. Oceans. 2006. 1-6.

Urick, R.J., 1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY, 1975.

Van Dolah, F.M., G.J. Doucette, F.M.D. Gulland, T.L. Rowles, and G.D. Bossart. 2003. Impacts of algal toxins on marine mammals. IN: J.G. Vos, G.D. Bossart, M. Fournier, and T.J. O'Shea, eds. Toxicology of Marine Mammals, Taylor & Francis, London and New York. pp. 247-269.

Van Dolah, F.M. 2005. Effects of Harmful Algal Blooms. IN: J.E. Reynolds III, W.F. Perrin, R.R. Reeves, S. Montgomery, T.J. Ragen. Marine Mammal Research. John Hopkins University Press, Baltimore. pp. 85-99.

Vanderlaan, A. S.M. and C.T. Taggart. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science. 23(1): 144-196.

Vidal, O. and J.-P. Gallo-Reynoso. 1996. Die-offs of marine mammals and sea birds in the Gulf of California, Mexico. Marine Mammal Science. 12(4): 627-635.

Visser, I.K.G., J.S. Teppema, and A.D.M.E. Ostrhaus. 1991. Virus infections of seals and other pinnipeds. Reviews in Medical Microbiology. 2:105-114.

Walker, M.M., J.L. Kirschvink, G. Ahmed and A.E. Dizon. 1992. Evidence that fin whales respond to the geomagnetic field during migration. Journal of Experimental Biology. 171:67-78.

Walker, R.J., E.O. Keith, A.E. Yankovsky and D.K. Odell. 2005. Environmental correlates of cetacean mass stranding in sites in Florida. Marine Mammal Science. 21:327-335.

Walsh, M.T., R.Y. Ewing, D.K. Odell and G.D. Bossart. 2001. Mass Stranding of Cetaceans. CRC Handbook of Marine Mammals. L.A. Dierauf and F.M.D. Gulland, CRC Press: pp. 83-93.

Wartzok, D. and D. Ketten, 1999. Marine mammal sensory systems. In: J.E. Reynolds III and S.A. Rommel, eds. The Biology of Marine Mammals. Smithsonian Institution Press, Washington, DC.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2003. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal. 37:6–15.

Watkins, W.A., 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science. 2:251-262.

Watkins, W.A. and W.E. Schevill, 1975. Sperm whales (*Physeter catodon*) react to pingers. Deep-Sea Research. 22:123-129.

Watkins, W.A., K.E. Moore, and P. Tyack, 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology. 49:1-15.

Weise, M.J., D.P. Costa, and R.M. Kudela. 2006. Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005. Geophysical Research Letters. 33:L22S10.

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. Chicago, Illinois: University of Chicago Press.

Wiley, D. N., R. A. Asmutis, T. D. Pitchford, and D. P. Gannon, 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin 93:196-205.

Wilkinson, D.M. 1991. Report to the Assistant Administrator for Fisheries, in Program Review of the Marine Mammal Stranding Network. U.S. Department of Commerce, National Oceanographic and Atmospheric Administrations, National Marine Fisheries Service, Silver Springs, MD. 171 pp.

Williams, A. D., R. Williams, and T. Brereton, 2002. The sighting of pygmy killer whales (*Feresa attenuata*) in the southern Bay of Biscay and their association with cetacean calves. Journal of the Marine Biological Association of the U. K. 82:509-511.

Zeeberg, J., A. Corten and E. de Graaf. 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. Fisheries Research. 78: 186-195.

Zimmer, W.M.X., and P.L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science. 23:888-925.

Zimmerman, S.T. 1991. A History of Marine Mammal Stranding Networks in Alaska, with Notes on the Distribution of the Most Commonly Stranded Cetacean Species, 1975-1987. Marine Mammal Strandings in the United States, Miami, FL, NMFS.

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Appendix G

Public Participation

TABLE OF CONTENTS

G PUBLIC PARTICIPATION G-1

G.1 PROJECT WEBSITE G-1
G.2 GENERAL SUMMARY OF THE SCOPING PERIOD G-1
G.2.1 Public Scoping Notification G-1
G.2.1.1 Federal Register Notice G-2
G.2.1.2 Newspaper Display Advertisements G-2
G.2.1.3 Scoping Notification Letters G-2
G.2.2 Public Scoping Comments G-5
G.2.2.1 Air Quality G-5
G.2.2.2 Alternatives G-5
G.2.2.3 Biological Resources – Marine Mammals, Fish, Birds and Marine Habitat G-5
G.2.2.4 Biological Resources—Onshore G-6
G.2.2.5 Cultural Resources G-6
G.2.2.6 Cumulative Impacts G-6
G.2.2.7 Environmental Justice G-6
G.2.2.8 Hazardous Materials/Hazardous Waste G-7
G.2.2.9 Health and Safety G-7
G.2.2.10 Noise G-7
G.2.2.11 Miscellaneous G-7
G.2.2.12 Mitigation Measures G-7
G.2.2.13 Meetings/National Environmental Policy Act Process G-8
G.2.2.14 Recreation G-8
G.2.2.15 Socioeconomics G-8
G.2.2.16 Sonar and Underwater Detonations G-8
G.2.2.17 Water Resources G-8
G.2.2.18 Summary of Comments G-8
G.3 PUBLIC REVIEW OF THE DRAFT EIS/OEIS G-9
G.3.1 Federal Register Notice G-9
G.3.2 Public Notification G-9
G.3.2.1 Project Website G-10
G.3.2.2 Newspaper Display Advertisements G-10
G.3.2.3 News Releases G-10
G.3.2.4 Public Service Announcement (PSA) G-11
G.3.2.5 Postcard Mailers G-11
G.3.2.6 Fliers G-11
G.3.2.7 Stake Holder Letters G-11
G.3.3 Public Hearings G-15
G.3.3.1 Public Hearing Comments G-15

LIST OF FIGURES

There are no figures in this section.

LIST OF TABLES

TABLE G-1: BREAKDOWN OF SCOPING COMMENTS BY RESOURCE AREA G-9

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G PUBLIC PARTICIPATION

This appendix includes information about the public's participation in the development of the Gulf of Alaska (GOA) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS). The first part of this appendix summarizes the public scoping process that began with the publication of the Notice of Intent (NOI) in the *Federal Register* in March 2008. The scoping period allowed a variety of opportunities for the public to comment on the scope of the EIS/OEIS, and included three public scoping meetings.

The second part of this appendix addresses the public's involvement in reviewing and commenting on the Draft EIS/OEIS. This section includes a summary of the Navy's public involvement efforts, including information about public hearings, media advertisements and notifications, letters to stakeholders, and meeting flyers. As part of this phase of public involvement, the Navy received comments to the Draft EIS/OEIS from individuals, agencies, elected officials, organizations, and tribes. These comments and the Navy's response to them are addressed in Appendix I, *Pubic Comments and Responses*.

G.1 PROJECT WEBSITE

A public website was established specifically for this project, http://www.gulfofalaskanavyeis.com/ and went active on March 14th, 2008. This website address was published in the initial Notice of Intent and has subsequently been re-printed in all newspaper advertisements, agency letters, and public postcards for both the Notice of Intent to Prepare an Environment Impact Statement and Notice of Availability of the Draft Environmental Impact Statement. The Draft EIS/OEIS, Scoping Meeting Fact Sheets, and various other materials have been available on the project website throughout the course of the project.

G.2 GENERAL SUMMARY OF THE SCOPING PERIOD

The scoping period for the Navy Training Activities in the GOA EIS/ OEIS began with publication of a Notice of Intent in the Federal Register on 17 March 2008. The scoping period began on this date and lasted 45 days, concluding on 30 April 2008. Three public scoping meetings were held on April 1, 2 and 3 in the cities of Kodiak, Anchorage, and Cordova, Alaska, respectively. The scoping meetings were held in an open house format, with informational posters and written information provided to participants and Navy staff and project experts were available to answer participants' questions. Additionally, a tape recorder was available to record participants' oral comments. The interaction during the information sessions was productive and helpful to the Navy.

Scoping participants could submit comments in five ways:

- Oral statements at the public meetings (as recorded by the tape recorder);
- Written comments at the public meetings;
- Written letters (received any time during the public comment period);
- Electronic mail (received any time during the public comment period); and
- Comments submitted directly on the project website (received any time during the public comment period).

G.2.1 Public Scoping Notification

The Navy made significant efforts at notifying the public to ensure maximum public participation during the scoping process. A summary of these efforts follows.

G.2.1.1 Federal Register Notice

A Notice of Intent and Notice of Public Scoping Meetings was published in the *Federal Register* on March 17, 2008.

G.2.1.2 Newspaper Display Advertisements

Advertisements were made to announce the scoping meetings in the following newspapers on the dates indicated below:

Anchorage Daily News
Tuesday, March 18th 2008
Wednesday, March 19th 2008
Thursday, March 20th 2008
Tuesday, April 1st 2008
Wednesday, April 2nd 2008 (Day of Meeting)

Peninsula Clarion
Tuesday, March 18th 2008
Wednesday, March 19th 2008
Thursday, March 20th 2008
Tuesday, April 1st 2008
Wednesday, April 2nd 2008 (Day of Meeting)

Kodiak Daily Mirror
Tuesday, March 18th 2008
Wednesday, March 19th 2008
Thursday, March 20th 2008
Monday, March 31st 2008
Tuesday, April 1st 2008 (Day of Meeting)

Cordova Times
Tuesday, March 18th 2008
Wednesday, March 19th 2008
Thursday, March 20th 2008
Thursday, March 27th 2008
Thursday, April 3rd 2008 (Day of Meeting)

G.2.1.3 Scoping Notification Letters

Notice of Intent/Notice of Scoping Meeting Letters were distributed on March 17, 2008 and included the notice of intent to prepare an EIS/OEIS and notification of scoping meetings. Recipients included:

Tribes and Nations

- Kaguyak Village
- Lesnoi Village
- Native Village of Afognak
- Native Village of Chenega
- Native Village of Eyak
- Native Village of Old Harbor
- Native Village of Ouzinkie
- Native Village of Port Graham
- Native Village of Port Lions
- Native Village of Tatitlek
- Shoonaq Tribe of Kodiak
- Yakutat Tlingit Tribe

Elected Officials

Federal:

- U.S. Senator, Alaska
- U.S. Senator, Alaska
- U.S. Representative, Alaska

State:

- Governor of Alaska
- Alaska State Senator, Alaska District A
- Alaska State Senator, Alaska District B
- Alaska State Senator, Alaska District C
- Alaska State Senator, Alaska District D
- Alaska State Senator, Alaska District E
- Alaska State Senator, Alaska District F
- Alaska State Senator, Alaska District G
- Alaska State Senator, Alaska District H
- Alaska State Senator, Alaska District I
- Alaska State Senator, Alaska District J
- Alaska State Senator, Alaska District K
- Alaska State Senator, Alaska District L
- Alaska State Senator, Alaska District M
- Alaska State Senator, Alaska District N
- Alaska State Senator, Alaska District O
- Alaska State Senator, Alaska District P
- Alaska State Senator, Alaska District Q
- Alaska State Senator, Alaska District R
- Alaska State Senator, Alaska District S
- Alaska State Senator, Alaska District T
- Alaska State Representative, Alaska District 1
- Alaska State Representative, Alaska District 2
- Alaska State Representative, Alaska District 3
- Alaska State Representative, Alaska District 4
- Alaska State Representative, Alaska District 5
- Alaska State Representative, Alaska District 6
- Alaska State Representative, Alaska District 7
- Alaska State Representative, Alaska District 8
- Alaska State Representative, Alaska District 9
- Alaska State Representative, Alaska District 10
- Alaska State Representative, Alaska District 11
- Alaska State Representative, Alaska District 12
- Alaska State Representative, Alaska District 13
- Alaska State Representative, Alaska District 14
- Alaska State Representative, Alaska District 15
- Alaska State Representative, Alaska District 16
- Alaska State Representative, Alaska District 17
- Alaska State Representative, Alaska District 18
- Alaska State Representative, Alaska District 19
- Alaska State Representative, Alaska District 20
- Alaska State Representative, Alaska District 21
- Alaska State Representative, Alaska District 22
- Alaska State Representative, Alaska District 23
- Alaska State Representative, Alaska District 24
- Alaska State Representative, Alaska District 25
- Alaska State Representative, Alaska District 26

- Alaska State Representative, Alaska District 27
- Alaska State Representative, Alaska District 28
- Alaska State Representative, Alaska District 29
- Alaska State Representative, Alaska District 30
- Alaska State Representative, Alaska District 31
- Alaska State Representative, Alaska District 32
- Alaska State Representative, Alaska District 33
- Alaska State Representative, Alaska District 34
- Alaska State Representative, Alaska District 35
- Alaska State Representative, Alaska District 36
- Alaska State Representative, Alaska District 37
- Alaska State Representative, Alaska District 38
- Alaska State Representative, Alaska District 39
- Alaska State Representative, Alaska District 40

Local:

- Mayor, Fairbanks North Star Borough
- Mayor, Kenai Peninsula Borough, Mayor
- Mayor, Kodiak Island Borough
- Mayor, Matanuska-Susitna Borough
- Mayor, Municipality of Anchorage
- Mayor, City of Cordova
- Mayor, City/Borough of Juneau

Federal Regulatory and Government Agencies

- Federal Aviation Administration
    - Washington D.C. headquarters
    - Alaska Region
    - Navy Liaison Officer
- Marine Mammal Commission
- National Oceanic and Atmospheric Administration
- National Marine Fisheries Service
    - Washington D.C. headquarters
    - Alaska Region
    - Office of Protected Resources
    - Habitat Conservation Division
    - Alaska Fisheries Science Center
- North Pacific Fisheries Management Council
- U.S. Army Corps of Engineers
    - Alaska District
- U.S. Department of the Air Force
- U.S. Department of the Army
    - Environmental Resources Division
- U.S. Coast Guard
    - Headquarters Office of Operating and Environmental Standards
    - District 17
- U.S. Department of the Interior
    - Bureau of Indian Affairs
    - Bureau of Land Management

    - Environmental Policy & Compliance Department
    - Minerals Management Service, Alaska Outer Continental Shelf Region
    - National Park Service, Glacier Bay
    - U.S. Fish & Wildlife Service, Alaska Region
    - U.S. Geological Survey, Alaska Science Center and Western Fisheries Research Center
- U.S. Environmental Protection Agency
    - Washington D.C. headquarters
    - Region X
- U.S. Fish and Wildlife Service
- U.S. Department of Agriculture
    - U.S. Forest Service, Alaska Region
- U.S. Department of Commerce

State Regulatory and Government Agencies

- Alaska Department of Fish and Game
- Alaska Department of Natural Resources
- Alaska Department of Commerce and Economic Development
- Alaska Department of Environmental Conservation
- Alaska Department of Transportation & Public Facilities
- Alaska Office of History and Archaeology
- Regulatory Commission of Alaska
- Alaska Department of Military and Veterans Affairs

G.2.2 Public Scoping Comments

In total, the Navy received comments from 77 individuals or organizations. These comments included 52 comments via the website, 18 comments via mail, and 7 comments made in person during the public scoping meetings. This summary gives an overview of comments received during the scoping period. Comments are organized by issue area.

G.2.2.1 Air Quality

Comments in this category expressed concern about the effects of military activities on air quality, specifically from carbon dioxide (CO_2) and greenhouse gases and their effects on global warming. Additional commenters expressed concerns with black carbon exhaust emissions from Navy vessels and their warming impact in the Arctic. Compliance with the Clean Air Act (CAA) was also mentioned. Commenters noted that the EIS/OEIS should discuss which areas do not meet National Ambient Air Quality Standards.

G.2.2.2 Alternatives

Comments regarding alternatives suggested that the Navy consider other sites to conduct its activities. Several commenters expressed that, of the three alternatives, they could only support the No Action Alternative. Additional comments expressed general disappointment with use of the term “No Action Alternative” to refer to continuing activities at current levels.

G.2.2.3 Biological Resources – Marine Mammals, Fish, Birds and Marine Habitat

The majority of comments received in this focus area expressed concerns about impacts to marine life. Many of these comments specifically raised concerns about the effect of Navy sonar on marine life, such as marine mammals, fish, sea turtles, sea invertebrates and zooplankton. Numerous comments were made about the number of endangered species in the GOA, particularly whales (seven whale species in total) and the North Pacific Right Whale specifically, and the presence of North Pacific Right Whale critical

habitat in the GOA. Participants frequently requested that the EIS/OEIS consider alternative technologies to mid-frequency active (MFA) sonar, while others stated that MFA and other forms of sonar are not required for training and should not be used within the GOA based upon "common knowledge" of the effects of sonar. Other commenters quoted previous EIS/OEIS's such as the Hawaii Range Complex Supplemental Draft EIS to state that the Navy, in this EIS, "…found that the use of MFA sonar and high-frequency active (HFA) sonar was harassment to a variety of whale species which included the endangered blue whale, fin whale, humpback and sperm, also Stellar Sea Lion." Several comments addressed protective and mitigation measures that are used now and that could be used for marine mammals when sonar is in use. Still, other comments voiced concern over the effects of all forms of sonar on migration patterns of whales, marine mammals, fish, and birds. A few comments expressed concern about potential negative impacts from sonar, both short- and long-term, to fish and the developing eggs/embryos of salmon and other commercial species (halibut, herring, haddock, pollock and crab). Other comments concerned sonar effects on the marine mammal food chain, including fish and zooplankton.

Several comments expressed general concern about Navy impacts, other than sonar, such as habitat quality and water quality, on marine life, while others identified specific policies that must be considered in the Navy's analysis, such as the Marine Mammal Protection Act, the Endangered Species Act, the Coastal Zone Management Act, the Magnuson-Stevens Fisheries Conservation Management Act, the Migratory Bird Treaty Act, and Executive Order 13158.

G.2.2.4 Biological Resources—Onshore

A few comments suggested that the EIS/OEIS should also evaluate impacts on plant species and habitats, and indirect impacts outside the defined project boundary. Several comments addressed the protection of birds, including shorebirds, seabirds and migratory birds. Potential stressors to birds mentioned in the comments included noise disturbance. Among other terrestrial issues were general concerns about impacts to Alaska's ecosystem and resources.

G.2.2.5 Cultural Resources

Participants commenting on cultural resources were primarily concerned with preserving the integrity of sport and subsistence activities to include native subsistence. A few comments also addressed the issue of pollution and potential damage to ancestral homelands.

G.2.2.6 Cumulative Impacts

Comments in this category expressed concern about the overall impact of past and present military activity in the GOA. One specific commenter asked "how the cumulative impact of noise from other sources (military, fisheries, ship traffic and other commercial and industrial sources) can be measured and monitored while the Navy sonar exercises are going on." Another commenter asked that the "…cumulative impacts on local communities, subsistence, endangered species, marine mammals, fish, birds, and the ecosystem, among others, to include the EXXON Valdez oil spill, be fully evaluated and presented to the public". Finally, one commenter noted that cumulative impacts should include the consideration of how Navy actions may impact climatic changes, given concerns about how climate change may already be stressing many species.

G.2.2.7 Environmental Justice

Commenters requested that the EIS/OEIS disclose what efforts were taken to meet environmental justice requirements consistent with Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income/Populations. These commenters also requested information describing the methodology and criteria for identifying low-income and minority populations as well as sources and references used within the DEIS analysis. Comments were also made in reference to making a complete analysis of impacts, including cumulative impacts, to low-income and minority communities, as well as

methods of input for low-income populations and the means of outreach to these potentially affected communities.

G.2.2.8 Hazardous Materials/Hazardous Waste

Of the comments regarding hazardous materials and waste, the primary concerns articulated were over spills, specifically fuel oil, other toxic liquids, wastewater ballast and other bilge water discharges. Another area of concern was the effects of depleted uranium use in munitions on the environment in general. Other comments were in regard to chemical composition of the munitions that would be released. Additionally, a few individuals commented on World War II dump sites that are designated on some marine charts. These individuals want these areas to be re-identified, the types and quantities of materials and containers revealed to the public, and this information factored in to the DEIS analysis as previous military impacts on top of present and future proposed activities, as well as used to establish a baseline for cumulative impacts analysis.

G.2.2.9 Health and Safety

One comment expressed concern about safety implications to recreational swimmers and divers from mid-frequency active sonar.

G.2.2.10 Noise

Several commenters expressed concern about noise from ordnance, mid-frequency sonar, sonar jamming signals, low-frequency communication and surveillance sonar, mid- and high- frequency communication sonars and mechanical noises associated with warfare exercises, to include engine noises, explosions and munitions firing. Another commenter wanted to know what the seismic and sonic noise impacts will be to marine mammals, especially whales, walrus, and seals, and to fish and birds. Another commenter stated that the EIS should describe the impacts of noise on human and wildlife health and behavior, as well as the measures that will be employed to mitigate those impacts, such as physical controls, operations plans and flight corridors. Commenters stated that noise analysis methodologies should be explained and the single-event and cumulative noise metrics utilized in the analysis should be defined. One commenter was concerned about air or noise pollution in ancestral homelands – on or off shore.

G.2.2.11 Miscellaneous

Several comments were received that stated that the Navy was, in effect, moving to Alaska to conduct training, specifically sonar training, because “Court orders and lawsuits ran the Navy out of both California and Hawaii for similar tests and now you are making (a) move on our Alaskan waters.” One commenter wanted to inform the Navy of vital telecommunication cables on the seafloor and indicated that Navy activities must be conducted away from these cables.

G.2.2.12 Mitigation Measures

Most comments regarding mitigation measures focused on marine mammals. For example, several comments expressed concern that spotting marine mammals is extremely difficult for even expert observers, and those commenters doubted that shipboard lookouts could detect animals in adverse sea conditions and especially at night. One commenter proposed that the Navy should use infrared imaging devices at night. Other commenters expressed concern about the effectiveness of the Navy’s training program for spotting animals. One commenter believed that it would be impossible to avoid encounters with whales and other marine animals no matter how many lookouts the Navy utilizes or what time of the year training is conducted. Others questioned how the Navy is going to mitigate sonar’s possible adverse impacts on marine mammals. Additionally, others asked that the Navy aggressively consider ways to expand, improve, and employ better protective measures in future sonar exercises, such as conducting more monitoring and enforcing larger safety zones around ships. Finally, comments were made that the Navy needs to better identify clear monitoring goals and objectives with specific parameters for

measuring success and provide a feedback mechanism for the public to view information on mitigation effectiveness and monitoring results.

G.2.2.13 Meetings/National Environmental Policy Act Process

Comments on the National Environmental Policy Act (NEPA) process included several that felt the information available during the scoping process was inadequate to provide informed comments or that the "poster" session was not the best format. Other commenters desired a more open forum type format, where all questions voiced could be heard by all. One commenter was disappointed that the Navy chose to hold scoping sessions in only three Alaska communities. Another requested that an additional scoping meeting be held in Homer, Alaska. Still other commenters desired the Navy to shift its meetings to later in the year (August), when there is less activity in the various fisheries.

G.2.2.14 Recreation

One comment expressed concern about preserving the integrity of commercial, sport and subsistence activities, including fishing and traditional harvesting of animals. Another comment concerned the possibility of being subjected to sonar while diving. Still others mentioned whale watching activities and how Navy activities might affect them.

G.2.2.15 Socioeconomics

Comments regarding socioeconomic concerns included questions about the effects and impacts on commercial fishing, tourism, and the economy in general.

G.2.2.16 Sonar and Underwater Detonations

Many comments mentioned concerns about the effect of Navy sonar on marine life, such as marine mammals, fish, sea turtles, and invertebrates. Others mentioned recent reports that fish suffer from hearing loss and widespread disorientation following loud noise intrusions and that catch rates of commercial species of fish have plummeted in the vicinity of noise sources. Some specific references to additional studies were received via comments. Others said that noise has been shown in several cases to kill, disable or disrupt the behavior of invertebrates and that little is known about the effects of MFAS on lower marine trophic levels such as phytoplankton and zooplankton. Participants frequently requested that the EIS/OEIS consider alternative technologies to sonar. Many felt that sonar activity is not necessary or appropriate for Alaska waters and that training could be accomplished through simulation and/or use of alternate technologies. Several comments addressed protective and mitigation measures for marine mammals when sonar is used. A few comments specifically mentioned concerns about possible acute and/or chronic effects on benthic and pelagic marine life from munitions discharges and explosions. Some commenters also discussed that analysis of possible impacts to the seafloor from expended materials during training exercises would need to be discussed.

G.2.2.17 Water Resources

Comments regarding water resources included general concerns about the potential effects on quality of both fresh and marine waters, not only in the designated training areas, but also in the land-based areas utilized for logistical support of the exercises, and areas adjacent to the training areas to be affected by military activities. Of specific concern were graywater (waste water from sinks, baths, showers, laundry, etc) and blackwater (waste water from human body wastes) that will be discharged from all vessels engaged in Northern Edge exercises, to include ballast water drawn from areas that may contain invasive species. A few of these comments quoted specific provisions of the Clean Water Act.

G.2.2.18 Summary of Comments

Table G-1 provides a breakdown of areas of concern based on comments received during scoping. Because most commenters provided comments on several issues, and because some commenters chose to

comment via multiple means, with only slight variations in their comments, the total count well exceeds the total number of 77 comments received.

Table G-1: Breakdown of Scoping Comments by Resource Area

Resource Area	Count	Percent of Total
Biological Resources - Marine Mammals	88	19.04%
Sonar and Underwater Detonations	74	16.01%
Biological Resources - Fish & Marine Habitat	45	9.74%
Mitigation	36	7.79%
Policy/NEPA	31	6.70%
Threatened and Endangered Species	30	6.49%
Commercial Fishing	27	5.84%
Alternatives	26	5.62%
Hazardous Materials / Hazardous Waste	24	5.19%
Socioeconomics	15	3.24%
Cumulative Impacts	11	2.38%
Water Resources	10	2.16%
Air Quality	8	1.73%
Biological Resources - Onshore	7	1.51%
Noise	6	1.29%
Miscellaneous	6	1.29%
Cultural Resources	5	1.08%
Proposed Action	5	1.08%
Coastal Zone Management Act	3	0.64%
Recreation	2	0.43%
Health and Safety	2	0.43%
Environmental Justice	1	0.21%
TOTAL	462	

G.3 PUBLIC REVIEW OF THE DRAFT EIS/OEIS

G.3.1 Federal Register Notice

On December 11, 2009, a Notice of Availability of the Draft EIS/OEIS was published in the *Federal Register*. This notice announced the availability of the Draft EIS/OEIS for public review. A news release was also issued and two media briefings were conducted to inform the public of the impending Notice publication. The Notice of Availability was the start of the public comment period for the Draft EIS/OEIS. The 45 day public comment period ended on January 25, 2010.

G.3.2 Public Notification

The Navy made significant efforts at notifying the public to ensure maximum public participation during the public hearing process. The public could submit comments in five ways:

- Oral statements at the public meetings (as recorded by the tape recorder);

- Written comments at the public meetings;
- Written letters (received any time during the public comment period);
- Electronic mail (received any time during the public comment period); and
- Comments submitted directly on the project website (received any time during the public comment period).

A summary of the Navy's public notification efforts follows.

G.3.2.1 Project Website

The Navy provided a public website that has been active since the NOI was published in March 2008. On the day of the public release of the Draft EIS/OEIS, this website made available an electronic (PDF) version of the Draft EIS/OEIS for download and review. A comment form could be downloaded from the website to allow the public to submit written comments. The website also provided a paperless capability for members of the public to enter a comment directly.

G.3.2.2 Newspaper Display Advertisements

Advertisements were made to announce the availability of the Draft EIS/OEIS and to announce the schedule and locations for public hearings as follows:

Anchorage Daily News
Monday, 14th December 2009
Tuesday, 15th December 2009
Wednesday, 16th December 2009
Monday, 28th December 2009
Wednesday, 6th January 2010
Thursday, 7th January 2010
Friday, 8th January 2010
Sunday, 10th January 2010
Monday, 11th January 2010

Peninsula Clarion
Monday, 14th December 2009
Tuesday, 15th December 2009
Wednesday, 16th December 2009
Monday, 28th December 2009
Wednesday, 30th December 2009
Wednesday, 6th January 2010
Thursday, 7th January 2010
Friday, 8th January 2010

Kodiak Daily Mirror
Monday, 14th December 2009
Tuesday, 15th December 2009
Wednesday, 16th December 2009
Monday, 28th December 2009
Tuesday, 5th January 2010
Wednesday, 6th January 2010
Thursday, 7th January 2010

Juneau Empire
Monday, 14th December 2009
Monday, 28th December 2009
Friday, 8th January 2010
Sunday, 10th January 2010
Monday, 11th January 2010
Cordova Times(Thursday only)
Thursday, 17th December 2009
Thursday, 24th December 2009
Thursday, 31th December 2009
Thursday, 7th January 2010

G.3.2.3 News Releases

Two news releases were distributed by the Commander, Navy Region Northwest Environmental Public Affairs Officer (CNRNW EPAO) to media outlets, elected officials and other potentially interested parties. The first news release was distributed on 11 December 2009, and announced the availability of the Draft EIS/OEIS. This news release included details on the Proposed Action, public hearings dates, locations, times and comment information.

A second news release was distributed by the CNRNW EPAO on 31 December 2009, and announced the Navy's upcoming public hearings. This news release, meant to encourage the public to attend the open

houses and presentation/oral comment sessions, provided detailed information on the location, dates, and times of the public hearings, in addition to comment information and details on the Proposed Action.

G.3.2.4 Public Service Announcement (PSA)

A PSA was distributed twice by CNRNW EPAO (31 December 2009, and 4 January 2010), announcing the public hearing locations, dates, time, close of comment period, and project Web site.

G.3.2.5 Postcard Mailers

Postcards announcing the availability of the Draft EIS/OEIS, comment information, and the public hearing dates, times, and locations were sent out to 691 individuals on the project mailing list on 23 December 2009.

G.3.2.6 Fliers

Fliers announcing the public open houses and presentation/oral comment sessions for each of the five public hearings locations were distributed to 45 locations.

G.3.2.7 Stake Holder Letters

DEIS Distribution/Public Hearings Letters were distributed 11 December 2009 and included the notification of public hearings and notice of availability of Draft EIS/OEIS (CD or hard copy of EIS included).

Following is a list of public officials, government agencies, Native American Tribes and Nations, organizations, and individuals who attended the public scoping meetings, provided comments during the scoping process, or have been identified by the Navy to be on the distribution list for the Gulf of Alaska Navy Training Activities Draft EIS/OEIS.

Federal and state regulatory agencies and project information repositories (noted below with an asterisk*) received both one (1) hard copy version and one (1) CD-ROM version of the Gulf of Alaska Navy Training Activities Draft EIS/OEIS. Stakeholders who specifically requested a hard copy version also received one, along with a CD-ROM version. All other stakeholders received one (1) CD-ROM version. Additional hard copies and/or CD-ROM versions of the Draft EIS/OEIS were made available when requested.

Information Repositories*

Loussac Library, Anchorage, AK

Alaska State Library, Juneau, AK

A. Holmes Johnson Memorial Library, Kodiak, AK

University of Alaska Fairbanks, Rasmussen Library, Fairbanks, AK

Cordova Public Library, Cordova, AK

Copper Valley Community Library, Glennallen, AK

Seward Community Library, Seward, AK

Humboldt Homer Public Library, Homer, AK

Federal Regulatory Agencies

Federal Aviation Administration
- Washington D.C. headquarters
- Alaska Region
- Navy Liaison Officer*

Marine Mammal Commission*

National Oceanic and Atmospheric Administration

National Marine Fisheries Service
- Washington D.C. headquarters*
- Alaska Region*
- Office of Protected Resources
- Habitat Conservation Division
- Alaska Fisheries Science Center

North Pacific Fisheries Management Council*

U.S. Army Corps of Engineers
- Alaska District

U.S. Department of the Air Force*

U.S. Department of the Army
-Environmental Resources Division*

U.S. Coast Guard
- Headquarters Office of Operating and Environmental Standards*
- District 17

U.S. Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Environmental Policy & Compliance Department*
- Minerals Management Service, Alaska Outer Continental Shelf Region*
- National Park Service, Glacier Bay*
- U.S. Fish & Wildlife Service, Alaska Region*
- U.S. Geological Survey, Alaska Science Center and Western Fisheries Research Center*

U.S. Environmental Protection Agency
- Washington D.C. headquarters*
- Region X*

U.S. Fish and Wildlife Service

U.S. Department of Agriculture
-U.S. Forest Service, Alaska Region

U.S. Department of Commerce

State Regulatory Agencies

Alaska Department of Fish and Game

Alaska Department of Natural Resources

Alaska Department of Commerce and Economic Development

Alaska Department of Environmental Conservation

Alaska Department of Transportation & Public Facilities

Alaska Office of History and Archaeology

Regulatory Commission of Alaska

Alaska Department of Military and Veterans Affairs

Native American Tribes and Nations*

Kaguyak Village

Lesnoi Village

Native Village of Afognak

Native Village of Chenega

Native Village of Eyak

Native Village of Old Harbor

Native Village of Ouzinkie

Native Village of Port Graham

Native Village of Port Lions

Native Village of Tatitlek

Shoonaq Tribe of Kodiak

Yakutat Tlingit Tribe

Federal Elected Officials

U.S. Representative
Hon. Donald Young, AK

U.S. Senator
Hon. Lisa Murkowski, AK

U.S. Senator
Hon. Mark Begich, AK

State Elected Officials

Governor of Alaska
Hon. Sean Parnell

Alaska State Senator
Hon. Bert Stedman
AK District A

Alaska State Senator
Hon. Dennis Egan
AK District B

Alaska State Senator
Hon. Albert Kookesh
AK District C

Alaska State Senator
Hon. Joe Thomas
AK District D

Alaska State Senator
Hon. Joe Paskvan
AK District E

Alaska State Senator
Hon. Gene Therriault
AK District F

Alaska State Senator
Hon. Linda Menard
AK District G

Alaska State Senator
Hon. Charlie Huggins
AK District H

Alaska State Senator
Hon. Fred Dyson
AK District I

Alaska State Senator
Hon. Bill Wielechowski
AK District J

Alaska State Senator
Hon. Bettye Davis
AK District K

Alaska State Senator
Hon. Johnny Ellis
AK District L

Alaska State Senator
Hon. Hollis French,
AK District M

Alaska State Senator
Hon. Lesil McGuire
AK District N

Alaska State Senator
Hon. Kevin Meyer
AK District O

Alaska State Senator
Hon. Con Bunde
AK District P

Alaska State Senator
Hon. Thomas Wagoner
AK District Q

Alaska State Senator
Hon. Gary Stevens
AK District R

Alaska State Senator
Hon. Lyman Hoffman
AK District S

Alaska State Senator
Hon. Donald Olson
AK District T

Alaska State Representative
Hon. Kyle Johansen
AK District 1

Alaska State Representative
Hon. Peggy Wilson
AK District 2

Alaska State Representative
Hon. Beth Kerttula
AK District 3

Alaska State Representative
Hon. Cathy Munoz
AK District 4

Alaska State Representative
Hon. Bill Thomas, Jr.
AK District 5

Alaska State Representative
Hon. Woodie Salmon
AK District 6

Alaska State Representative
Hon. Mike Kelly
AK District 7

Alaska State Representative
Hon. David Guttenberg
AK District 8

Alaska State Representative
Hon. Scott Kawaski
AK District 9

Alaska State Representative
Hon. Jay Ramras
AK District 10

Alaska State Representative
Hon. John Coghill
AK District 11

Alaska State Representative
Hon. John Harris
AK District 12

Alaska State Representative
Hon. Carl Gatto
AK District 13

Alaska State Representative
Hon. Wes Keller
AK District 14

Alaska State Representative
Hon. Mark Neuman
AK District 15

Alaska State Representative
Hon. Bill Stoltze
AK District 16

Alaska State Representative
Hon. Anna Fairclough,
AK District 17

Alaska State Representative
Hon. Nancy Dahlstrom
AK District 18

Alaska State Representative
Hon. Pete Peterson
AK District 19

Alaska State Representative
Hon. Max Gruenberg
AK District 20

Alaska State Representative
Hon. Harry Crawford
AK District 21

Alaska State Representative
Hon. Sharon Cissna
AK District 22

Alaska State Representative
Hon. Les Gara
AK District 23

Alaska State Representative
Hon. Berta Gardner
AK District 24

Alaska State Representative
Hon. Mike Doogan
AK District 25

Alaska State Representative
Hon. Lindsey Holmes
AK District 26

Alaska State Representative
Hon. Bob Buch
AK District 27

Alaska State Representative
Hon. Craig Johnson
AK District 28

Alaska State Representative
Hon. Chris Tuck
AK District 29

Alaska State Representative
Hon. Charisse Millet
AK District 30

Alaska State Representative
Hon. Bob Lynn
AK District 31

Alaska State Representative
Hon. Mike Hawker
AK District 32

Alaska State Representative
Hon. Kurt Olson
AK District 33

Alaska State Representative
Hon. Mike Chenault
AK District 34

Alaska State Representative
Hon. Paul Seaton
AK District 35

Alaska State Representative
Hon. Alan Austerman
AK District 36

Alaska State Representative
Hon. Bryce Edgmon
AK District 37

Alaska State Representative
Hon. Bob Herron
AK District 38

Alaska State Representative
Hon. Richard Foster
AK District 39

Alaska State Representative
Hon. Reggie Joule
AK District 40

Local Elected Officials

Fairbanks North Star Borough
Hon. Luke Hopkins
Mayor

Kenai Peninsula Borough
Hon. David R. Carey
Mayor

Kodiak Island Borough
Hon. Jerome M. Selby
Mayor

Matanuska-Susitna Borough
Hon. Talis Colberg
Mayor

Municipality of Anchorage
Hon. Dan Sullivan
Mayor

City of Cordova
Hon. Timothy L. Joyce
Mayor

City/Borough of Juneau
Hon. Bruce Botelho
Mayor

Individuals

Tom Anderson
Cordova, AK

Claudia Anderson
Kodiak, AK

Brad Barr
Kodiak, AK

Wendy Beck
Kodiak, AK

Robert Berceli
Cordova, AK

Allison Bidlack
Cordova, AK

Cheryl Boehlan
Kodiak, AK

Richard Brenner
Cordova, AK

Bruce Cain
Cordova, AK

Mark Cammrys
Cordova, AK

Madelene Caselli
Palmer, AK

Al Clayton
Anchorage, AK

Taral Clayton
Anchorage, AK

Trevor Clayton
Anchorage, AK

Mark Cummings
Cordova, AK

Terry Cummings
Anchorage, AK

Dean Cwrzah
Kodiak, AK

Tess Dietrich
Kodiak, AK

Don Dunn
Kodiak, AK

James Fisher
Soldotna, AK

Robert Fisher
Kingwood, TX

Susan Glinton
Nassau, Bahamas

Lavonne Heacock
Rhododendron, OR

Pat Heitman
Kodiak, AK

Carolyn Heitman*
Kodiak, AK

Leona Heitsch
Bourbon, MI

Pat Holmes
Kodiak, AK

Deb Jaros
Kodiak, AK

Joanna Kappele
Chicago, IL

Lee Keller
Seward, AK

Kimberly Kopanuk
Anchorage, AK

Robert Kopchak
Cordova, AK

Aldone Kowenta
Kodiak, AK

Kurt Krieter
Palmer, AK

Alexis Kwachka
Kodiak, AK

Dave Lacey
Fairbanks, AK

Ann Mallard
Fairbanks, AK

Craig Matkin
Homer, AK

Irene Miramontes
Nassau, Bahamas

Maria Nasif
Tuscon, AZ

Susan Payne
Kodiak, AK

Geneneiva Pearson
Kodiak, AK

Susan Peehl
Cold Springs, NY

Barbara Sachau
Florham Park, NJ

Mike Sirofchruk
Kodiak, AK

Ralph Sirofchruk
Kodiak, AK

Michael Sirofchuck
Kodiak, AK

Erin Starr-Hollow
Kodiak, AK

Joan Stempniak
Homer, AK

Dany Stihl
Kodiak, AK

Delores Stokes
Kodiak, AK

John F. Thomas
Cordova, AK

Kip Thomet
Kodiak, AK

Hans Tscherich
Cordova, AK

Keith Van den Broek
Cordova, AK

Barbara Volpe
Kodiak, AK

Elise Wolf
Fritz Creek, AK

G.3.3 Public Hearings

During the public comment period the Navy held public hearings to present information from the EIS/OEIS and to solicit public comments. Public hearings were held on the following dates and locations in Alaska: 7 January 2010, Kodiak; 8 January 2010, Anchorage; 9 January 2010, Homer, Alaska; 11 January 2010, Juneau; 12 January 2010, Cordova. Staffed poster stations with detailed information about the project and the Draft EIS/OEIS results were open for each meeting from 5:00 to 7:00 PM. During this time, Navy experts were available to answer questions and receive comments from members of the public. At 7 PM during each meeting a more formal, structured public hearing began in which the Navy presented a briefing on the Draft EIS/OEIS and the study conclusions. Following that presentation, individuals provided oral comments. All oral comments were captured by a court reporter and have been reproduced later in this appendix. In addition to oral comments, the Navy received written comments during these hearings.

G.3.3.1 Public Hearing Comments

In total, the Navy received comments from 213 individuals or organizations. These comments included 140 comments via the website, 38 comments via mail, and 64 comments made in person during the public hearing meetings. Comments were further broken out into 1,127 comment issues to best respond to each concern of the individual or organization.

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Appendix H

Acoustic Systems Descriptions

TABLE OF CONTENTS

H ACOUSTIC SYSTEMS DESCRIPTIONS H-1

H.1 GENERAL SUMMARY OF ACOUSTIC SYSTEMS H-1
H.1.1 SURFACE SHIP SONARS H-1
H.1.2 SURFACE SHIP FATHOMETER H-2
H.1.3 SUBMARINE SONARS H-3
H.1.4 SUBMARINE AUXILIARY SONAR SYSTEMS H-4
H.1.5 AIRCRAFT SONAR SYSTEMS H-4
H.1.6 TORPEDOES H-7
H.1.7 EXERCISE TRAINING TARGETS H-7
H.1.8 TRACKING PINGERS, TRANSPONDERS, AND ACOUSTICAL COMMUNICATIONS (ACOMS) H-8
H.1.9 PORTABLE UNDERSEA TRAINING RANGE (PUTR) H-8
H.1.10 ADVANCED EXTENDED ECHO RANGING (AEER) H-9

LIST OF FIGURES

FIGURE H-1. ARLEIGH BURKE CLASS DDG EQUIPPED WITH AN/SQS-53 (L); TICONDEROGA CLASS CG SHOWING AN/SQS-53 (R) H-1
FIGURE H-2. OLIVER HAZARD PERRY CLASS FFG EQUIPPED WITH AN/SQS-56 ..... H-2
FIGURE H-3. AN/SQR-19 ..... H-2
FIGURE H-4. AN/BQQ-5 ..... H-3
FIGURE H-5. SAILORS OPERATING AN/BQQ-10 ..... H-3
FIGURE H-6. AN/BQS-15 DISPLAY (L), AND SENSOR COMPONENTS (R) H-4
FIGURE H-7. AN/WQC-2 TRANSDUCER (L), AND CONTROL UNIT (R) H-4
FIGURE H-8. AN/AQS-13 BEING DEPLOYED BY A NAVY HELICOPTER H-5
FIGURE H-9. AN/AQS-22 BEING DEPLOYED BY A NAVY HELICOPTER H-5
FIGURE H-10. AN/SQS-62 (L); MPA EQUIPPED WITH AN/SQS-62 SONOBUOYS (R) H-6
FIGURE H-11. MPA DEPLOYING AN/SSQ-110A H-6
FIGURE H-12. AN/SSQ-53 (L); AN/SSQ-53 BEING LOADED ONTO MPA (R) H-7
FIGURE H-13. MK 48/MK 48 ADCAP (L); SEAWOLF CLASS SSN LAUNCHING MK-48/MK-48 ADCAP (R) H-7
FIGURE H-14. MK 39 EMATT (L) AND MK 30 (R) H-8
FIGURE H-15. MK 84 ..... H-8
FIGURE H-16. PORTABLE UNDERSEA TRAINING RANGE DEEP (PUTR-D) TRANSPONDER CONFIGURATION H-9

LIST OF TABLES

TABLE H-1: ECHO RANGING SYSTEMS H-9

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H ACOUSTIC SYSTEMS DESCRIPTIONS

H.1 GENERAL SUMMARY OF ACOUSTIC SYSTEMS

Various active acoustic sources that may or may not affect the local marine mammal population are deployed by platforms during various training activities, exercises and maintenance events. The following sections discuss the acoustic sources that could be present during such training activities, exercises, and maintenance events.

H.1.1 Surface Ship Sonars

- AN/SQS-53 – a computer-controlled, hull-mounted surface-ship sonar that has both active and passive operating capabilities, providing precise information for anti-submarine warfare (ASW) weapons control and guidance. The system is designed to perform direct-path ASW search, detection, localization, and tracking from a hull-mounted transducer array. The AN/SQS-53 (Figure H-1) is characterized as a mid-frequency active (MFA) sonar, operating from 1 to 10 kilohertz (kHz); however, the exact frequency is classified. The AN/SQS-53 sonar is the major component to the AN/SQQ-89 sonar suite, and it is installed on Arleigh Burke Class guided missile destroyers (DDGs), and Ticonderoga Class guided missile cruisers (CGs).

Figure H-1. Arleigh Burke Class DDG equipped with AN/SQS-53 (L); Ticonderoga Class CG showing AN/SQS-53 (R)

- AN/SQS-53 Kingfisher – a modification to the AN/SQS-53 sonar system that provides the surface ship with an object detection capability. The system uses MFA sonar, although the exact frequency range is classified. This sonar system is installed on Arleigh Burke Class DDGs, and Ticonderoga Class CGs.
- AN/SQS-56 – a hull-mounted sonar that features digital implementation, system control by a built-in mini computer, and an advanced display system. The sonar is an active/passive, preformed beam, digital sonar providing panoramic active echo ranging and passive digital multibeam steering (DIMUS) surveillance. The sonar system is characterized as MFA sonar, although the exact frequency range is classified. The AN/SQS-56 (Figure H-2) is the major component of the AN/SQQ-89 sonar suite and is installed on Oliver Hazard Perry Class frigates (FFGs).

Figure H-2. Oliver Hazard Perry Class FFG equipped with AN/SQS-56

- AN/SQR-19 – a tactical towed array sonar (TACTAS) that is able to passively detect adversary submarines at a very long range. The AN/SQR-19, which is a component of the AN/SQQ-89 sonar suite, is a series of passive hydrophones towed from a cable several thousand feet behind the ship. This sonar system is a passive sensing device; therefore, it is not analyzed in this Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). The AN/SQR-19 (Figure H-3) can be deployed by Arleigh Burke Class DDGs, Ticonderoga Class CGs, and Oliver Hazard Perry Class FFGs.

Figure H-3. AN/SQR-19

H.1.2 Surface Ship Fathometer

The surface ship fathometer (AN/UQN-4) is used to measure the depth of water from the ship's keel to the ocean floor for safe operational navigation. Fathometers are operated from all classes of United States (U.S.) Navy surface ships and are considered MFA sonar, although the exact frequency range is classified.

H.1.3 Submarine Sonars

- AN/BQQ-5 – a bow- and hull-mounted passive and active search and attack sonar system. The system includes the TB-16 and TB-23 or TB-29 towed arrays and Combat Control System (CCS) MK 2. This sonar system is characterized as MFA, although the exact frequency range is classified. The AN/BQQ-5 (Figure H-4) sonar system is installed on Los Angeles Class nuclear attack submarines (SSNs) and Ohio Class ballistic missile nuclear submarines (SSBNs), although the AN/BQQ-5 systems installed on Ohio Class SSBNs do not have an active sonar capability. The AN/BQQ-5 system is being phased out on all submarines in favor of the AN/BQQ-10 sonar. The operating parameters of both systems with regard to sound output in the ocean are almost identical. For these reasons, these systems will be referred to as AN/BQQ-10 in this EIS.

Figure H-4. AN/BQQ-5

- AN/BQQ-10 (also known as Advanced Rapid Commercial-Off-the-Shelf Insertion [ARCI]) – a four-phase program for transforming existing submarine sonar systems (i.e., AN/BQQ-5) from legacy systems to more capable and flexible active and passive systems with enhanced processing using commercial-off-the-shelf (COTS) components. The system is characterized as MFA, although the exact frequency range is classified. The AN/BQQ-10 (Figure H-5) is installed on Seawolf Class SSNs, Virginia Class SSNs, Los Angeles Class SSNs, and Ohio Class SSBN/nuclear guided missile submarines (SSGNs). The BQQ-10 systems installed on Ohio Class SSBNs do not have an active sonar capability.

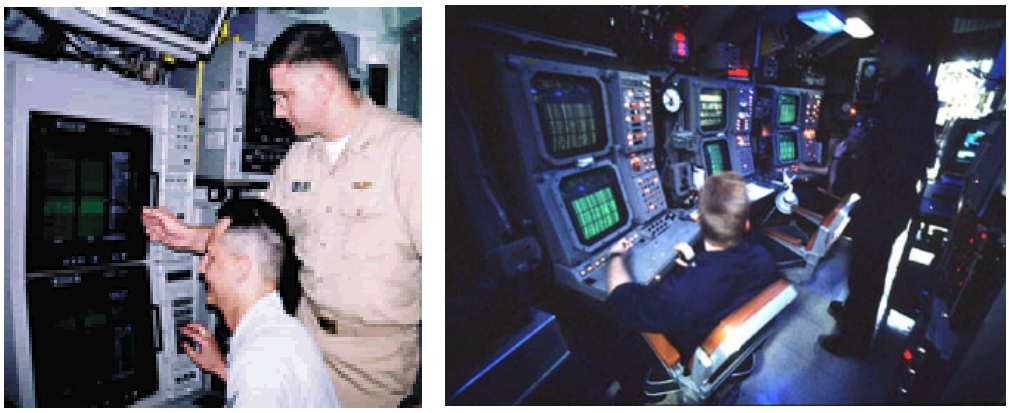

Figure H-5. Sailors operating AN/BQQ-10

H.1.4 Submarine Auxiliary Sonar Systems

- AN/BQS-15 – an under-ice navigation and mine-hunting sonar (Figure H-6) that uses both mid- and high-frequency (i.e., greater than 10 kHz) active sonar, although the exact frequencies are classified. Later versions of the AN/BQS-15 are also referred to as Submarine Active Detection Sonar (SADS). The Advanced Mine Detection System (AMDS) is being phased in on all ships and will eventually replace the AN/BQS-15 and SADS. These systems are installed on Seawolf Class SSNs, Virginia Class SSNs, Los Angeles Class SSNs, and Ohio Class SSGNs.

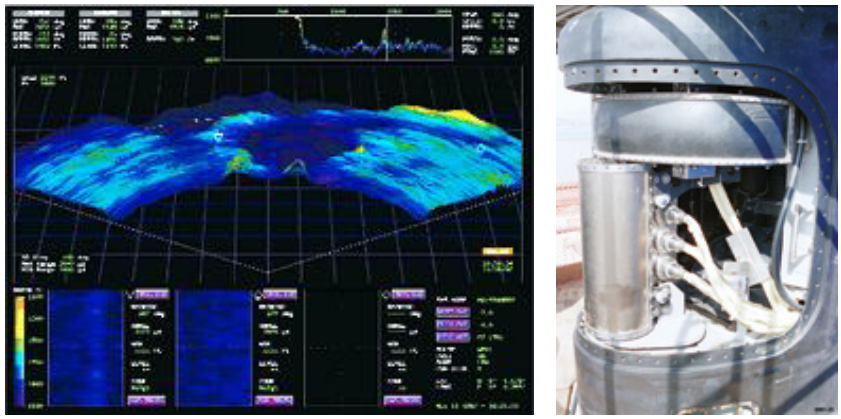

Figure H-6. AN/BQS-15 display (L), and sensor components (R)

- AN/WQC-25 – an MFA sonar underwater communications system that can transmit either voice or signal data in two bands, 1.5 to 3.1 kHz or 8.3 to 11.1 kHz. The AN/WQC-2 (Figure H-7), also referred to as the "underwater telephone" (UWT), is on all submarines and most surface ships, and allows voice and tonal communications between ships and submarines.

Figure H-7. AN/WQC-2 transducer (L), and control unit (R)

H.1.5 Aircraft Sonar Systems

Aircraft sonar systems that could be deployed during active sonar events include sonobuoys (tonal [active], listening [passive], and extended echo ranging [EER] or improved extended echo ranging [IEER]) and dipping sonar (AN/AQS-13/22 or AN/AOS-22). Sonobuoys may be deployed by Marine Patrol Aircraft (MPA) or MH-60R helicopters. A sonobuoy is an expendable device used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Most sonobuoys are passive, but some can generate active acoustic signals as well as listen passively. Dipping sonars are used by MH-60R helicopters. Dipping sonar is an active or passive

sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. A description of various types of sonobuoys and dipping sonar is provided below.

- AN/AQS-13 Helicopter Dipping Sonar – an active scanning sonar that detects and maintains contact with underwater targets through a transducer lowered into the water from a hovering helicopter. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-13 (Figure H-8) is operated by MH-60R helicopters.

Figure H-8. AN/AQS-13 being deployed by a Navy helicopter

- AN/AQS-22 Airborne Low-Frequency Sonar (ALFS) – the U.S. Navy's dipping sonar system for the MH-60R helicopter Light Airborne Multi-Purpose System III (LAMPS III), which is deployed from aircraft carriers, cruisers, destroyers, and frigates. It operates at mid-frequency, although the exact frequency is classified. The AN/AQS-22 (Figure H-9) employs both deep- and shallow-water capabilities.

Figure H-9. AN/AQS-22 being deployed by a Navy helicopter

- AN/SSQ-62C Directional Command Activated Sonobuoy System (DICASS) – sonobuoy that operates under direct command from ASW fixed-wing aircraft or MH-60R helicopters (Figure H-10). The system can determine the range and bearing of the target relative to the sonobuoys position and can deploy to various depths within the water column. The active sonar operates at mid-frequency, although the exact frequency range is classified. After water entry, the sonobuoy transmits sonar pulses (continuous waveform [CW] or linear frequency modulation [LFM]) upon command from the aircraft. The echoes from the active sonar signal are processed in the buoy and transmitted to the receiving station onboard the launching aircraft.

Figure H-10. AN/SQS-62 (L); MPA equipped with AN/SQS-62 sonobuoys (R)

- AN/SSQ-110A Explosive Source Sonobuoy – a commandable, air-dropped, high source level explosive sonobuoy. The AN/SSQ-110A explosive source sonobuoy (Figure H-11) is composed of two sections, an active (explosive) section and a passive section. The upper section is called the "control buoy" and is similar to the upper electronics package of the AN/SSQ-62 DICASS sonobuoy. The lower section consists of two signal underwater sound (SUS) explosive payloads of Class A explosive weighing 1.9 kg (4.2 lbs) each. The arming and firing mechanism is hydrostatically armed and detonated. Once in the water, the SUS charges explode, creating a loud acoustic signal. The echoes from the explosive charge are then analyzed on the aircraft to determine a submarine's position. The AN/SSQ-110A explosive source sonobuoy is deployed by MPA.

Figure H-11. MPA deploying AN/SSQ-110A

- AN/SSQ-53D/E Directional Frequency Analysis and Recording (DIFAR) – a passive sonobuoy deployed by MPA aircraft and MH-60R helicopters. The DIFAR sonobuoy (Figure H-12) provides acoustic signature data and bearing of the target of interest to the monitoring unit(s) and can be used for search, detection, and classification. The buoy uses a hydrophone with directional detection capabilities in the very low frequency, low frequency, and mid-frequency ranges, as well as an omnidirectional hydrophone for general listening purposes.

Figure H-12. AN/SSQ-53 (L); AN/SSQ-53 being loaded onto MPA (R)

H.1.6 Torpedoes

Torpedoes are the primary ASW weapon used by surface ships, aircraft, and submarines. When torpedoes operate actively, they transmit an active acoustic signal to ensonify the target and use the received echoes for guidance.

- MK 48 and MK 48 Advanced Capability (ADCAP) (Figure H-13) are heavyweight torpedoes deployed on all classes of Navy submarines. MK 48 and MK 48 ADCAP torpedoes are inert and considered HF sonar, but the frequency ranges are classified. Due to the fact that both torpedoes are essentially identical in terms of environmental interaction, they will be referred to collectively as the MK48 in this EIS.

Figure H-13. MK 48/MK 48 ADCAP (L); Seawolf Class SSN launching MK-48/MK-48 ADCAP (R)

H.1.7 Exercise Training Targets

There are two types of training targets, the MK 30 Acoustic Target and the MK 39 Expendable Mobile ASW Training Target (EMATT) (Figure H-14). ASW training targets simulate submarines as an ASW target in the absence of participation by a submarine in an exercise. They are equipped with acoustic projectors emanating sounds to simulate submarine acoustic signatures, and echo repeaters to simulate the characteristics of the reflection of a sonar signal from a submarine.

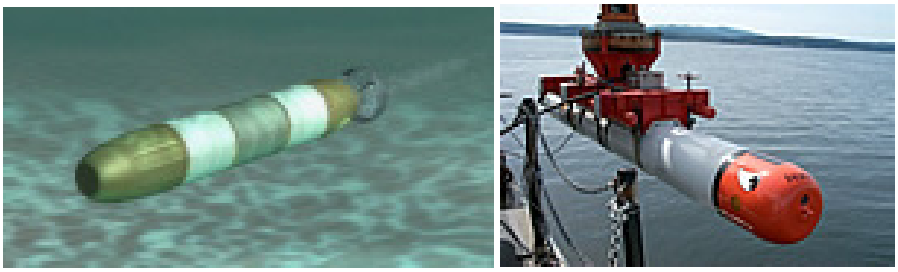

Figure H-14. MK 39 EMATT (L) and MK 30 (R)

In addition, surface targets such as "sleds" (aluminum catamarans), seaborne powered targets (radio-controlled high-speed boats), and target drone units (TDUs) could also be deployed during training exercises.

H.1.8 Tracking Pingers, Transponders, and Acoustical Communications (ACOMs)

Tracking pingers are installed on training platforms to track the position of underwater vehicles. The pingers generate a precise, preset, acoustic signal for each target to be tracked. ACOMs and transponders provide the communication link between sensor packages and base platform allowing information to be exchanged.

- MK 84 Pinger Signal, Underwater Sound (SUS) – an air or surface dropped noisemaking device (Figure H-15) that emits one of five mid-frequency tonal patterns using two MFA sonars with frequencies at 3.1 and 3.5 kHz; it is used to provide prearranged signal communications to submerged submarines.

Figure H-15. MK 84

H.1.9 Portable Undersea Training Range (PUTR)

The Portable Undersea Training Range (PUTR) is a self-contained, portable, undersea tracking capability that employs modern technologies to support coordinated USW training for Forward Deployed Naval Forces (FDNF). PUTR will be available in two variants to support both shallow and deep water remote operations in keeping with Navy requirements to exercise and evaluate weapons systems and crews in the environments that replicate the potential combat area.

PUTR-D, shown below in Figure H-16, consists of a set of transponders which will be deployed by a ship of opportunity and anchored to the ocean bottom. Once deployed a survey is conducted by a range vessel to determine the transponder locations and to test tracking accuracy. The transponder is activated by utilizing an acoustic command signal during operations and commanded into sleep mode when not in use. Operational lifetime, due to transponder battery life, will meet the key performance parameters, including the operating objective of actual tracking time. The transponders can remain deployed for up to 12 months in a dormant state. Transponders will be recovered for battery/buoy maintenance or for range recovery by transmitting an acoustic command which releases the transponder electronics/floatation buoy

package from the anchor. The ship of opportunity will then retrieve the transponders leaving the anchor *in-situ*.

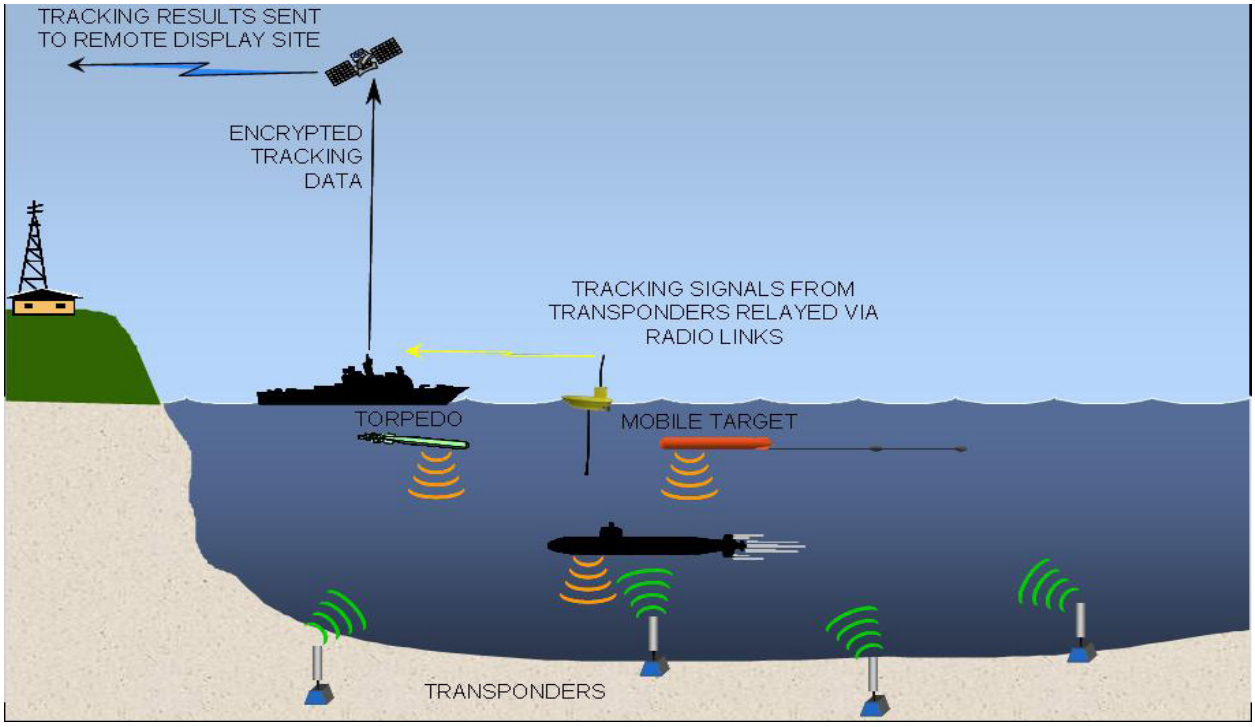

Figure H-16. Portable Undersea Training Range Deep (PUTR-D) Transponder Configuration

H.1.10 Advanced Extended Echo Ranging (AEER)

The Advance Extended Echo Ranging program examines improvements in both long-range shallow and deep water ASW search using active sources (Air Deployable Low Frequency Projector (ADLFP), Advance Ranging Source (ARS)) and passive sonobuoy receivers (Air Deployable Active Radar Receiver (ADAR)). The signal processing is provided by research conducted under Advanced Multi-static Processing Program (AMSP).

The AEER system is similar to the IEER system in that it uses the AN/SSQ-101 Air Deployed Active Receiver (ADAR) sonobuoy. But instead of the SSQ-110A Extended Echo Range Sonobuoy it is coupled with the SSQ-125 Air Deployable Coherent Source Sonobuoy. The SSQ-125 system is in the R&D stage with two types of sensor technology being considered (the ADLFP and ARS). The buoy is intended to provide the user with a sonobuoy with an improved bi-static acoustic source and better signal processing for harsh water environments. Table H-1 below is a comparison of the echo ranging systems.

Table H-1. Echo Ranging Systems

	Current System	Current System	Future System
Aircraft System =	EER	IEER	AEER
Buoys = (Source)	SSQ-110 (EER)	SSQ-110 (EER)	SSQ-125 (ADLFP)
Buoys = (Receiver)	SSQ-77 (VLAD)	SSQ-101 (ADAR)	SSQ-101 (ADAR)
Area of use =	Deep Water Only	Littoral &Deep Water	Enhanced Littoral & Deep Water
Used by	P-3C	P-3C (IOC)	P-3C/MH-60R

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