NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION AND CONFERENCE REPORT

Action Agency: Permits and Conservation Division of the Office of Protected Resources, National Oceanic and Atmospheric Administration's National Marine Fisheries Service

Activity Considered: Issuance of permit number 18529 to Jan Straley for research on marine mammals in the Gulf of Alaska, pursuant to section 10(a)(1)(A) of the Endangered Species Act.

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service

Approved: for

Donna S. Wieting
Director, Office of Protected Resources

Date: AUG - 8 2016

Public Consultation Tracking System (PCTS) number: PCTS FPR-2016-9162

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (16 USC 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7 (a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. When a Federal agency's action "may affect" a protected species, that agency is required to consult formally with the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS or the USFWS concurs with that conclusion (50 CFR §402.14(b)).

The Federal action agency shall confer with the NMFS, USFWS, or both, on any action which is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat (50 CFR §402.10). If requested by the Federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in §402.14.

Section 7(b)(3) of the ESA requires that at the conclusion of consultation or conference NMFS, USFWS, or both provide an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modifytheir designated critical habitat. If either Service determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, that Service provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7 (b)(4) requires the consulting agency to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

For the actions described in this document, the action agency is the Permits and Conservation Division of the Office of Protected Resources within the NMFS at the NOAA.

The biological opinion (opinion) and incidental take statement were prepared by the NMFS Endangered Species Act Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This document represents the NMFS' opinion on the effects of these actions on endangered and threatened species and critical habitat that has been designated for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

On April, 20, 2010 the NMFS Office of Protected Resources Permits and Conservation Division submitted a draft Environmental Assessment to the NMFS' Office of Protected Resouces ESA Interagency Cooperation Division for the propsed issuance of permit number (No.) 14122: Biology of Large Whales in Alaskan Waters to Jan Straley and seven additional permits to other scientific researchers. The Permits and Conservation Division subsequently consulted with us on the issuance of the proposed research permit and on July 14, 2010, we issued our biological opinion concluding that the issuance of these permits was not likely to jeopardize the continued existence of currently ESA-listed species, nor adversely modify designated critical habitat. Permit No. 14122 was a five year permit, which was later given a one year extension, and ends on July 31, 2016. The issuance of permit No.18529 by the Permits and Conservation Division would be a renewal of Jan Straley's existing permit activities with several modifications to the proposed research activities.

1.2 Consultation History

- On August 21, 2015, the Permits and Conservation Division sent application materials to the ESA Interagency Cooperation Division on a proposal to issue a permit for research on the habitat use and foraging ecology of sympatric marine mammals in the Gulf of Alaska.
- On January 26, 2016, the ESA Interagency Cooperation Division requested additional information from the Permits and Conservation Division regarding the permit application.
- On March 31, 2016, the ESA Interagency Cooperation Division requested additional information from the Permits and Conservation Division regarding the permit application.
- On April 12, 2016, the Permits and Conservation Division provided a response to the ESA Interagency Cooperation Division questions from March 31, 2016.
- On May 25, 2016, the Permits and Conservation Division sent updated application materials to the ESA Interagency Cooperation Division.
- On June 21, 2016, the Permits and Conservation Division requested section 7 consultation with the ESA Interagency Cooperation Division.
- On June 27, 2016, the ESA Interagency Cooperation Division deemed the application complete and initiated formal consultation with the Permits and Conservation Division.

2 DESCRIPTION OF THE PROPOSED ACTION

Issuance of permit number (No.) 18529 to Jan Straley would authorize research on humpback (*Megaptera novaeangliae*) , sperm (*Physeter macrocephalus*), and killer whales (*Orcinus orca*) in the Gulf of Alaska; other species will be included in the study as opportunities arises. Species listed under the ESA that would be studied include: blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), gray (*Eschrichtius robustus*) (Western North Pacific Distinct Population Segment (DPS)), humpback (*Megaptera novaeangliae)* (currently ESA-listed range-wide as endangered; proposed threatened Western North Pacific DPS would be studied), North Pacific right (*Eubalaena japonica*), sei (*Balaenoptera borealis*) , and sperm whales. Dolphin and whale species that are not listed under the ESA that will be studied are Dall's porpoises (*Phocoenoides dalli*), Harbor porpoises (*Phocoena phocoena*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), northern minke whales (*Balaenoptera acutorostrata*), unidentified beaked whales (*Ziphiidae*), Stejnegers beaked whales (*Mesoplodon stejnegeri*), Cuvier's beaked whales (*Ziphius cavirostris*), and Baird's beaked whales (*Berardius bairdii*).

The proposed research aims to: (1) improve and expand humpback whale studies; (2) study the movements, foraging behavior, and depredation activities of sperm whales; (3) study seasonal movements, foraging behavior, migration patterns, and depredation activities by killer whales; and, (4) enhance the overall knowledge, stock structure, and current species status through research activities involving disturbance, biological sampling, and tagging. If issued, the permit would be valid for five years (August 1, 2016 through July 31, 2020). The proposed research activities and "take" authorizations for the species that are ESA-listed are provided in Table 1. Research activities and take authorizations pursuant to the MMPA for species not listed under the ESA can be found in the permit application.

Table 1. Proposed "takes" of Endangered Species Act listed cetaceans during Jan Straley's research activities in the Gulf of Alaska under permit number 18529

Species	Proposed Activity/stressor	Life stage and sex	Annual Takes
Cetacean, unidentified	Collection of remains for killer whale predation study	All sex and age classes	25
Pinniped, unidentified (including ESA-listed remains)	Collection of remains for killer whale predation study	All sex and age classes	25
Blue whale	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	50
	Instrument, suction-cup (e.g. Very High Frequencey (VHF), Time Depth Recorder (TDR))	All >6 mo. age	15
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment	All >6 mo. age	15
	Sample, skin and blubber biopsy	All >6 mo. age	25
Fin whale	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	100
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All >6 mo. age	15

	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment;	All >6 mo. age	15
	Sample, skin and blubber biopsy	All >6 mo. age	40
Gray whale (Western North Pacific DPS)	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; measure; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	100
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All sex and age classes	20
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment;	Adult/juvenile	20
	Sample, skin and blubber biopsy	All sex and age classes	50
Humpback whale (current listing range-wide, proposed Western North Pacific DPS)	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	2000
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All >4 mo. age	50
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment;	All >4 mo. age	50
	Sample, skin and blubber biopsy	All >4 mo. age	200
	Instrument, suction-cup (e.g. VHF, TDR); Instrument, dart.barb tag	All >4 mo. age	20
North Pacific Right whale	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	50
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All >6 mo. age	10
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment; Instrument, implantable (e.g. satellite tag)	All >6 mo. age	10
	Sample, skin and blubber biopsy	All >6 mo. age	10
Sei whale	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; measure; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	50
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All >6 mo. age	15
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge	All >6 mo. age	15

	attachment; Instrument, implantable (e.g. satellite tag)		
	Sample, skin and blubber biopsy	All >6 mo. age	30
Sperm whale	Acoustic, passive recording; acoustic, sonar for prey mapping; Collect, sloughed skin; count/survey; import/export/receive, parts; observation: monitoring and behavioral; photo-id; photograph/video; sample, exhaled air; sample, fecal; tracking underwater photo/videography	All sex and age classes	500
	Acoustic, active playback/broadcast; Observation, monitoring and behavioral	Adult/juvenile	50
	Instrument, suction-cup (e.g., VHF, TDR); Tracking	All >6 mo. age	75
	Instrument, dart/barb tag; Instrument, dorsal fin/ridge attachment; Instrument, implantable (e.g. satellite tag)	All >6 mo. age	75
	Sample, skin and blubber biopsy	All >6 mo. age	200
	Acoustic, passive recording; Acoustic, sonar for prey mapping; Collect, sloughed skin; Count/survey; Import/export/receive, parts; Instrument, dart/barb tag; Instrument, suction-cup (e.g. VHF, TDR); Observation, monitoring; Observations, behavioral; Photo-id; Photograph/Video; Sample, exhaled air; Sample, fecal; Tracking; Underwater photo/videorgraphy	All >6 mo. age	20

2.1 Proposed Activities

The Permits and Conservation Division proposes to authorize the researcher’s directed take of several ESA-listed whale species to fulfill their scientific research objectives. Activities authorized under the proposed permit will include field research activities and the collection of marine mammal parts. The proposed activities are explained in detail below followed by measures that will be used to minimize disturbance to target and non-target species. Research activities include: modifying longline fishing procedures to assess whale behavior during fisheries, attachment of suction cup tags to whales, attachment of penetrating satellite tags to whales, taking photographs of whales, deploying and operating acoustic instrumentation that produce and monitor sounds, and collection of biological samples from whales and other cetaceans.

2.1.1 **Close approach by vessel**

All activities will be conducted during open water surveys in the Gulf of Alaska from boats ranging in size from less than 10 meters to a maximum of 25 meters. Longline vessels may be used to approach sperm whales during depredation studies as they are accustomed to these vessels. Research vessel surveys do not follow a particular route, rather are random in nature and designed to find aggregations of whales.

Close vessel approach will be used for photo identification, biopsy sampling, and/or to attach a tag. Whales will be slowly and cautiously approached within one to two body lengths, or sufficient distance to obtain a photograph of the ventral surface of the flukes, a dorsal fin or a biopsy sample. Individuals will be approached from behind or alongside (perpendicular) at a distance of 8 meters (25 feet) or more. Single lens reflex (SLR) digital cameras equipped with telephoto lenses or digital video cameras will be used for photography.

Efforts to mitigate excessive disturbance include the following:

- The vessel will avoid quick changes in speed and rotations per minute of the motor.
- Individual animals will not be approached for longer than one hour per day, or repeatedly in the same day.
- Close approaches will be terminated if animal disturbance is evident (i.e., changes in behavior, stress vocalizations, abrupt shifts in direction of movement).
- Close approaches will not be made in cases of resting or suckling animals.
- All efforts will be made to avoid separating mother and calf pairs.

2.1.2 **Directed fishing operation modifications**

During directed fishing operation modification experimentation, researchers will maintain control by providing oversight to direct and monitor normal fishing. To reduce depredation, modifications to fishing behavior will be used to determine what cues sperm whales are using to locate vessels and how whales are removing fish from longline fishing gear. Normal fishing sounds will be used to alter whale depredation behaviors. These normal fishing sounds consist of noise produced by the vessel when the hydraulic system, fisheries sonar, and engines are deliberately activated during times when fishing gear is not being hauled from the water. These sounds will be produced simultaneously and only just before, during, and just after normal fishing operations (“just before” and “just after” is generally 30 minutes). These controlled operations are needed to assess the cues whales use to find fishing vessels and longline fishing gear. During the proposed activities, an observer would be present on the fishing vessel to monitor whale behavior pre-, during, and post-fishing operation modifications and to photographyically identify individuals.

Normal operating conditions include the following:

- A longliner would arrive in a deployment area and immediately begin deploying longline gear on the ocean floor.
- The vessels might then either depart the area or loiter in the vicinity in neutral gear.
- After 3-17 hours the vessel would then travel to one end of the longline, marked by a surface flag, turn on its hydraulic system, grab the flag, and begin hauling the line to the surface.
- Once actual hooks arrive on the surface, the fishing vessel would generally engage and disengage its engine in an attempt to adjust the angle at which the fishing line is emerging from the water, with a goal of keeping the line as vertical as possible.
- At the same time the vessel generally is running its echosounder.

  - Under normal operations up to four distinct acoustic signals are being generated simultaneously: hydraulic system, cavitation bubble clouds from engine cycling operations, the engine sounds themselves, and the echosounder.

Modifications to operating conditions include the following:

- Upon arrival at an area, the fishing vessels would deploy autonomous passive acoustic recording devices (Figure 1). These recorders will monitor all subsequent acoustic activity in the area and may be attached to the vertical anchor lines of the longline or set apart from the longline on their own buoyed line. The deployment of this gear generally takes one to two hours. This activity is connected to the other activities because the recorders will monitor all acoustic activities from whales and vessels. The recorders remain in the water prior to and after all fishing activities have been completed.

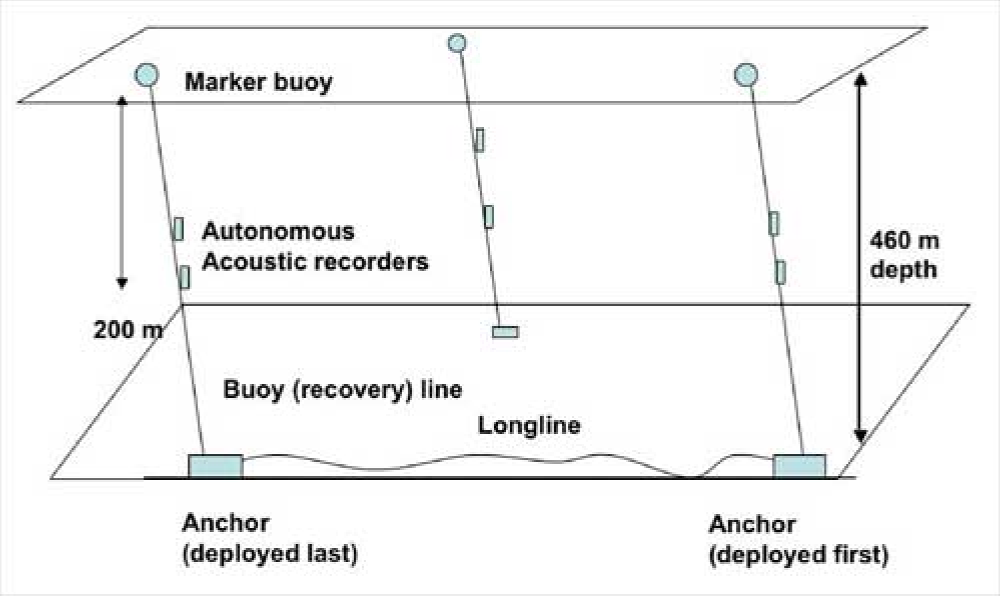

Figure 1. Setup of autonomous acoustic recorders

- The vessel operator would be requested to activate various systems in sequential fashion before the haul, to isolate the effects of various cues on animals' acoustic behavior. These activities would take place over times varying from eight hours to 30 minutes before the start of an actual haul. Specifically, the vessel operator would be asked to suspend then activate the echosounder, then after two minutes, activate the hydraulics, then two minutes after that, cycle the engines in a manner that simulates an active haul. After 3-10 such engine cycling the deliberate manipulation of the engine controls would cease.

Efforts to mitigate disturbance include the following:

- Controlled experiment will only occur once per deployment of fishing gear.
- Approaches will not exceed three times per year per individual.
- Close monitoring will occur so altering the behavior of an individual whale beyond four times annually is not exceeded.
- If, during deployments of scientific instrumentation, a whale becomes entangled, the line would be cut and all research activity stopped.

2.1.3 **Prey mapping**

Focal follows will be done on tagged whales or whales exhibiting a behavior of interest. These focal follows will occur from a vessel following behind the animal at a distance of approximately 100 meters. Laser range finders may be used to assess distance and bearing from the research platform with each surfacing. Follow-up photos will be used to confirm the identiy of the whale, note changes in group composition, and tag placement. Hydroacoustic sampling of the prey field may occur around animals using a towable or mounted echosounder. Vessels will follow behind whales to document the extent of their target prey. Such focal follows will occur until the tag falls off, the behavior of interst is terminated, or the crew retires. Focal follows may occur continuously for up to 18 hours.

2.1.4 **Tagging of whales**

Whales will be tagged with one of several tag types, including suction cup tags, satellite tages, and modified satellite tags designed to collected physiological data. These tag types are described in more detail below according to how they attach the the whale.

Suction cup tagging

Tagging by the suction cup method will record whale movement behavior (i.e., diving depth and three-axis acceleration) and vocalizations produced by the tagged whale as well as other non-target whale sounds (other marine life and vessel noise). There are two variations of suction cup tag that may be deployed: bioacoustic and Crittercam-type underwater video camera (Burgess 2000; Marshall 1998). Each tag can record temperature, depth, sound, acceleration, and position. Only the Crittercam-type suction cup tag records video. Each tag weighs about a 1.5 pounds or less, has similar dimensions (6-10 inches by 1.5-2 inches), and can be deployed using a long pole. The bioacoustic tag has two suction cups (Figure 2 and Figure 3) whereas the Crittercam only has one (Figure 4). Neither variation of suction cup tag produces sound, they simply passively record sounds made by the whale and surrounding environment. Depending on the quality of suction cup attachment, expected attachment times range from 2-18 hours. The suction cups do not use vacuum suction or other "active" methods to increase the success of the attachment. General procedures for the attachment of these tags are similar to procedures documented in Johnson and Tyack (2003). Tagging of whales will occur from small vessels and not from the fishing longline vessel. The type of tag deployed will depend on availability and if video recording is necessary. The acoustic recording capabilities of each tag are variable and will be taken into consideration when selecting which type of tag to apply to which species.

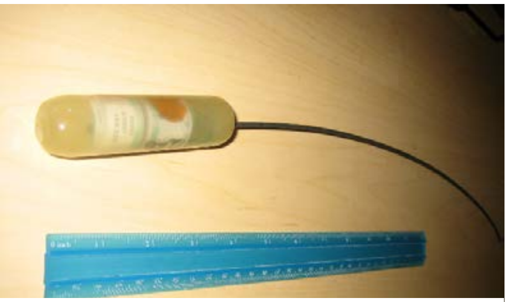

Figure 3. Very high frequency radio transmitter used with bioacoustic suction cup tag

Figure 2. Bioacoustic tag attached to a sperm whale in the Eastern Gulf of Alaska

Figure 4. Crittercam Generation 5.7, bioacoustic and video camera suction cup tag.

Successfully tagged whales will be tracked as long as whales and sea state permit. Monitoring of tagged whales will include photographing the site of attachment, evaluating tag attachment on the body (skin condition), tag movement, and observing whale behavior.

Efforts to mitigate disturbance include the following:

- A whale may be suction cup tagged up to four times annually; however it may require multiple approaches per successful deployment to assess whether the whale is in a behavioral state conducive to tagging.
- Approaches for photography and evaluation of behavior will be from a distance of 8 meters (25 feet) or greater and obtaining a trackline of movement will be done after the whale dives and the boat moves to the dive location to record position.
- Tags will be deployed without capturing individuals, thus eliminating risk associated with capture and handling.
- Approaches for the purposes of tagging will be made in a way as to minimize disturbance to individuals, with the research vessel gradually reducing speed as the group is approached to match the group/individual speed and direction.
- Photographs taken by other researchers working with the same individuals will be obtained when possible.

After tagging, whales will be monitored through focal follows (typically, no more than 3 hours) at a considerable distance to observe tag longevity and recover the tag after it has detached from the whale.

Dart/barb tags

Tagging by a dart/barb method will quantify movement patterns and dive behavior through satellite-linked transmitters and the Service Argos satellite system. Two different types of dart/barb tags will be used: 1) a "barnacle" or Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) style tag that consists of the electronics package sitting outside the whale and one, two, or three small attachment darts being inserted into the dorsal fin area (all species), and 2) a physiological style tag that is a modification of the dart/barb-style tag.

Barnacle/LIMPET: For sperm and humpback whales only, the barnacle/LIMPET style tag (Figure 5) will be the first choice of tag. The preferred approach distance will be 3-10 meters from the whale for both species and all tag types and deployment methods. The barnacle-style transmitters are deployed from a crossbow or an air gun, and the darts implant into the dorsal fin or body just below the dorsal fin (Andrews et al. 2005). The standard barnacle/LIMPET tag transmitters are approximately 6.0 centimeters by 3.5 centimeters by 2.5 centimeters and weigh approximately 50 grams with two barbed titanium or stainless steel darts. The darts will not penetrate deeper than 10.0 centimeters. The whales will be approached from a small vessel at a slow speed (as slowly as possible) to achieve deployment success and minimize harassment. It is anticipated that the basic barnacle type satellite tags will remain attached for approximately 1-2 months, with a maximum retention of approximately 8 months. The standard LIMPET tag sinks when the attachment eventually fails. For some whales, a barnacle-style tag that floats after release so that it can be recovered for retrieval of the data stored in internal memory will be used. The floating tag can be attached using an air-gun or with a hand-held pole. These tags typically incorporate 3 of the LIMPET-style darts that are approximately 4-5 millimeters in diameter and that penetrate no more than 10 centimeters into tissue. The shape and size of the current floating tag is shaped similar to a teacup, with a height of 65 millimeters and a diameter of 95 millimeters. The floating barnacle-style tags may fall off of their own accord, or they may be triggered to release from the whale using a radio link, or "remote-release" mechanism. The remote-release tags will incorporate a baseplate that attaches to the three darts, and the tag electronics will separate from this baseplate after receiving the release command. The baseplate with the three darts remains in the whale and will eventually be shed just as any barnacle style tag due to the water drag on the external components.

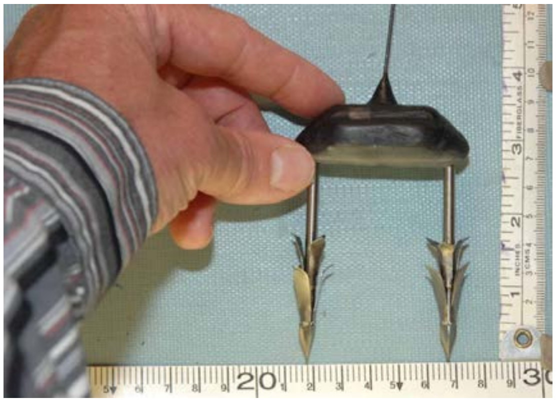

Figure 5. Satellite tag with two barbed darts.

Physiological tag: A modification of the floating barnacle-style tag with LIMPET darts is the Physiological tag. The Physiological tag utilizes satellite transmission capabilities for tracking movements of the whale, however the majority of physiological data will be stored in the internal memory of the tag, making recovery of the tag, after it falls off the whale, imperative. The floating Physiological tag will be deployed using a hand-held pole. When deployed with the secondary electrode on the tethered cable, a second pole held by a second tagger will be used, and both pieces of the tag will be placed onto the whale as close to simultaneously as possible. The target location for the main body of the Physiological tag with its three attachment darts is the flank of the whale, along the lateral or dorsal surface, no further forward than the front insertion of the pectoral flipper, and possibly as far back as the dorsal fin. The target location for the secondary electrode dart would be approximately 1 meter behind the main tag, in the flank anterior to the dorsal fin. The Physiological tag includes the main body of the tag with three attachment darts and a secondary smaller piece incorporating a remote electrocardiogram electrode that is tethered to the main body of the tag via an insulated electrical cable that can stretch to 1.5 meters. As with the barnacle/LIMPET tag the current design for the main body of the Physiological tag that is anticipated for use is shaped similar to a teacup, with a height of 80 millimeters and a diameter of 120 millimeters. It is attached using three darts that are approximately 4-5 millimeters in diameter and penetrate no more than 7 centimeters into tissue. The secondary electrode is a similar dart, measuring approximately 4-5 millimeters in diameter and having a length that penetrates no more than 7 centimeters into tissue. Therefore, the complete Physiological tag includes four darts that penetrate into the tissue. Similarly to the floating tag described above, the Physiological tag may fall off due to water drag or contact with another object by the tagged whale, or it may incorporate a remote-release mechanism which will sever the main body of the floating tag from the attachment darts. The attachment darts will then fall out over time due to the water drag pulling on the baseplate that ties the three darts together.

The satellite transmitters send ultra-high frequency (UHF) radio signals to Advanced Research and Global Observation Satellite (ARGOS) receivers on five NOAA Television Infrared Observation Satellites (TIROS-N series) weather satellites. The signals are sent only when the whales come to the surface, and consist of a 750 millisecond phase-modulated transmission at 401.650 Megahertz. The floating tags for measuring behavior or physiology are larger tags that are expected to fall off by themselves within 2 weeks. The floating tags with a remote-release mechanism will likely be triggered via radio link to release from the whale approximately 1 week after tagging.

An individual whale (all species excluding sperm whales) may be successfully satellite tagged once annually. Sperm whales may be successfully tagged three times annually due to tag failure (i.e. tag falling off or failing to transmit behavioral data). A whale satellite tagged may be approached for all activities requested in the take table for that species/age class.

2.1.5 **Playback device**

In order to determine whether an acoustic decoy can be used to attract sperm and killer whales away from fishing gear, acoustic playbacks of recorded fishing vessel hauling sounds will be deployed. The playback device is autonomous in that it has a self-contained power supply and electronics that permit it to be deployed without external connections to a power or signal source. All "attracting," or decoy, playbacks would play continuously for three to four hours during actual fishing hauls, looping over a 3-15 minute recording.

The playback device will be deployed on a buoyed line or fishing anchor lines, independently of any surface vessel, at depths of 20 meters or less. The playback device would be activated by radio signals by fishermen actively hauling a catch 2000-20000 meters away from the playback device. Under these circumstances continuous real-time visual monitoring may not be possible. Playbacks will be broadcast at levels no greater than 190 dB re 1 uPa at 1m (root mean square (rms) pressure), broadcast during daylight hours, and be monitored by autonomous passive acoustic recorders within 100 meters of the playback device on the same deployment line. Autonomous passive acoustic recorders, that are present, will document the signals being broadcast, and record the presence of acoustically active animals during playbacks. The restriction of source level to 190 dB guarantees that no target or non-target animal will be exposed to received impulsive levels greater than 160 dB at ranges greater than 30 m from the source. Visual observation of whales approaching the true fishing haul will be possible and occur from the fishing vessel in this experiment. The playback will be stopped via remote control, and if any observer notes signs of major disturbance, the "disable" signal will be sent to the acoustic playback device to halt the trial. The following will be interpreted as signs of major disturbance: (1) breaching; (2) tail slaps; and (3) underwater bubble cloud releases.

For sperm whales only:

(1) Video cameras may be placed on demersal longlines under normal fishing operations to identify and record whales at depth interacting with fishing gear.
(2) The camera may use artificial lighting to be recorded 3-5 meters from the camera.
(3) Lights are 2000 lumens, sourced from Mountain Electronics (or a similar company), and prgrammed to be on for a limited time (around 2 hours).

An individual will be not be taken by playback more than two times each year. During playback a whale will not be approached during the same encounter for any other permitted activity but may be approached outside playback for disturbance by harassment, biological sampling, tagging or fishing modification (sperm whale only).

2.1.6 **Biological Sampling**

As part of the research, whales will be sampled using a variety of different methods to address the research objectives. Samples will include biopsies, sloughed skin, blow, prey parts, dead parts, and feces. Each are discussed in more detail below.

Biopsy

Biopsy sampling for genetic analysis will be obtained using a small, ultra-light dart, about 5 millimeter in diameter, fired from a modified 22 pneumatic rifle (described in Barrett-Lennard et al. 1996) or a crossbow (Lambertsen 1987; Winn et al. 1973). The dart will hit the dorsal flank and extract a small tissue sample and bounce off. The hollow shaft and dart will float and can be retrieved by the research team. Biopsy samples may be collected upon any age class of individual. It is important to obtain a representative sample of individuals within a population for stock definition, sex, age/length, reproductive status, prey, familial relationships, among other parameters. Samples from calves are necessary for paternity and are valuable in describing gene flow within a population. Biopsies will be obtained from all species, with some individuals sampled more than once. Multiple biopsies over time are necessary to assess shifts in diet for foraging studies across seasons and changes in prey and habitat over time. Each whale will at a minimum be photo-identified prior to or at the time of biopsy.

Efforts to mitigate excessive disturbance include the following:

- Calves will be sampled on the feeding grounds, after completing one oceanic migration, and could be 4-12 months in age.
- Care will be taken to minimize disturbance to mothers and calves.
- No animal will be biopsied needlessly and activity will stop if the mother shields the calf or is otherwise disturbed.
- Cumulative activities per individual will not exceed ten approaches daily.
- On average less than one hour will be spent with any whale (typically only 10 minutes/approach with humpback whales).

Preserved skin samples (either frozen, or stored in dimethyl sulfoxide (DMSO) or ethanol) will be kept in appropriate storage at the University of Alaska (institute of principle investigator) or sent to colleagues at the Southwest Fisheries Science Center (SWFSC) genetic laboratory for archiving, or to Dr. C.S. Baker at Oregon State University in Newport, Oregon for genetic analysis, or to a laboratory at the University of Alaska or NOAA (Juneau, Alaska) for stable isotope analysis of diet and trophic levels using the isoptopic signal indicating but not limited to the isotopes of nitrogen (15N/14N) and carbon (13C/12C).

Sloughed skin

Unlimited sloughed skin samples will be taken from all species discussed throughout the proposed permit time frame. The sloughed skin will be collected by skimming the water surface after a whale is surface active (breaching or otherwise slapping their body upon the water's surface). Preserved skin samples (either frozen, or stored in DMSO or ethanol) will be kept in appropriate storage at the University of Alaska or sent to colleagues at the SWFSC genetic laboratory for archiving or to Dr. C.S. Baker, Oregon State University, Newport, Oregon for genetic analysis.

Blow samples

Blow samples will be collected to study the microbial communities, DNA, and hormones of the respiratory system of free-swimming whales. Studying microbial communities of free-swimming whales may provide a proxy to follow population health and in addition act as a tool to look at social relationships between whales by examining the patterns of shared microbial communities. Additionally, blow samples will be evaluated, if sufficient DNA material is present, for genetic analysis as this may provide a non-invasive alternative to biopsy sampling.

Hormones, specifically glucocorticoids like cortisol, are essential to an animal's ability to adapt to fluctuations in environment and physiological demands. Glucocorticoid levels can be used as a measurement of stress and will vary in response to perceived stressors, including anthropogenic effects. In some cases, blow and biopsy samples will be collected during the same approach on a whale to compare the two methods.

The collection device is a wood frame with two Velcro connection points. Two 25 centimeter by 25 centimeter sterile polystyrene dishes are affixed to the Velcro. This collection device is attached to a six to 10 meter carbon fiber pole. The collection pole is extended towards the exhaled blow of the whale. The blow samples or exhaled breath condensate (EBC) will be collected onto a variety of collection media including: Petri dish, cotton gauze, nylon, microbial swabs, and agar plates, which are secured over the collection frame.

Individual whales will be approached from behind and the boat maneuvered so that the wind will push the blow sample towards the sampling device on the vessel at a distance within 10 meters.

Prey parts, dead parts, and feces

Killer whale prey parts and dead parts will be collected after a killer whale makes a kill. These prey parts may be from any ESA-listed species in the area, as well as species not listed under the ESA. Tissues obtained from prey parts and dead parts will be used to determine target prey species.

The remains of feeding bouts, will be fragments of floating skin, blubber, and occasionally an uneaten body organ. In this study, killer whales will be followed at distances exceeding 200 meters, and observed where they move in relation to the distribution of sea lions and other potential prey (small and large cetaceans). Careful observation of all predation events will occur aboard a research vessel using high-powered binoculars which may aide in the identification of prey species. When whales change location remains of prey will be collected for genetic analysis to determine prey species and related information. An approach to the whale, prey parts, or dead parts will not be made until it is clear that the kill has been made, whales are done feeding, and bits or discarded pieces of prey are suspected to be present. Parts will be collected with a long handled dip net and either frozen or placed in vials of DMSO or ethanol for later genetic analysis. Parts will be sent for species and sex identification to Craig Matkin, North Gulf Oceanic Society, Homer, Alaska and/or to NMFS, Northwest Fisheries Science Center (NWFSC), Southwest Fisheries Science Center (SWFSC), La Jolla, California for archiving at the SWFSC genetics laboratory. Parts may be exported to Canada for species identification and sex as well. Samples will be sent to the most appropriate lab that can conduct the necessary analyses. The archived portion of the sample will be insurance against loss or analysis failure and can be used for future unforeseen analyses. Prey parts from kills by killer whales may be from Steller sea lions, harbor seals, harbor and Dall's porpoises', Northern fur seals, Pacific white-sided dolphins and all large cetaceans. The number of samples requested annually will likely not exceed 25 each year but the species cannot be predicted in advance.

Fecal samples are collected after defecation is observed for all cetacean species. It is collected with a skim net after the whale leaves the area, usually at a distance of 20 meters or more. Fecal samples will be collected from all cetacean species with unlimited samples per individual.

2.2 Action Area

Research would occur in the Gulf of Alaska along the continental shelf break from 55º 10’ N, 153º 45’ W to 54º 10’ N, 134º 0’ W (Figure 6).

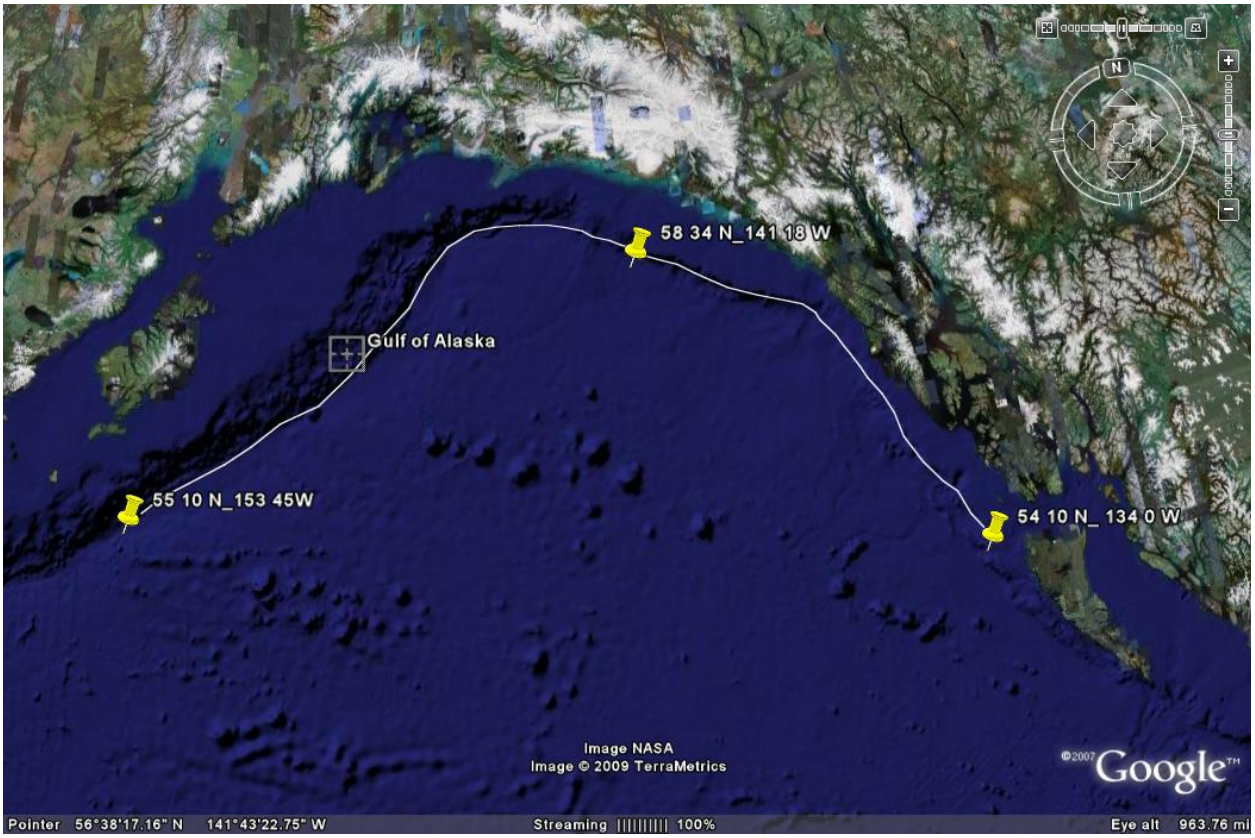

Figure 6. Google map showing latitude and longitude coordinates of main area of research within the action area, Gulf of Alaksa

2.3 Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS determined that there are not interrelated or interdependent actions outside the scope of this consultation.

3 OVERVIEW OF THE ASSESSMENT FRAMEWORK

Section 7 (a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions either are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

“To jeopardize the continued existence of an ESA-listed species” means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). The jeopardy analysis considers both survival and recovery of the species.

Section 7 assessment involves the following steps:

1) We identify the proposed action and those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on the physical, chemical, and biotic environment within the action area, including the spatial and temporal extent of those stressors.
2) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time.
3) We describe the environmental baseline in the action area including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, impacts of state or private actions that are contemporaneous with the consultation in process.
4) We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. This is our exposure analysis.
5) We evaluate the available evidence to determine how those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.
6) We assess the consequences of these responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. This is our risk analysis.
7) The adverse modification analysis considers the impacts of the proposed action on the critical habitat features and conservation value of designated critical habitat. This opinion relies on the recently updated regulatory definition of “destruction or adverse modification” of critical habitat at 50 CFR §402.02: a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.
8) We describe any cumulative effects of the proposed action in the action area.

   Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

9) We integrate and synthesize the above factors by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:
    a) Reduce appreciably the likelihood of both survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or
    b) Reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the status of the species and critical habitat.
10) We state our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

To comply with our obligation to use the best scientific and commercial data available, we conducted electronic and manual searches to identify information relevant to the potential stressors and responses of marine mammals, sea turtles, and fish species that may be affected by the proposed action to draw conclusions about the likely risks to the continued existence of these species and the conservation value of their critical habitat.

4 STATUS OF ENDANGERED SPECIES ACT LISTED SPECIES

This section identifies the ESA-listed species that may be affected by issuance of permit No. 18529 (Table 3). It then summarizes the biology and ecology of those species and what is known about their life histories in the action area. The species potentially occurring within the action area are ESA-listed in Table 3, along with their regulatory status.

For this and all subsequent species, the term “population” refers to groups of individuals whose patterns of increase or decrease in abundance over time are determined by internal dynamics (births resulting from sexual interactions between individuals in the group and deaths of those individuals) rather than external dynamics (immigration or emigration). This definition is a reformulation of definitions articulated by Futuymda (1986) and Wells and Richmond (1995) and is more restrictive than those uses of ‘population’ that refer to groups of individuals that co-occur in space and time but do not have internal dynamics that determine whether the size of the group increases or decreases over time (Wells and Richmond 1995). The definition we apply is important to section 7 consultations because such concepts as ‘population decline,’ ‘population collapse,’ ‘population extinction,’ and ‘population recovery’ apply to the restrictive definition of ‘population’ but do not explicitly apply to alternative definitions. As a result, we do not treat the different whale “stocks” recognized by the International Whaling Commission (IWC) or other authorities as populations unless those distinctions were clearly based on demographic criteria. We do, however, acknowledge those "stock" distinctions in these narratives.

Table 2. Endangered Species Act listed threatened and endangered species that may be affected by Jan Straley's marine mammal research in the Gulf of Alaska.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Beluga Whale (*Delphinapterus leucas)*- Cook Inlet DPS	E – 73 FR 62919	-- --	05/2015
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Gray Whale (*Eschrichtius robustus)*- Western North Pacific DPS	E – 35 FR 18319	-- --	
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538
Humpback Whale (Megaptera novaeangliae)- Proposed threatened Western North Pacific DPS	E – 35 FR 18319 and 80 FR 22304 (Proposed)	-- --	55 FR 29646
North Pacific Right Whale (Eubalaena glacialis)	E – 73 FR 12024	59 FR 28805	70 FR 32293
Sei Whale (Balaenoptera borealis)	E – 35 FR 18319	-- --	76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584
Marine Mammals – Pinnipeds			
Steller Sea Lion (*Eumetopias jubatus)*- Western DPS	T – 55 FR 49204	58 FR 45269	03/2008
Sea Turtles			
Leatherback Turtle (*Dermochelys coriacea*)	E – 61 FR 17	44 FR 17710	63 FR 28359
Fishes			
Chinook salmon (*Oncorhynchus tshawytscha)*			
California costal ESU	T -- 70 FR 37160	70 FR 52488	80 FR 60125
Central Valley spring-run ESU	T -- 70 FR 37160	70 FR 52488	79 FR 42504
Lower Columbia River ESU	T -- 70 FR 37160	70 FR 52630	78 FR 41911
Upper Columbia River spring-run ESU	E -- 70 FR 37160	70 FR 52630	72 FR 57303
Puget Sound ESU	E -- 70 FR 37160	70 FR 52630	72 FR 2493
Sacramento River winter-run ESU	E -- 70 FR 37160	58 FR 33212	79 FR 42504
Snake River fall-run ESU	T -- 70 FR 37160	58 FR 68543	Draft Recovery Plan (9/2015)
Snake River spring/summer-run ESU	E -- 70 FR 37160	64 FR 57399	Draft Recovery Plan (2011)
Upper Wilametter River spring-run ESU	T -- 70 FR 37160	70 FR 52630	76 FR 52317
Chum salmon (*Oncorhynchus keta)*			

Species	ESA Status	Critical Habitat	Recovery Plan
Columbia River ESU	T -- 70 FR 37160	70 FR 52630	78 FR 41911
Hood Canal summer-run ESU	T -- 70 FR 37160	70 FR 52630	Recovery Plan (6/2005)
Coho salmon (*Oncorhynchus kisutch)*			
Central California coast ESU	E -- 70 FR 37160	64 FR 24049	77 FR 54565
Lower Columbia River ESU	T -- 70 FR 37160	81 FR 9251	78 FR 41911
Oregon coast ESU	T -- 73 FR 7816	73 FR 7816	80 FR 61379
Southern Oregon and Northern California coasts ESU	T -- 70 FR 37160	64 FR 24049	79 FR 58750
Eulachon (*Thaleichthys pacificus)*			
Southern DPS	T -- 75 FR 13012	76 FR 65323	-- --
Sockeye salmon (*Oncorhynchus nerka)*			
Ozette Lake ESU	T -- 70 FR 37160	70 FR 52630	74 FR 25706
Snake River ESU	E -- 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead (*Oncorhynchus mykiss)*			
Puget Sound DPS	T -- 72 FR 26722	81 FR 9251	72 FR 2493
Central California coast DPS	T -- 71 FR 834	70 FR 52488	80 FR 60125
Snake River DPS	T -- 71 FR 834	70 FR 52630	Draft Recovery Plan (2011)
Upper Columbia River DPS	T -- 71 FR 834	70 FR 52630	72 FR 57303
Southern California DPS	E -- 71 FR 834	70 FR 52488	77 FR 1669
Middle Columbia River DPS	T -- 71 FR 834	70 FR 52630	74 FR 50165
Lower Columbia River DPS	T -- 71 FR 834	70 FR 52630	78 FR 41911
Upper Willametter River DPS	T -- 71 FR 834	70 FR 52630	76 FR 52317
Northern California DPS	T -- 71 FR 834	70 FR 52488	80 FR 60125
South-Central California coast DPS	T -- 71 FR 834	70 FR 52488	78 FR 77430
California Central Valley DPS	T -- 71 FR 834	70 FR 52488	79 FR 42504

4.1 Endangered Species Act listed Species and Critical Habitat Not Likely to be Adversely Affected

The proposed action is not likely to adversely affect some ESA-listed species and designated critical habitats that occur in the action area because the anticipated effects on those species and habitats are expected to be either insignificant or discountable. “Insignificant” effects relate to the size of impact and do not result in take. “Discountable” effects are those that we consider unlikely to occur.

4.1.1 **Cook Inlet Beluga Whales**

Though rare, beluga whales, likely from the Cook Inlet distinct population segment (DPS), have been observed in the vicinity of Kodiak Island (Laidre et al. 2000), one of the focus areas of the proposed research. The research vessel will have trained observers onboard that will assist in avoiding non-target species, such as beluga whales. If an individual or group is encountered, the research vessel will minimize disturbance by not approaching within 90 meters or halting research operations until the whale(s) have left the area. Because of the distinct physical characteristics of beluga whales, in the rare chance they are present in the research location they are likely to be observed and avoided. Additionally, the slow transit speeds of the research vessel should minimize the possibility of a ship strike (Section 6.2.1 has further detail on potential impacts from research vessel traffic). The risk to Cook Inlet beluga whales is discountable and we conclude that Cook Inlet beluga whales are not likely to be adversely affected by the issuance of permit No. 18529 and we do not discuss beluga whales further in this opinion.

4.1.2 **Western Distinct Population Segment Stellar Sea Lions**

Steller sea lions were originally listed as threatened under the ESA on November 26, 1990 (55 FR 49204), following a decline in the U.S. of about 64 percent over the previous three decades. In 1997, the species was split into two separate DPSs based on demographic and genetic differences (Bickham et al. 1996; Loughlin 1997), and the western DPS was reclassified to endangered (62 FR 24345) while the eastern DPS remained threatened (62 FR 30772). On April 18, 2012, the NMFS proposed to delist the eastern DPS of Steller sea lions (77 FR 23209). On November 4, 2013, the NMFS announced that as of December 4, 2013, the eastern DPS of Steller sea lions would be delisted and no longer protected under the ESA (78 FR 66139).

Steller sea lion centers of abundance and distribution are in Gulf of Alaska and the Aleutian Islands, and therefore could occur in the action area in the marine waters around Kodiak Island and the Shumagin Islands. The NMFS currently estimates the western DPS to have 52,209 individuals (Allen and Angliss 2013). Although data vary for the 31 major rookeries, as a whole, the DPS has been increasing in size by an average of 1.8 percent annually from 2001 through 2011 (Allen and Angliss 2013).

Most adult Steller sea lions occupy rookeries during the summer pupping and breeding season and exhibit a high level of site fidelity. During the breeding season, some juveniles and nonbreeding adults occur at or near the rookeries, but most are on haulouts (sites that provide regular retreat from the water on exposed rocky shoreline, gravel beaches, and wave-cut platforms or ice) (Ban 2005; Call and Loughlin 2005; Rice 1998). Adult males may disperse widely after the breeding season. During fall and winter many sea lions disperse from rookeries and increase use of haulouts, particularly on terrestrial sites but also on sea ice in the Bering Sea. Western Stellers appear to be moving from western Alaska to the central and eastern Gulf of Alaska areas (Fritz et al. 2013). Diving activity is highly variable in Steller sea lion by sex and season. During the breeding season, when both males and females occupy rookeries, adult breeding males rarely, if ever, leave the beach (Loughlin 2002). However, females tend to feed at night on one to two day trips and return to nurse pups (NRC 2003a). Female foraging trips during winter are longer (130 kilometers) and dives are deeper (frequently greater than 250 meters). Summer foraging dives, however, are closer to shore (about 16 kilometers) and shallower (100-250 meters) (Loughlin 2002; Merrick and Loughlin 1997). As pups mature and start foraging for themselves, they develop greater diving ability until roughly 10 years of age (Pitcher et al. 2005). Juveniles usually make shallow dives of 70 to 140 meters over 1 to 2 minutes, but much deeper dives in excess of 300 meters are known (Loughlin et al. 2003; Merrick and Loughlin 1997; Rehberg et al. 2001). Young animals also tend to stay in shallower water less than 100 meters deep and within 20 kilometers from shore (Fadely et al. 2005).

Based on the species’ distribution, life history, and the location of the proposed research, Western DPS Steller sea lions could come in close proximity to vessels during research activities. We expect Steller sea lions in close proximity to the research vessel to exhibit either no visible reaction or short-term behavioral responses such as temporarily leaving the immediate area of the field research. We do not believe Steller sea lions are at risk of being struck by research vessels due to their mobility and because we expect the research vessel operators would be able to locate, identify, and avoid all sea lions during transit and research activities. For these reasons, we find the risk to Steller sea lions to be discountable and that the proposed action is not likely to adversely affect Western DPS Steller sea lions. Therefore we do not consider this species further in this opinion.

4.1.3 **Leatherback Sea Turtle**

Authorized activities would not be conducted in sea turtle critical habitat or near nesting sites. We believe that encounters with Leatherback sea turtles would be uncommon due to the fact that proposed activities are designed with the purpose of finding and conducting research on cetaceans and the low overall density of leatherback sea turtles. The frequency and occurrence of leatherback sea turtles in the Gulf of Alaska is extremely rare. In 47 years there have only been 19 documented occurences in the Gulf of Alaska (DoN 2006; Hodge and Wing 2000). There are no density estimates available at this time due to the rarity in presence. The research vessel will have trained observers onboard that will assist in avoiding non-target species, such as Leatherback sea turtles. If a Leatherback sea turtle is encountered, the research vessel will make efforts to minimize disturbance by not approaching within 90 meters or halting research operations until the individual has left the area. Additionally, the slow transit speeds of the research vessel should minimize the possibility of a ship strike. For these reasons, we find the risk to leatherback turtles to be discountable and that the proposed action is not likely to adversely affect leatherback turtles. Therefore, we do not consider this species further in this opinion.

4.1.4 Fishes

The ESA-listed fish species that may occur in the action area spend years in the marine environment before returning to natal streams to spawn. Research efforts under the proposed permit would be conducted in ways that should only affect target cetaceans. No netting, hooks, or other devices would be placed in the water column that could pose a risk to fish species.The directed fishing operation modification experimentation is not expected to have any effect to ESA-listed fish in the action area. The fishing operation modifications involve altering the order in which normal fishing vessel sounds are played and do not involve an increase in volume. Longline fishing vessels in the Gulf of Alaska target Pacific Cod, Black Cod, and Turbot none of which are ESA-listed species of fish. Additionally, we consider it highly unlikely that listed fish species would be exposed to ship strikes and consider any threats posed by this stressor to be discountable and we conclude that the proposed action is not likely to adversely affect ESA-listed fishes. Therefore, we do not consider any ESA-listed fish species further in this opinion.

4.1.5 Western Distinct Population Segment Steller Sea Lion Critical Habitat

The proposed action will occur within designated Critical Habitat for Western DPS Steller sea lions. Critical habitat for the species was designated on August 27, 1993 (58 FR 45269). In Alaska, major Steller sea lion rookeries, haulouts, and associated terrestrial, air, and aquatic zones are designated as critical habitat. Terrestrial and air zones of rookeries and haulouts will not be affected by this action because research activities will only occur in the aquatic environment. Aquatic areas surrounding major rookeries and haulout sites, where the proposed action will occur, provide foraging habitats, prey resources, and refuge considered essential to the conservation of Steller sea lions. Proposed research activities will not affect prey resources, and only disturb foraging behavior and use of refuge habitat at the surface of the water temporarily. It is expected that Steller sea lions would resume normal foraging and use of refuge habitat shortly after researchers leave the area. Therefore, the proposed activities are not likely to destroy or adversely modify the designated critical habitat for Steller sea lions, and Steller sea lion critical habitat is not addressed further in this opinion.

4.1.6 North Pacific Right Whale Critical Habitat

In July 2006, NMFS designated two areas as critical habitat for right whales in the North Pacific (71 FR 38277). The areas encompass about 36,750 square miles of marine habitat, which include feeding areas within the Gulf of Alaska and the Bering Sea that support the species. The primary constituent element to this critical habitat is the presence of large copepods and oceanographic factors that concentrate this prey. At present, the presence of large copepods has not been significantly degraded due to human activity. However, significant concern has been voiced regarding the impact that oceanic contamination of pollutants may have on the food chain and consequent bioaccumulation of toxins by marine predators. Changes due to global warming have also been raised as a concern that could affect the distribution or abundance of copepod prey for several marine mammals, including right whales.

The study area does overlap Critical Habitat for North Pacific right whales in the Gulf of Alaska. Effects to designated critical habitat may include vessel noise, pollution from the vessel, and sea-surface disturbance. We do not expect the proposed research activities to effect the oceanographic features that concentrate copepod prey in the area. Copepod aggregation density is based upon oceanographic factors such as circulation patterns, water depth, thermal fronts, and hydrographic density gradients (Pace III and Merrick 2008). During daylight hours, when research would occur, copepods are usually found below the surface of the water which would minimize disturbance from vessel traffic. Furthermore, vessel pollution would be minimal, diluted, and likely not reach them. In addition, we could not find any evidence suggesting that sound alters the densities of copepods (Bennet et al. 1994). Thus, we consider the effects of vessel noise, pollution from the vessel, and sea-surface disturbance to be insignificant. Therefore, the proposed action is not likely to destroy or adversely modify the critical habitat that has been designated for North Pacific right whales. As a result, critical habitat of North Pacific right whales will not be considered further in this opinion.

4.2 Endangered Species Act listed Species Likely to be Adversely Affected

Based on the anticipated exposure and response of species to stressors, we identified the endangered and threatened species that are likely to be adversely affected by the proposed research activities. This section of the opinion consists of narratives for each of the threatened and endangered species that occur in the action area and that may be adversely affected by the proposed research activities. In each narrative, we present a summary of information on each species to provide a foundation for the exposure analyses that appear later in this opinion.

4.2.1 **Blue Whale**

The blue whale, *Balaenoptera musculus*, is a cosmopolitan species of baleen whale. It is the largest animal ever known to have lived on Earth with recorded body lengths of adults in Antarctica reaching about 33 meters (108 feet) and weights of 150,000 kilograms (330,700 pounds) or more. The largest blue whales reported from the North Pacific are a female that measured 26.8 meters (88 feet) taken at Port Hobron in 1932 (Reeves et al. 1985) and a 27.1 meter (89 feet) female taken by Japanese pelagic whaling operations in 1959 (NMFS 1998).

As is true of other mysticeti, female blue whales are somewhat larger than males. Blue whales are identified by the following characteristics: a long-body and comparatively slender shape; a broad, flat "rostrum" (snout) when viewed from above; a proportionately smaller dorsal fin than other mysticeti; and, a mottled gray color pattern that appears light blue when seen through the water.

Distribution

Blue whales inhabit all oceans from sub-polar to sub-tropical latitudes, and typically occur near the coast, over the continental shelf, but have also been found in oceanic waters. Poleward movements in spring allow the whales to take advantage of high zooplankton production in summer. They migrate seasonally between summer and winter; however some evidence suggests that individuals remain in certain areas year-round. Information about distribution and movement varies with location, and migratory routes are not well known, but it is thought that the distribution of blue whales is largely driven by the presence of their primary food source, krill.

In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California south to Costa Rica in the east. They occur primarily south of the Aleutian Islands and the Bering Sea.

Population Structure

Little is known about population and stock structure of blue whales, however studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Some suggest that as many as 10 global populations exist, while others suggest that the species is composed of a single panmictic (random mating) population (Gambell 1979; Gilpatrick Jr. and Perryman 2009; NMFS 1998). For management purposes, the IWC considers all Pacific blue whales to be a single stock, whereas under the MMPA, the NMFS recognizes four stocks of blue whales: western North Pacific Ocean, eastern North Pacific Ocean, Northern Indian Ocean, and Southern Hemisphere.

Until recently, blue whale population structure had not been tested using molecular or nuclear genetic analyses (NMFS 1998). Blue whales in the North Pacific probably exist in two sub-populations:

- Eastern North Pacific
- Western North Pacific

The Eastern stock is believed to spend winters off of Mexico and Central America, and feed during summer off the U.S. West Coast and, to a lesser extent, in the Gulf of Alaska and central North Pacific waters.

The Western stock appears to feed in summer in the southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska (Stafford 2003). In winter, they migrate to lower latitudes in the western Pacific and, less frequently, in the central Pacific, including Hawaii (Stafford et al. 2001).

Blue whales accompanied by young calves have been observed often in the Gulf of California from December through March therefore proving that this area may be important for blue whale calving and nursing.

Acoustic monitoring has recorded blue whales off Oahu and the Midway Islands, although sightings or strandings in Hawaiian waters have not been reported (Barlow et al. 1997; Northrop et al. 1970; Thompson and Friedl 1982). These recordings also showed bimodal peaks of blue whales, suggesting migration into the area during summer and winter (McDonald and Fox 1999; Thompson and Friedl 1982). Nishiwaki (1966) notes blue whale occurrence among the Aleutian Islands and in the Gulf of Alaska, but until recently, no one has sighted a blue whale in Alaska for some time, despite several surveys (Carretta et al. 2005; Forney and Brownell Jr. 1996; Leatherwood et al. 1982; Stewart et al. 1987), possibly supporting a return to historical migration patterns (Calambokidis et al. 2009a).

Blue whales from both the eastern and western North Pacific have been heard, tracked, or harvested in waters off Kodiak Island, however call detection of blue whales from the western North Pacific indicate a greater likelihood of these individuals occurring southwest of Kodiak Island (COSEWIC 2002; Ivashin and Rovnin 1967; Moore et al. 2006; Stafford et al. 2007; Yochem and Leatherwood 1985). Acoustic detections in the Gulf of Alaska were absent since the late 1960s, however, recordings increased from 1999-2002 and a few sightings have been made in the northern Gulf of Alaska (Calambokidis et al. 2009a; Moore et al. 2006; Stafford 2003; Stafford et al. 2007; Stafford and Moore 2005). Surveys conducted in the western Gulf of Alaska and east of Kodiak Island have not found blue whales (Rone et al. 2010; Zerbini et al. 2006).

Movement

Blue whales are highly mobile; however their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). It is understood that blue whales primarily migrate toward the warmer waters of the subtropics in the fall to reduce energy costs, avoid ice entrapment, and reproduce.

Satellite tagging indicates that, for blue whales tagged off Southern California, movement is more linear and faster (3.7 kilometers/hour) while traveling versus while foraging (1.7 kilometers/hour) (Bailey et al. 2010). Data gather from tagged individuals indicates that residency times in what are likely prey patches averages 21 days and constitutes 29 percent of an individual’s time overall, although foraging could occur at any time of year (Bailey et al. 2010). Broad scale movements also vary greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2010). Blue whales along Southern California were found to be traveling 85 percent of the time and milling 11 percent (Bacon et al. 2011).

Reproduction

Blue whale gestation takes 10-12 months, followed by a 6-7 month nursing period. Sexual maturity occurs at 5-15 years of age and calves are born at 2-3 year intervals (COSEWIC 2002; NMFS 1998; Yochem and Leatherwood 1985). The mean intercalving interval in the Gulf of California is roughly two and a half years (Sears et al. 2014). Once mature, females return to the same areas where they were born to give birth themselves (Sears et al. 2014). Blue whales may reach 70-80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

Diving and Social Behavior

Blue whales spend more than 94 percent of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 second intervals before a deep dive of 3-30 minutes (Croll et al. 1999a; Leatherwood et al. 1976; Maser et al. 1981; Yochem and

Leatherwood 1985). Average foraging dives are 140 meters deep and last for 7.8 minuntes (Croll et al. 2001a). Non-foraging dives are shallower and shorter, averaging 68 meters and 4.9 minuntes (Croll et al. 2001a). Dives of up to 300 meters are known to have been recorded (Calambokidis et al. 2003). Nighttime dives have also been recorded and their data shows more shallow depths of approximately 50 meters.

Blue whales typically occur alone or in groups of up to five animals, although larger foraging aggregations of up to 50 have been reported including aggregations mixed with other rorquals such as fin whales (Corkeron et al. 1999; Shirihai 2002). Little is known of the mating behavior of blue whales.

Feeding

Data indicates that some summer feeding takes place at low latitudes in upwelling-modified waters, and that some whales remain year-round at either low or high latitudes (Clarke and Charif 1998; Hucke-Gaete et al. 2004; Reilly and Thayer 1990; Yochem and Leatherwood 1985). The availability of krill, the primary prey of blue whales in the North Pacific, likely dictates blue whale distribution throughout the year (Burtenshaw et al. 2004; Clapham et al. 1999; Kawamura 1980; Sears 2002 as cited in NMFS 2006a; Yochem and Leatherwood 1985). The large size of blue whales requires higher energy requirements than smaller whales and potentially prohibits fasting (Mate et al. 1999). While feeding, blue whales show slow and less obvious avoidance behavior when compared to not feeding (Sears et al. 1983 as cited in NMFS 2005).

Vocalization and Hearing

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Edds-Walton 1997; Payne and Webb 1971; Thompson et al. 1992). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hertz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Edds-Walton 1997; Payne and Webb 1971). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999). Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hertz. Reported source levels are 180-188 dB re 1µPa, but may reach 195 dB re 1µPa (Aburto et al. 1997; Clark and Ellison 2004; Ketten 1998; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μPa_{rms} at 1 m in the 17-30 Hertz range and pygmy blue whale calls at 175± 1 dB re 1 µPa$_{rms}$ at 1 m in the 17-50 Hertz range. Blue whale vocalizations tend to be long (>20 seconds), low-frequency (<100 Hertz) signals, with a range of 12-400 Hertz and dominant energy in the infrasonic range of 12-25 Hertz (Ketten 1998; McDonald et al. 2001; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls. Calls are short-duration sounds (2-5 seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80-30 Hertz), with seasonally variable occurrence.

Blue whale songs consist of repetitively patterned sounds produced over time spans of minutes to hours, or even days at frequencies of 16-60 Hertz (Cummings and Thompson 1971b; McDonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, which are repeated combinations of 1-5 units (Mellinger and Clark 2003; Payne and McVay 1971). A song is composed of many repeated phrases. Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recordings from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hertz compared to approximately 22.5 Hertz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world’s ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist, but none have emerged as the probable cause.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific have also been reported (Stafford et al. 2001) however, some overlap in calls from these geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005).

Calling rates of blue whales tend to vary based on feeding behavior. Stafford and Moore (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds than during migration (Burtenshaw et al. 2004).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticeti (baleen whales) have acute infrasonic hearing.

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hertz (Croll et al. 2001b; Oleson et al. 2007b; Stafford and Moore 2005). In terms of functional hearing capability, blue whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 22 Kilohertz (Southall et al. 2007).

Status and Trends

Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status has continued since the inception of the ESA in 1973. Blue whales are also listed as endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Animals (IUCN 2010) and are protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the MMPA.

It is difficult to assess the current status of blue whales globally because (1) there is no general agreement on the size of the blue whale population prior to whaling and (2) estimates of the current size of the different blue whale populations vary widely. We may never know the size of the blue whale population in the North Pacific prior to whaling, although some authors have concluded that their population numbered about 200,000 animals. Similarly, estimates of the global abundance of blue whales are uncertain. Since the cessation of whaling, the global population of blue whales has been estimated to range from 11,200-13,000 animals, however these estimates are more than 20 years old (Maser et al. 1981).

Prior to whaling, Gambell (1976) reported there may have been as many as 4,900 blue whales present in the North Pacific. Blue whales were hunted in the Pacific Ocean, where 5,761 were killed from 1889-1965 (Perry et al. 1999). This estimate does not account for under-reporting by Soviet whalers, who took approximately 800 more individuals than were reported (Ivashchenko et al. 2013). The IWC banned commercial whaling in the North Pacific in 1966, although Soviet whaling continued after the ban. Blue whale abundance has likely increased since its protection in 1966 but, the possibility of unauthorized harvest by Soviet whaling vessel, incidental ship strikes, and gillnet mortalities make this uncertain. Punt (2010) estimated the rate of increase for blue whales in the eastern North Pacific to be 3.2 percent annually (1.4 standard error) between 1991-2005, while Calambokidis et al. (2009b) estimated a growth rate of 3 percent annually.

Natural Threats

As the world's largest animals, blue whales are only occasionally known to be killed by killer whales (Sears et al. 1990; Tarpy 1979). Blue whales engage in a flight response to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Blue whales are known to become infected with the nematode *Carricauda boopis*, which are believed to cause mortality due to renal failure (Lambertsen 1986).

Anthropogenic Threats

Blue whales have faced threats from several historical and current sources. Their populations were severely depleted originally due to historical whaling activity. Increasing oceanic noise may impair blue whale behavior as well. Although available data do not presently support traumatic injury from sonar, the general trend in increasing ambient low frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011).

Ship strikes were implicated in the deaths of five blue whales, from 2004-2008 off the Pacific coast (Carretta et al. 2012). Four of these deaths occurred in 2007, the highest number recorded for any year. From 2004-2008, there were an additional eight injuries of unidentified large whales attributed to ship strikes. Ship strike is an issue for blue whales of Sri Lanka engaged in foraging in shipping lanes, with several individuals stranding or being found with evidence of being struck (De Vos et al. 2013; Ilangakoon 2012).

There is a paucity of contaminant data regarding blue whales. Available information indicates that organochlorines, including dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCB), benzene hexachloride (HCH), hexachlorobenzene (HCB), chlordane, dieldrin, methoxychlor, and mirex have been isolated from blue whale blubber and liver samples (Gauthier et al. 1997; Metcalfe et al. 2004). Contaminant transfer between mother and calf occurs, meaning that young often start life with concentrations of contaminants equal to their mothers, before accumulating additional contaminant loads during life and passing higher loads to the next generation (Gauthier et al. 1997; Metcalfe et al. 2004). This is supported by ear plug data showing maternal transfer of pesticides and flame retardants in the first year of life (Trumble et al. 2013). These data also support pulses of mercury in body tissues of males studied (Trumble et al. 2013).

Critical Habitat

NMFS has not designated critical habitat for blue whales.

4.2.2 Fin Whale

The fin whale, *Balaenoptera physalus*, is a cosmopolitan species of baleen whale (Gambell 1985a). Fin whales are the second-largest whale species by length, they are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. Their streamlined appearance can change during feeding when their pleated throat and chest area becomes distended by the influx of prey and seawater, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, with a complex pigmentation pattern. The lower jaw is gray or black on the left side and creamy white on the right side. This asymmetrical coloration extends to the baleen plates as well, and is reversed on the tongue. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990).

Distribution

Fin whales are distributed widely in every ocean except the Arctic Ocean. They undertake migrations from low-latitude winter breeding grounds to high-latitude summer foraging grounds and extensive longitudinal movements both within and between years (Kjeld et al. 2006; Macleod et al. 2006; Mizroch et al. 1999). Fin whales are sparsely distributed November through April, from 60° N, south to the northern edge of the tropics, where mating and calving may take place (Mizroch et al. 1999). Throughout winter months, fin whales have been sighted as far as 60° N (Mizroch et al. 1999). The overall distribution and migratory patterns of fin whale may be largely based on the availability and abundance of prey and their ability to adapt to high areas of productivity (Canese et al. 2006; Reeves et al. 2002).

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska; in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California and locations south of there; in the western Pacific, they winter from the Sea of Japan, the East China Sea, Yellow Sea, and the Philippine Sea (Gambell 1985a).

Population Structure

Fin whales have two recognized subspecies: *Balaoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p. quoyi* (Fischer 1829) occurs in the Southern Ocean. These subspecies and North Pacific fin whales appear to be organized into separate populations, although there is a lack of consensus in the published literature as to population structure. Globally, fin whales are sub-divided into three major groups: Atlantic, Pacific, and Antarctic. Within these major areas, different organizations use different population structure.

Movement

Fin whales along Southern California were found to be traveling 87 percent of the time and milling 5 percent in groups that averaged 1.7 individuals (Bacon et al. 2011). They are one of the fastest cetaceans, capable of attaining speeds of 25 miles (40.2 kilometers) per hour (Jefferson et al. 2008; Marini et al. 1996).

Habitat

Fin whales are larger, faster, and less concentrated in nearshore environments when compare to humpback and right whales. Fin whale concentrations generally form along frontal boundary, or mixing zones between coastal and oceanic waters, which corresponds roughly to the 200 meters isobath (Cotte et al. 2009; Nasu 1974). Fin whales tend to avoid tropical and pack-ice waters, with the high-latitude limit of their range set by ice and the lower-latitude limit by warm water of approximately 15° C (Sergeant 1977). They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally.

Reproduction

Fin whales reach sexual maturity between 5-15 years of age (COSEWIC 2005; Gambell 1985a; Lockyer 1972). Mating and calving occurs primarily from October through January, gestation lasts approximately 11 months, and nursing occurs for 6-11 months (Boyd et al. 1999; Hain et al. 1992). The average calving interval in the North Atlantic is estimated at about 2-3 years (Agler et al. 1993; Christensen et al. 1992). The location of winter breeding grounds is uncertain but mating is assumed to occur in pelagic mid-latitude waters (Perry et al. 1999). This was recently contradicted by acoustic surveys in the Davis Strait and off Greenland, where singing by fin whales peaked in November through December; leading the authors to suggest that mating may occur prior to southbound migration (Simon et al. 2010). Although seasonal migration occurs between presumed foraging and breeding locations, fin whales have been acoustically detected throughout the North Atlantic Ocean and Mediterranean Sea year-round, implying that not all individuals follow a set migratory pattern (Notarbartolo-Di-Sciara et al. 1999; Simon et al. 2010). Reductions in pregnancy rates appear correlated with reduced blubber thickness and prey availability (Williams et al. 2013). Recent IWC scientific whaling data suggest that, compared to commercial whaling periods, pregnancy rates have decreased, age at sexual maturity has increased, size growth is slowing, and males now compose a slightly higher proportion of the population than females (Gunnlaugsson et al. 2013). Fin whales live 70-80 years of age (Kjeld et al. 2006).

Diving and Social Behavior

The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives, each 13-20 seconds in duration, followed by a deep dive of 1.5-15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2-6 minutes (Hain et al. 1992; Watkins 1981a). The most recent data support average dives of 98 meters and 6.3 minutes for foraging fin whales, while non-foraging dives are 59 meters and 4.2 minutes (Croll et al. 2001a). Foraging dives in excess of 150 meters are known to occur and have been recorded on occasion (Panigada et al. 1999). Group sizes of 12-18 individuals are common (Wynne et al. 2005), although average group sizes of 2.1-2.9 have been found for the Aleutian Islands, Bering Sea, and western Gulf of Alaska (Moore et al. 2000b; Wade et al. 2003b; Waite 2003).

Feeding

In the North Pacific, fin whales prefer euphausiids (krill) and large copepods, followed by schooling fish such as herring, walleye pollock, and capelin (Kawamura 1982a; Kawamura 1982b; Ladrón de Guevara P. et al. 2008; Nemoto 1970). Fin whales frequently forage along cold eastern current boundaries (Perry et al. 1999). Fin whale foraging may occur in waters as shallow as 10 meters when prey are at the surface, but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Nature Conservancy Council 1979 as citied in DoN 2001; Gaskin 1972; Panigada et al. 2008; Sergeant 1977).

Vocalization and Hearing

Although their function is still in doubt, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts can last for a day or more (Tyack 1999). Fin whales produce a variety of low frequency (< 1 Kilohertz) sounds in the 10-200 Hertz range, but the most typically recorded frequency is a 20 Hertz pulse lasting about 1 second, and reaching source levels of 189 ± 4 dB re 1 µPam (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson and Wursig 1995; Sirovic et al. 2007; Thompson et al. 1992; Watkins 1981a; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23-18 Hertz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998). The seasonality and stereotypic nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981a; Watkins et al. 1987); a notion further supported by recent data linking these vocalizations to male fin whales only (Croll et al. 2002). Au and Green (2000) reported moans of 14-118 Hertz, with a dominant frequency of 20 Hertz, tonal vocalizations of 34-150 Hertz, and songs of 17-25 Hertz (Cummings and Thompson 1994; Edds 1988; Watkins 1981a). In Southern California, the 20 Hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (DoN 2012). An additional fin whale sound, the 40 Hertz call described by Watkins (1981a), was also frequently recorded, although these calls are not as common as the 20 Hertz fin whale pulses. Seasonality of the 40 Hertz calls differed from the 20 Hertz calls, since 40 Hertz calls were more prominent in the spring, as observed at other sites across the northeast Pacific (Sirovic et al. 2012). Source levels of Eastern Pacific fin whale 20-Hertz calls have been reported as 189 +/-

5.8 dB re 1uPa at 1 meter and 140-200 dB re 1uPam at 50 meters (Clark and Gagnon 2004; Watkins et al. 1987; Weirathmueller et al. 2013). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992; Watkins et al. 1987).

Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). Also, there is speculation that the sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hertz and 12 Kilohertz and a maximum sensitivity to sounds in the 1- 2 Kilohertz range. This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than at mid- to high-frequencies (Ketten 1997). Several fin whales were tagged during the Southern California-10 behavioral response studies and no obvious responses to a mid-frequency sound source were detected by the visual observers or in the initial tag analysis (Southall et al. 2011). Results of studies on blue whales (Goldbogen et al. 2013; Southall et al. 2011), which have similar auditory physiology compared to fin whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context.

Status and Trends

Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status has continued since the inception of the ESA in 1973. Pre-exploitation fin whale abundance is estimated at 464,000 individuals worldwide; the estimate for 1991 was roughly 25 percent of this (Braham 1991). Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989). According to the most recent status assessment report to Congress (2014) the minimum estimated abundance of fin whales in the northeastern Pacific Ocean is 1,368 individuals west of the Kenai Pennisula (Friday et al. 2013). The most recent abundance estimates for fin whales that we are aware of are 16,625 individuals in the North Pacific Ocean and 119,000 individuals worldwide (Braham 1991). Fin whales of the north Pacific appear to be increasing in abundance although the trend is unclear or declining throughout the rest of their range (NMFS 2011).

Based on ecological theory and demographic patterns derived from several hundred imperiled species and populations, fin whales appear to exist at population sizes that are large enough to avoid demographic phenomena that are known to increase the extinction probability of species that exist as "small" populations (that is, "small" populations experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their population size to become a threat in and of itself). As a result, we assume that fin whales are likely to be threatened more by exogenous threats such as anthropogenic activities (primarily whaling, entanglement, and ship strikes) or natural phenomena (such as disease, predation, or changes in the distribution and abundance of their prey in response to changing climate) than endogenous threats caused by the small size of their population.

Natural Threats

Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04-0.06 for northeast Atlantic fin whales. The occurrence of the nematode, *Crassicauda boopis,* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1992). Adult fin whales engage in a flight responses (up to 40 kilometers/hour) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999).

Anthropogenic Threats

Fin whales have undergone significant exploitation, but are currently protected under the IWC but are still hunted in subsistence fisheries off West Greenland. In 2003, two males and four females were landed and two others were struck and lost (IWC 2005). In 2004, five males and six females were killed, and two other fin whales were struck and lost. Between 2003-2007, the IWC set a catch limit of up to 19 fin whales in this subsistence fishery. However, the scientific recommendation was to limit the number killed to four individuals until accurate populations could be produced (IWC 2005). In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each year for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit (NMFS 2006c). Japanese whalers plan to kill 50 whales per year starting in the 2007-2008 season and continuing for the next 12 years (IWC 2006; Nishiwaki et al. 2006). Fin whales also experience injury and mortality from fishing gear and ship strikes (Carretta et al. 2007; Douglas et al. 2008; Lien 1994; Perkins and Beamish 1979; Waring et al. 2007). Between 1969-1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979). According to Waring et al. (2007), four fin whales in the western North Atlantic died or were seriously injured in fishing gear, while another five were killed or injured as a result of ship strikes between January 2000 and December 2004. Between 1999 and 2005, there were 15 reports of fin whale strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005; Nelson et al. 2007a). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Similarly, 2.4 percent of living fin whales from the Mediterranean show ship strike injury and 16 percent of stranded individuals were killed by vessel collision (Panigada et al. 2006). There are also numerous reports of ship strikes off the Atlantic coasts of France and England (Jensen and Silber 2004).

Management measures aimed at reducing the risk of ships hitting right whales should also reduce the risk of collisions with fin whales. In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June-December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to be capable of reducing fin whale ship strike mortality by 27 percent. A review of the NMFS's ship strike database by Jensen and Silber (2004) revealed fin whales as the most frequently confirmed victims of ship strikes (26 percent of the recorded ship strikes [n = 75/292 records]), with most collisions occurring off the east coast, followed by the west coast of the U.S. and Alaska/Hawaii. Five of seven fin whales stranded along Washington State and Oregon showed evidence of ship strike with incidence increasing since 2002 (Douglas et al. 2008). From 1994-1998, two fin whales were presumed killed by ship strikes. More recently, in 2002, three fin whales were struck and killed by vessels in the eastern North Pacific (Jensen and Silber 2004).

Increased noise in the ocean stemming from shipping seems to alter the acoustic patterns of singing fin whales, possibly hampering reproductive parameters across wide regions (Castellote et al. 2012).

The organochlorines dichlorodiphenyldichloroethylene (DDE), DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Critical Habitat

NMFS has not designated critical habitat for fin whales.

4.2.3 Western North Pacific Gray Whale

The gray whale, *Eschrichtius robustus,* is a species of baleen whale and the only species in the family Eschrichtiidae. Gray whales can grow to around 50 feet (15 meters) long, and weigh approximately 80,000 pounds (35,000 kilograms). Normally, females are larger than males.

They have a mottled gray body, with small eyes located just above the corners of the mouth. Their pectoral fins are broad, paddle-shaped, and pointed at the tips. Gray whales do not have a dorsal fin typical of other baleen whales, instead they have a "dorsal hump" located about two-thirds of the way back on their body, and a series of 8-14 small bumps, known as “knuckles,” between the dorsal hump and tail flukes. The tail flukes are more than 3 meters wide, have S-shaped trailing edges and a deep median notch.

Distribution

Western North Pacific gray whales exhibit extensive plasticity in their occurrence, shifting use areas within and between years, as well as over longer time frames, such as in response to oceanic climate cycles (e.g., El Nino-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation)(Gardner and Chavez-Rosales 2000; Meier et al. 2007; Tyurneva et al. 2009; Vladimirov et al. 2006; Vladimirov et al. 2005; Vladimirov et al. 2008; Vladimirov et al. 2009; Vladimirov et al. 2010; Weller et al. 2012; Yablokov and Bogoslovskaya 1984; Yakovlev and Tyurneva 2005). Species distribution extends south along Japan, the Koreas, and China from the Kamchatka Peninsula (IWC 2003; Kato and Kasuya 2002; Omura 1988; Reeves et al. 2008; Weller et al. 2003). Other possible range states include Vietnam, the Philippines, and Taiwan, although only historical whaling records support occurrence in these areas (Henderson 1990; Ilyashenko 2009). Range has likely contracted from the Koreas and other southern portions of the range versus pre-whaling periods. Cetacean surveys off Korea from 2003 to 2011 failed to find any gray whales (Kim et al. 2013). Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by western North Pacific gray whales (Clarke and Moore 2002; Moore 2000).

Population Structure

Gray whales occur in two genetically and spatially distinct populations on the eastern and western sides of the North Pacific Ocean (Brownell Jr. et al. 2009; Burdin et al. 2011; Kanda et al. 2010; Lang et al. 2004; Lang et al. 2005; Lang et al. 2010b; Leduc et al. 2002; Swartz et al. 2006; Weller et al. 2007; Weller et al. 2004b; Weller et al. 2006a).

Movement

Western North Pacific gray whales migrate annually along Asia during autumn, although migration routes are poorly known. Migration from summer foraging areas off the northeastern coasts of Sakhalin Island and south-eastern Kamchatka along the Japanese coasts to the South China Sea is suspected (Commission 2004; IWC 2003; Omura 1988; Tsidulko et al. 2005; Weller et al. 2008a; Weller et al. 2012).

Eastern and western North Pacific gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data refute this. Two western North Pacific gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington State and Oregonian coasts in one case (Mate et al. 2011) and to the southern tip of Baja California and back to Sakhalin Island in another (IWC 2012). Comparisons of eastern and western North Pacific gray whale catalogs have thus far identified 21-23 western gray whales occurring on the eastern side of the basin (IWC 2012; Urban R. et al. 2013; Weller et al. 2011). During one field season off Vancouver Island, western gray whales were found to constitute 6 of 74 (8.1 percent) of photo-identifications (Weller et al. 2012). In addition, two genetic matches of western gray whales off Santa Barbara, California have been made (Lang et al. 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al. 2012).

Group sizes vary, but are roughly 2 (range 1-14) for non-calf groups and slightly larger for groups containing calves (Weller et al. 2007; Weller et al. 2004b; Weller et al. 2006a; Weller et al. 1999; Yakovlev and Tyurneva 2004).

Habitat

The northern Bering and southern Chukchi Seas was once considered the primary foraging areas for gray whales in the North Pacific (Braham 1984; Kim and Oliver 1989; Moore et al. 1986a; Moore et al. 2000a; Moore et al. 1986b). However, with shifting oceanographic properties in the 1980's, prey abundance declined sharply, followed by a gray whale mortality event and reduced sighting rates in the region (Grebmeier et al. 2006a; Grebmeier et al. 2006b; Highsmith and Coyle 1992; Highsmith and Coyle. 1990; Moore et al. 2003; Yablokov and Bogoslovskaya 1984). Western North Pacific gray whales utilize several coastal migratory corridors as well as and feeding and breeding areas, with an apparent gap in distribution along the eastern shore of the Kamchatka Peninsula between the Okhotsk and Bering Seas (Reeves et al. 2008; Swartz et al. 2006; Weller et al. 2003).

Reproduction

Very little information is available regarding western North Pacific gray whale reproduction. We therefore present information from the eastern population and assume it is similar for the western population. Eastern gray whale females produce their first a calf between 5-12 years of age (median of 6-9 years)(Bradford et al. 2010; Rice and Wolman 1971). Both sexes are promiscuous, utilizing sperm competition in mate selection (Jones and Swartz 1984; Lang et al. 2010a). Females have a three-week period of estrus during late November to early December during their southbound migration, during which time mating occurs (Rice and Wolman 1971; Shelden et al. 2004). A secondary estrus may occur if conception has not occurred and lasts for roughly 40 days (Rice and Wolman 1971). Gestation lasts 13.5 months (Rice et al. 1984).

The only western North Pacific gray whale calf observed long enough to have produced a calf did so at the age of seven, meaning the individual was sexually mature no later than six years of age. From 2-11 calves have been documented annually in foraging areas, with each mother having been observed to produce from one to five calves over the course of researchers monitoring western North Pacific grey whales in the field. The time between calves varies, with 50 percent at two years, 34 percent at three years, and 11 percent at four years (Weller et al. 2009b). These values have grown progressively shorter over the past decade, some of which coincides with reduced industrial activity in foraging areas (Burdin et al. 2003; Cooke et al.

2006). Annual birth rate has varied between 4.3-14.8 percent in the late 1990s (IWC 2003).

Feeding

Gray whales of the western North Pacific population have thus far been documented to forage primarily off northeastern Sakhalin Island, specifically in a nearshore (<20 meters deep) area adjacent to Piltun Lagoon and in an area further offshore (Blokhin et al. 2003; Fadeev 2011; Meier et al. 2007; Tyurneva et al. 2010; Tyurneva et al. 2009; Vladimirov et al. 2006; Vladimirov et al. 2005; Vladimirov et al. 2008; Vladimirov et al. 2009; Vladimirov et al. 2011; Vladimirov et al. 2010; Weller et al. 1999; Yakovlev and Tyurneva 2004; Yakovlev and Tyurneva 2005). Other areas may also be significant foraging areas, such as near the Kurile and Commander Islands, off the mainland coast of Kamchatka, in the northern Sea of Okhotsk, and Olga Bay along the Kamchatka Peninsula (Ilyashenko 2009; Tyurneva et al. 2011; Tyurneva et al. 2010; Tyurneva et al. 2009; Vladimirov et al. 2009; Weller et al. 2003; Yakovlev et al. 2011). Although eastern North Pacific gray whales exhibit a diversity of foraging behaviors, western gray whales have only been observed to forage on the benthos. Invertebrate abundance studies, as well as stomach content and fecal analyses of gray whales support several amphipods and isopods as the gray whales' primary prey (Fadeev 2009; Fadeev 2011). Sand lance may also be significant prey for gray whales in the area (Fadeev 2011).

Vocalization and Hearing

No data are available regarding western North Pacific gray whale hearing or communication. We assume that eastern North Pacific gray whale communication is representative of the western population and present information stemming from this population. Individuals produce broadband sounds within the 100 Hertz to 12 Kilohertz range (Dahlheim et al. 1984; Jones and Swartz 2002). The most common sounds encountered are on feeding and breeding grounds, where "knocks" of roughly 142 dB re: 1 µPa at 1 meter (source level) have been recorded (Cummings et al. 1968; Jones and Swartz 2002). However, other sounds have also been recorded in Russian foraging areas, including rattles, clicks, chirps, squeaks, snorts, thumps, knocks, bellows, and sharp blasts at frequencies of 400 Hertz to 5 Kilohertz (Petrochenko et al. 1991). Estimated source levels for these sounds ranged from 167-188 dB re: 1 µPa at 1 meter (Petrochenko et al. 1991). Low frequency (<1.5 Kilohertz) "bangs" and "moans" are most often recorded during migration and during ice-entrapment (Carroll et al. 1989; Crane and Lashkari. 1996). Sounds vary by social context and may be associated with startle responses (Rohrkasse-Charles et al. 2011). Calves exhibit the greatest variation in frequency range used, while adults are narrowest; groups with calves were never silent while in calving grounds (Rohrkasse-Charles et al. 2011). Based upon a single captive calf, moans were more frequent when the calf was less than a year old, but after a year, croaks were the predominant call type (Wisdom et al. 1999).

Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992a; Ketten 1992b). Responses of free-ranging and captive individuals to playbacks in the 160 Hertz to 2 Kilohertz range demonstrate the ability of individuals to hear within this range (Buck and Tyack 2000;

Cummings and Thompson 1971a; Dahlheim and Ljungblad 1990; Moore and Clark 2002; Wisdom et al. 2001). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986; Moore and Clark 2002).

Status and Trends

Gray whales throughout the North Pacific Ocean were originally listed on June 2, 1970 (35 FR 8495). On June 16, 1994 (59 FR 21094), the eastern North Pacific gray whales were delisted, but western North Pacific gray whales remained listed through the present as endangered.

Alter et al. (2007) concluded that eastern and western North Pacific gray whales historically numbered between 76,000-118,000 individuals combined prior to whaling; the proportion of individuals that was in each population is unknown. However, whaling dramatically reduced the population to a tiny fraction of its former abundance, with 100-130 non-calves remaining (Burdin et al. 2010; Cooke et al. 2005; Cooke et al. 2008; Reeves et al. 2008; Wade et al. 2003a; Weller et al. 2005; Weller et al. 2006a) . The most recent estimate of western gray whale abundance is 155 individuals, with 30 reproductively active females (Burdin et al. 2013). The population was believed extinct in the 1970's (Bradford et al. 2003). At least 1,700-2,000 individuals were commercially harvested from the late 1800's to the mid-20th century (Commission 2004; IWC 2003). Findings that eastern North Pacific gray whales may be found within the range of western North Pacific gray whales may mean that even fewer individuals compose the western population, as individuals formerly believed to be western individuals may actually be part of the eastern population (Lang et al. 2010b).

Fortunately, the latest data on population growth indicates a positive trajectory for available data over 1994-2007 of roughly 2.5-3.2 percent growth per year (Bradford et al. 2008b; Cooke et al. 2008; Cooke et al. 2007; Cooke et al. 2006). The Sakhalin Island group has been increasing at a rate of 3.3 percent annually from 2002-2012 (Cooke et al. 2013). However, the loss of a single adult female would strongly decrease this trajectory (Cooke et al. 2005). In 2009, Burdin et al. (2010) reported 26 mature females observed since 1995. Genetic findings have found that although genetic diversity is relatively high in western North Pacific gray whales considering their population size, significant portions of this diversity are retained in a few or single individuals (IWC 2003). The loss of one or a few of these individuals would greatly reduce the genetic diversity of the population as a whole. Also of significance is that only about half of males fathering offspring have been identified, supporting a larger population size than is currently known (Lang et al. 2010a; Lang et al. 2010b). There is a strong male bias in calf production of roughly 2:1 (Burdin et al. 2003; Cooke et al. 2008; Weller et al. 2009b; Weller et al. 2008b; Weller et al. 2004a; Weller et al. 2004b). Clapham et al. (1999) conducted a review of western North Pacific gray whales, among other endangered whales, and found that this population matches in virtually all characteristics that would make a small population extinction-prone.

Natural Threats

Predation by killer whales is a significant threat to gray whales, with calves being particularly susceptible during their northward migration (Fay et al. 1978; Goley and Straley 1994; Poole 1984; Rice and Wolman 1971; Ternullo and Black 2002). However, not all attacks are fatal and many individuals escape with scars from the encounters. Killer whales are frequently observed in the primary western North Pacific gray whale foraging area and roughly one-third to one half of observed gray whales bear tooth marks from killer whales (30 percent of them during the course of the 10 year study)(Bradford et al. 2003; Bradford et al. 2006a; Weller et al. 2009a; Weller et al. 2002a). Vladimirov (2005) documented an attack on a mother-calf pair in shallow waters of the Piltun Bay foraging area. This rate is among the highest rate found amongst baleen whales. Researchers have also expressed significant concern about whales that appear “skinny”; the cause and consequences remain unknown (Bradford et al. 2007; Bradford et al. 2008a; Bradford et al. 2012; Burdin et al. 2003; IWC 2003; Weller et al. 2008b; Weller et al. 2007; Weller et al. 2005; Weller et al. 2004a; Weller et al. 2004b; Weller et al. 2006a; Yakovlev and Tyurneva 2004). Lactating females appear to be in particularly poor body condition (Bradford et al. 2012).

Anthropogenic Threats

Western North Pacific gray whales are experience many of the same human-induced threats as other baleen whales, including entanglement and ship strike. At least one fifth of individuals show evidence of entanglement in fishing gear (Bradford et al. 2006b; Bradford et al. 2009). Four females were bycaught in fishing nets and died along Japan from 2005-2007 (Bradford et al. 2006b; Brownell Jr. 2007; Cooke et al. 2005; Cooke et al. 2008; Cooke et al. 2007; Kato et al. 2006; Kato et al. 2007; Weller et al. 2008b). Bradford et al. (2006b) and (2009) found that 1.8-2.0 percent of individuals showed scars consistent with ship strike. Another individual was found stranded in 1996 with several harpoons in it, likely from Japanese fishers (Brownell Jr. and Kasuya. 1999). Extensive oil and gas exploration and development is occurring near the summer foraging areas for western North Pacific gray whales, introducing noise, additional ship strike, pollutants, and the potential for oil spills to the region that causes concern for the recovery of western North Pacific gray whales (Brownell 2004; Commission 2004; Donovan 2005; Gailey et al. 2007; IWC 2003; Johnson et al. 2007; Nowacek et al. 2012; Reeves et al. 2005; Reeves 2005; Webster 2003; Weller et al. 2008b; Weller et al. 2002b; Weller et al. 2006b; Weller et al. 2006c; Yazvenko et al. 2007a; Yazvenko et al. 2007b).

Critical Habitat

NMFS has not designated critical habitat for gray whales.

4.2.4 Humpback Whale

Humpback whales, *Megaptera novaeangliae,* are distinguished from other baleen whales by extraordinarily long flippers (up to 5 meters or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), a more variable dorsal fin, and utilization of very long (up to 30 minutes), complex, repetitive vocalizations (songs) during courtship (Payne and McVay 1971). Their grayish-black baleen plates, approximately 270-440 on each side of the jaw, are intermediate in length (6,570 centimeters) compared to those of other baleen whales. Humpbacks in different geographical areas vary somewhat in body length, but the maximum recorded size is 18 meters (Winn and Reichley 1985).

Humpback whales generally have a dark back and may have substantial areas of natural white pigmentation on their flippers, sides, ventral surface of the body, and flukes in addition to acquired scars (white or black). Researchers distinguish individual humpbacks by the apparently unique black and white patterns on the underside of the flukes as well as other individually variable features (Glockner and Venus 1983; Katona and Whitehead 1981; Kaufman and Osmond 1987).

Distribution

Humpback whales are a cosmopolitan species that can be found in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed). During both seasonal migrations, humpback whales tend to occupy coastal waters. Migrations by humpback whales are undertaken through deep, pelagic waters (Winn and Reichley 1985). Some individuals may not migrate, or occurrence of humpback whales in foraging areas may extend beyond summer months (Van Opzeeland et al. 2013).

In the eastern and central North Pacific Ocean, the summer range of humpback whales includes coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). Whales found in these waters migrate to calving grounds near Hawaii, southern Japan, the Mariana Islands, and Mexico during the winter months. It has been observed that more northerly penetrations in Arctic waters can occur (Hashagen et al. 2009). Additional evidence, such as songs sung in northern latitudes during winter, provide additional support to plastic seasonal distribution (Smith and Pike 2009).

Population Structure

Though the ESA-listed entity is the worldwide population of humpback whales, some evidence suggests there may be multiple distinct populations within the North Pacific Ocean. Descriptions of the population structure of humpback whales differ depending on whether an author focuses on where humpback whales winter or where they summer. In summer months, humpback whales from different “reproductive areas” will congregate to feed; in the winter months, whales will migrate from different foraging areas to a single wintering area. In either case, humpback whales appear to form “open” populations; that is, populations that are connected through the movement of individual animals.

Based on genetic and photo-identification studies, Hill and Demaster (1998) recognized four stocks, likely corresponding to populations of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific. Although Hill and Demaster (1998) have identified four distinct stocks of humpback whales in the North Pacific Ocean, evidence suggests gene flow may exist among them.

In the Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2010). The NMFS has designated four stocks for management purposes under the MMPA: (1) the Central North Pacific stock, with feeding areas from Southeast Alaska to the Alaska Peninsula; (2) the Western North Pacific stock, with feeding areas from the Aleutian Islands, Bering Sea, and Russia; (3) the California, Oregon, Washington, and Mexico stock, with feeding areas off the U.S. west coast; and (4) the American Samoa stock, with feeding areas as far south as the Antarctic Peninsula (Allen and Angliss 2010).

Central North Pacific population

The central North Pacific population winters in the waters around Hawaii while the eastern North Pacific population (also called the California-Oregon-Washington stock) winters along Central America and Mexico. Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure and gene flow.

Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawaii and Mexico (with further mixing resulting from feeding areas in Alaska) and suggested that humpback whales that winter in Hawaii may have emigrated from Mexican wintering areas. There is a "population" of humpback whales that winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in Guam, Rota, and Saipan from January through March (Darling and Cerchio 1993; Eldredge 1991; Eldredge 2003; Fulling et al. 2011; Rice 1998). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2008; Calambokidis 1997; Calambokidis et al. 2001).

Separate feeding groups of humpback whales are thought to inhabit western U.S. and Canadian waters, with the boundary between them located roughly at the U.S./Canadian border. The southern feeding ground ranges between 32-48° N, with limited interchange with areas north of Washington State (Calambokidis et al. 2004; Calambokidis et al. 1996).

Reproduction

Calving occurs in the warmest, shallow coastal waters of continental shelves and oceanic islands worldwide (Perry et al. 1999). Gestation takes about 11 months, followed by a nursing period of up to 1 year (Baraff and Weinrich 1993). Sexual maturity is reached at between five to seven years of age in the western North Atlantic, but may take as long as 11 years in the North Pacific, and perhaps over 11 years (e.g., southeast Alaksa) (Gabriele et al. 2007). Females usually breed every two to three years, although consecutive calving is not unheard of (Clapham and Mayo 1987; Glockner-Ferrari and Ferrari 1985; Weinrich et al. 1993). Larger females tend to produce larger calves that may have a greater chance of survival and appear to preferentially select larger-sized males (Pack et al. 2012; Pack et al. 2009). Offspring appear to return to the same breeding areas at which they were born once they are independent (Baker et al. 2013). Males appear to return to breeding grounds more frequently than do females (Herman et al. 2011).

In calving areas, males sing long complex songs directed towards females, other males, or both. The breeding season can best be described as a floating lek (aggregation of males) or male dominance polygamy (Clapham 1996). Males court females in escort groups and compete for proximity and access to reproducing females (particularly larger females) (Pack et al. 2009). Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp et al. 2010).

Generation time for humpback whales is estimated at 21.5 years, with individuals surviving from 80-100 years (COSEWIC 2011).

Diving and Social Behavior

Maximum recorded diving depths for humpback whales are approximately 170 meters (but usually <60 meters), with a very deep dive (240 meters) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 minutes, although feeding dives ranged from 2.1-5.1 minutes in the North Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 minutes for feeding whales, 3.0 minutes for non-feeding whales, and 4.3 minutes for resting whales (Dolphin 1987). In the Gulf of California, humpback whale dive durations averaged 3.5 minutes (Strong 1990). Most humpback whale dives are relatively shallow due to the fact that their prey is typically found within 300 meters of the surface. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 meters and 120 meters; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

Average group size near Kodiak Island is 2-4 individuals, although larger groups are seen near Shuyak and Sitkalidak islands and groups of 20 or more have been documented (Wynne et al. 2005).

Feeding

During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992; Witteveen et al. 2011).

There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low- latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto de Sa Alves et al. 2009). Relatively high rates of resighting in foraging sites suggest whales return to the same areas year after year (Ashe et al. 2013; Boye et al. 2010). This trend appears to be maternally linked, with offspring returning to the same areas their mother brought them once calves are independent (Baker et al. 2013; Barendse et al. 2013). Humpback whales in foraging areas may forage largely or exclusively at night when prey are closer to the surface (Friedlaender et al. 2013). Humpback whales primarily feed along the shelf break and continental slope (Green et al. 1992; Tynan et al. 2005). Humpback whale foraging grounds are in cold, productive, coastal waters.

Vocalization and Hearing

Humpback whale vocalization is much better understood than their hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hertz to 4 Kilohertz with estimated source levels from 144 to 174 dB (Au et al. 2006; Au et al. 2000; Frazer and Mercado III 2000; Richardson and Wursig 1995; Winn et al. 1970b). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hertz to 10 Kilohertz and having most energy below 3 Kilohertz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack 1983). Other social sounds from 50 Hertz to 10 Kilohertz (most energy below 3 Kilohertz) are also produced in breeding areas (Richardson and Wursig 1995; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hertz to 1.9 Kilohertz), pulses (25 to 89 Hertz), and songs (ranging from 30 Hertz to 8 Kilohertz but dominant frequencies of 120 Hertz to 4 Kilohertz) which can be very loud (175 to 192 dB re 1 Pa at 1 m) (Au et al. 2000; Erbe 2002a; Payne 1985; Richardson and Wursig 1995; Thompson et al. 1986). In northern feeding areas humpbacks tend to be less vocal compared to southern breeding areas (Richardson and Wursig 1995).

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds. Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). There is geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. The song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and McVay 1971). Components of the song range from below 20 Hertz up to 4 Kilohertz, with source levels measured between 151-189 dB re 1 Pa-m and high-frequency harmonics extending beyond 24 Kilohertz (Au et al. 2006; Winn et al. 1970a).

Social calls range from 20 Hertz to 10 Kilohertz, with dominant frequencies below 3 Kilohertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simao and Moreira 2005). Female vocalizations appear to be simple with little complexity (Simao and Moreira 2005).

“Feeding” calls, unlike song and social sounds, are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hertz to 2 Kilohertz, less than 1 second in duration, and have source levels of 162-192 dB re 1 Pa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hertz (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic has been documented with Digital Acoustic Recording Tags (DTAGs4) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple bouts of broadband click trains that were acoustically different from toothed whale echolocation (Stimpert et al. 2007). Stimpert et al. (2007) termed these sounds “mega-clicks” which showed relatively low received levels at the DTAGs (143 to 154 dB re 1 Pa), with the majority of acoustic energy below 2 Kilohertz.

Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hertz to 10 Kilohertz, with maximum relative sensitivity between 2 Kilohertz and 6 Kilohertz (Ketten and Mountain 2014). Previously mentioned research by Au et al. (2001) and Au et al. (2006) off Hawaii indicated the presence of high-frequency harmonics in vocalizations up to and beyond 24 Kilohertz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpbacks can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpbacks to hear frequencies around 3 Kilohertz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 Kilohertz at 219 dB re 1Pa-m or frequency sweep of 3.1-3.6 Kilohertz. It is important to note that the system had some low frequency components (below 1 Kilohertz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Results of studies on blue whales (Goldbogen et al. 2013; Southall et al. 2011), which have similar auditory physiology compared to humpback whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. In terms of functional hearing capability humpback whales belong to low-frequency cetaceans which have a hearing range of 7 Hertz to 22 Kilohertz (Southall et al. 2007).

Status and Trends

Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. On April 21, 2015, the NMFS issued a proposed rule to divide the globally listed endangered humpback whale population into 14 DPSs, to remove the current species-level listing, and, in its place, to list two DPSs as endangered (the Cape Verde Islands/Northwest Africa and the Arabian Sea DPSs) and two DPSs as threatened (the Western North Pacific and the Central America DPSs) (80 FR 22304). The humpback whales in the action area may belong to the proposed threatened Western North Pacific DPS, or to the Hawaii or Mexico DPSs which, as proposed, would not be listed under the ESA.

While the proposed rule is still pending, our biological opinions and conference reports will continue to address effects to the rangewide population of humpback whales in addition to the proposed threatened and endangered DPSs so that action agencies have the benefit of the NMFS' analysis of the consequences of the proposed action on the DPS(s) present in the action area, even though the proposed rule to divide the species into 14 DPSs was not in effect at the time this opinion and conference report was written.

It was estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978a). From 1905-1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999). The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation = 0.04), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicates the North Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, therefore approximately doubling every 10 years (Calambokidis et al. 2008).

Modeled abundance increase in southeastern Alaska was 5.1 percent annually from 1986-2008 (Hendrix et al. 2012); a more specific estimate from Glacier Bay, the site of a long-term monitoring study over roughly the same time frame found a rate of increase of 4.4 percent (Saracco et al. 2013). For Asia, an annual rate of growth of 6.7 percent has been estimated (Calambokidis et al. 2008).

Natural Threats

Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008). Juveniles appear to be the primary age group targeted during attacks.

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999). The occurrence of the nematode, *Crassicauda boopis*, appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992).

Anthropogenic Threats

Three human activities are known to threaten humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for listing several species as endangered.

Humpback whales have also been killed or injured during interactions with commercial fishing gear. A total of 595 humpback whales were reported captured in coastal fisheries in Newfoundland and Labrador, Canada between 1969-1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). From 1979 through 2008, 1,209 whales were recorded entangled, 80 percent of which were humpback whales (Benjamins et al. 2012). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005; Nelson et al. 2007b). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Along the Pacific coast of Canada, 40 humpback whales have been reported as entangled since 1980, four of which are known to have died (COSEWIC 2011; Ford et al. 2009).

Alava et al. (2012) reported that 0.53 percent of humpback whale populations breeding along Ecuador are bycaught annually in commercial fishing gear (mortality of 15-33 individuals per year). From 2004-2008, 18 humpback whales were observed to be entangled along the U.S. west coast, of which 14 were considered seriously injured and two are known to have died (Carretta et al. 2013). From 2006-2010, 29 entangled whales were identified with serious injury or mortality resulting from the entanglement (Waring et al. 2013). From 1996-2000, 22 humpback whales of the Central North Pacific population were found entangled in fishing gear (Angliss and Lodge 2004). In 1996, a vessel from the Navy Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale. A photography study of humpback whales in southeastern Alaska in 2003 and 2004 found at least 53 percent of individuals showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005).

Many of the entangled humpback whales observed in Hawaiian waters brought the gear with them from higher latitude feeding grounds; for example, the whale the U.S. Navy rescued in 1996 had been entangled in gear that was traced to a recreational fisherman in southeast Alaska. Six of the entangled humpback whales observed in the Hawaiian Islands have been confirmed to have been entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawaiian Islands. Since 2001, there have been five observed interactions between humpback whales and gear associated with the Hawaii-based longline fisheries (NMFS 2008). Fortunately, in each instance, all of the whales were disentangled and released or they were able to break free from the gear without reports of impairment of the animal's ability to swim or feed.

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2004). Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975-1996, 10 (8.1 percent) showed evidence of collisions with ships (Laist et al. 2001). From 1975-2011, 68 collisions were actually witnessed in the main Hawaiian Islands, 63 percent involving calves and subadults, with the rate of collisions increasing over time even accounting for higher numbers of whales present (Lammers et al. 2013). Between 1999-2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the U.S. and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007b). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. Along Pacific Canada, 21 reports of ship strikes involving humpback whales were reported from 2001 to 2008 (COSEWIC 2011; Ford et al. 2009). From 2006-2010, 10 instances of mortality stemming from vessel collision were documented (Waring et al. 2013). Two humpbacks were recorded as ship struck and died along the west coast from 2004-2008; a third was known to have been struck but its outcome is unknown (Carretta et al. 2013). On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow et al. 1997).

Organochlorines, including PCBs and DDT, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher PCB levels have been observed in western Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010); eastern Atlantic individuals fall between these two in contaminant burden (Ryan et al. 2014). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). As with blue whales, these contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Compared to blue whales, contaminant levels in humpback whales are much higher as a result of humpback whale prey being higher up on the food chain.

Critical Habitat

NMFS has not designated critical habitat for humpback whales.

4.2.5 **North Pacific Right Whale**

The North Pacific right whale is a large baleen whale that grows to between 45-55 feet in length and can weigh up to 70 tons. Females tend to be larger than males. Right whales are generally black (some with white belly patches) and stocky-bodied, lack a dorsal fin, and have large heads (about 1/4 of the body length) with strongly-bowed lower lips. Raised patches of rough skin, or callosities are found around their head, and frequently serve to differentiate individuals. Two rows of long, dark baleen plates hang from the upper jaw, with about 225 plates on each side. The tail is broad, deeply notched, and all black with a smooth trailing edge.

Distribution

Very little is known of the distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. Right whales have occurred historically in all the world's oceans from temperate to subpolar latitudes. Historical whaling records indicate that right whales ranged across the North Pacific north of 30° N latitude and occasionally as far south as 20° N, with a bimodal distribution longitudinally favoring the eastern and western North Pacific and occurring infrequently in the central North Pacific (Gregr and Coyle 2009; Josephson et al. 2008; Maury 1853; Scarff 1991; Townsend 1935). North Pacific right whales summered in the North Pacific and southern Bering Sea from April or May to September, with a peak in sightings in coastal waters of Alaska in June and July (Klumov 2001; Maury 1852; Omura 1958; Omura et al. 1969; Townsend 1935). However, they were particularly abundant in the Gulf of Alaska from 145-151°W, and apparently concentrated in the Gulf of Alaska, especially south of Kodiak Islands and in eastern Aleutian Islands and southern Bering Sea waters (Berzin and Rovnin 1966; Braham and Rice 1984). Sightings have been made with greater regularity in the western North Pacific, notably in the Okhotsk Sea, Kuril Islands, and adjacent areas (Brownell Jr. et al. 2001).

Current information on the seasonal distribution of right whales is spotty. In the eastern North Pacific, this includes sightings over the middle shelf of the Bering Sea, Bristol Bay, Aleutian and Pribilof Islands (Goddard and Rugh 1998; Hill and Demaster 1998; Perryman et al. 1999; Waite et al. 2003). Some more southerly records also record occurrence along Hawaii, California, Washington, and British Columbia (Herman et al. 1980; Scarff 1986). Records from Mexico and California may suggest historical wintering grounds in offshore southern North Pacific latitudes (Brownell Jr. et al. 2001; Gregr and Coyle 2009).

Historical concentrations of sightings in the Bering Sea together with some recent sightings indicate that this region, together with the Gulf of Alaska, may represent an important summer habitat for eastern North Pacific right whales (Brownell Jr. et al. 2001; Clapham et al. 2005; Clapham et al. 2004; Goddard and Rugh 1998; Scarff 1986). North Pacific right whale occurrence in the Bering Sea during summer appears to be strongly influenced by the occurrence and abundance of the copepod, *Calanus marshallae* (Baumgartner et al. 2013). Few sighting data are available from the eastern North Pacific, with a single sighting of 17 individuals in the southeast Bering Sea being by far the greatest known occurrence (Wade et al. 2006). Some further sightings have occurred in the northern Gulf of Alaska (Wade et al. 2006). Recent eastern sightings tend to occur over the continental shelf, although acoustic monitoring has identified whales over abyssal waters (Mellinger et al. 2004). It has been suggested that North Pacific right whales have shifted their preferred habitat as a result of reduced population numbers, with oceanic habitat taking on a far smaller component compared to shelf and slope waters (Shelden et al. 2005). The area where North Pacific right whales are densest in the Gulf of Alaska is between 150-170° W and south to 52° N (Shelden 2006), but present occurrence there is very rare (Wade et al. 2011). Four sightings were made from 2004-2006 off Kodiak Island in association with high zooplankton concentrations (Wade et al. 2011). A right whale was sighted southeast of Kodiak Island in July 1998 and acoustic detections have been made off Kodiak Island, although no detections occurred from April to August 2003 or in April 2009 (Munger et al. 2008; Rone et al. 2010; Waite et al. 2003).

Historical sighting and catch records provide the only information on possible migration patterns for North Pacific right whales (Omura 1958; Omura et al. 1969; Scarff 1986). During summer, whales have been found in the Gulf of Alaska, along both coasts of the Kamchatka Peninsula, the Kuril Islands, the Aleutian Islands, the southeastern Bering Sea, and in the Okhotsk Sea. Fall and spring distribution was the most widely dispersed, with whales occurring in mid-ocean waters and extending from the Sea of Japan to the eastern Bering Sea. In winter, right whales have been found in the Ryukyu Islands (south of Kyushu, Japan), the Bonin Islands, the Yellow Sea, and the Sea of Japan. Whalers never reported winter calving areas in the North Pacific and where calving occurs remains unknown (Clapham et al. 2004; Gregr and Coyle 2009; Scarff 1986). North Pacific right whales probably migrate north from lower latitudes in spring and may occur throughout the North Pacific from May through August north of 40°N from marginal seas to the Gulf of Alaska and Bering Sea, although absence from the central North Pacific has been argued due to inconsistencies in whaling records (Clapham et al. 2004; Josephson et al. 2008). This follows generalized patterns of migration from high-latitude feeding grounds in summer to more temperate, possibly offshore waters, during winter (Braham and Rice 1984; Clapham et al. 2004; Scarff 1986).

Population Structure

All North Pacific right whales constitute a single population, although debate exists about subdivisions (Kennedy et al. 2012; Leduc et al. 2012).

Habitat

They primarily occur in coastal or shelf waters, although movements over deep waters are known. For much of the year, their distribution is strongly correlated to the distribution of their prey.

Reproduction

While no reproductive data are known for the North Pacific, studies of North Atlantic right whales suggest calving intervals of two to seven years and growth rates that are likely dependent on feeding success (Best et al. 2001; Burnell 2001; Kenney 2002; Knowlton et al. 1994; Reynolds III et al. 2002). It is presumed that right whales calve during mid-winter (Clapham et al. 2004), and lifespans of up to 70 years can be expected. Most known right whale nursery areas are in shallow, coastal waters.

Feeding

Stomach contents from North Pacific right whales indicate copepods and, to a lesser extent, euphausiid crustaceans are the whales' primary prey (Omura et al. 1969). North Pacific right whales have also been observed feeding on coccolithophore blooms (Tynan et al. 2001). Their diet is likely more varied than North Atlantic right whales, due to the multiple blooms of different prey available in the North Pacific from January through August (Gregr and Coyle 2009). Based upon trends in prey blooms, it is predicted that North Pacific right whales may shift from feeding offshore to over the shelf edge during late summer and fall (Gregr and Coyle 2009). North Pacific right whales, due to the larger size of North Pacific copepods, have been proposed to be capable of exploiting younger age classes of prey as well as a greater variety of species. Also as a result, they may require prey densities that are one-half to one-third those of North Atlantic right whales (Gregr and Coyle 2009). Right whales feed by continuously filtering prey through their baleen while moving, mouth agape, through patches of planktonic crustaceans. Right whales are believed to rely on a combination of experience, matrilinear learning, and sensing of oceanographic conditions to locate prey concentrations in the open ocean (Gregr and Coyle 2009; Kenney 2001).

Vocalization and Hearing

Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300-600 Hertz range with up- and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hertz and above 900 Hertz are rare (Vanderlaan et al. 2003). Calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100-400 Hertz (Gillespie and Leaper 2001). Gunshots appear to be a largely or exclusively male vocalization (Parks et al. 2005b). Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 meters of the surface (Matthews et al. 2001). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 Pa p-p (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar top their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). Source levels for these calls in surface active groups range from 137-162 dB rms re: 1 μPa-m, except for gunshots, which are 174-192 dB rms re: 1 μPa-m (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves (Parks and Clark 2007). Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks and Clark 2007; Parks et al. 2005a; Parks et al. 2007a; Parks et al. 2011; Parks et al. 2010; Parks et al. 2012b; Parks et al. 2006), particularly the peak frequency (Parks et al. 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004).

No direct measurements of right whale hearing have been undertaken (Parks and Clark 2007). Models based upon right whale auditory anatomy suggest a hearing range of 10 Hertz to 22 Kilohertz (Parks et al. 2007b).

Status and Trends

Right whales have been listed as endangered under the ESA since its passage in 1973 (35 FR 8495). The original listing included both the North Atlantic and the North Pacific 'populations', although subsequent genetic studies conducted by Rosenbaum et al. (2000) resulted in strong evidence that the North Atlantic and North Pacific right whales are separate species. Following a comprehensive status review, NMFS concluded that Northern right whales are indeed two separate species. On December 27, 2006, NMFS published two proposed rules to list these species separately as North Atlantic and North Pacific right whales (71 FR 77704 and 71 FR 77694). The final rule published on March 6, 2008 (73 FR 12024).

Very little is known about right whales in the eastern North Pacific, which were severely depleted by commercial whaling in the 1800s (Brownell Jr. et al. 2001). At least 11,500 individuals were taken by American whalers in the early- to mid-19th century, but harvesting continued into the 20th century (Best 1987). Illegal Soviet whaling took 661 individuals between 1962-1968, with 529 from the eastern North Pacific and 152 from the Okhotsk Sea, mostly of large mature individuals (Brownell Jr. et al. 2001; Ivashchenko and Clapham 2012; Ivashchenko et al. 2013). In the last several decades there have been markedly fewer sightings due to a drastic reduction in number, caused by illegal Soviet whaling in the 1960s (Doroshenko 2000). The current population size of right whales in the North Pacific is likely fewer than 1,000 animals compared to possibly 11,000 individuals or more prior to exploitation (NMFS 1991; NMFS 2006e). Based upon mark-recapture estimates of abundance right whales in the Bering Sea and Aleutian Islands numbered 31 individuals (95 percent CL 23-54, CV=0.22) and 28 (95 percent CL 24-42), respectively and composed of eight females and 20 males (Wade et al. 2011).

Abundance estimates and other vital rate indices in both the eastern and western North Pacific are not well established. Where such estimates exist, they have very wide confidence limits. Previous estimates of the size of the right whale population in the Pacific Ocean range from a low of 100-200 to a high of 220-500 (Berzin and Yablokov 1978; Braham and Rice 1984).

Reeves et al. (2003) and Brownell Jr. et al. (2001) concluded that North Pacific right whales in the eastern Pacific Ocean exist as a small population of individuals while the western population of right whales probably consists of several hundred animals. Clapham et al. (2005) placed this population at likely under 100 individuals and Wade et al. (2011) estimated 25-38 individuals. Brownell Jr. et al. (2001) reviewed sighting records and also estimated that the abundance of right whales in the western North Pacific was likely in the low hundreds. From 2007-2010, 12 individuals were observed in the southeastern Bering Sea (some on multiple occasions) (Allen and Angliss 2013). Genetic analyses indicate genetic diversity to be low, but not as low as North Atlantic right whales (Leduc et al. 2012), and higher than what might be expected from such a small population (Slikas et al. 2013). Genetic diversity in the next generation is expected to be severely reduced (Slikas et al. 2013).

Scientists participating in a recent study utilizing acoustic detection and satellite tracking identified 17 right whales (10 males and 7 females) in the Bering Sea, which is almost threefold the number seen in any previous year in the last four decades (Wade et al. 2006). These sightings increased the number of individual North Pacific right whales identified in the genetic catalog for the eastern Bering Sea to 23. Amidst the uncertainty of the eastern North Pacific right whale’s future, the discovery of females and calves gives hope that this endangered population may still possess the capacity to recover (Wade et al. 2006). Available age composition of the North Pacific right whale population indicates most individuals are adults (Kenney 2002). Length measurements for two whales observed off California suggest at least one of these whales was not yet sexually mature and two calves have been observed in the Bering Sea (Carretta et al. 1994; Wade et al. 2006). To date, there is no evidence of reproductive success (i.e., young reared to independence) in the eastern North Pacific.

Natural Threats

Right whales have been subjects of killer whale attacks and, because of their robust size and slow swimming speed, tend to fight killer whales when confronted (Ford and Reeves 2008). Mortality or debilitation from disease and red tide events are not known, but have the potential to be significant problems in the recovery of right whales because of their small population size.

Anthropogenic Threats

Whaling for North Pacific right whales was discontinued in 1966 with the IWC whaling moratorium. However, North Pacific right whales remain at high risk of extinction. Demographic stressors include but are not limited to the following: (1) life history characteristics such as slow growth rate, long calving intervals, and longevity; (2) distorted age structure of the population and reduced reproductive success; (3) strong depensatory or Allee effects; (4) habitat specificity or site fidelity; and (5) habitat sensitivity. The proximity of the other known right whale habitats to shipping lanes (e.g. Unimak Pass) suggests that collisions with vessels may also represent a threat to North Pacific right whales (Elvin and Taggart 2008).

Climate change may have a dramatic effect on survival of North Pacific right whales. Right whale life history characteristics make them very slow to adapt to rapid changes in their habitat (Reynolds III et al. 2002). They are also feeding specialists that require exceptionally high densities of their prey (Baumgartner and Mate 2003). Zooplankton abundance and density in the Bering Sea has been shown to be highly variable, affected by climate, weather, and ocean processes and in particular ice extent (Baier and Napp 2003; Napp and Hunt Jr. 2001). The largest concentrations of copepods occurred in years with the greatest southern extent of sea ice (Baier and Napp 2003). It is possible that changes in ice extent, density, and persistence may alter the dynamics of the Bering Sea shelf zooplankton community and in turn affect the foraging behavior and success of right whales. No data are available for the western North Pacific.

Critical Habitat

North Pacific right whale critical habitat is considered in Section 4.1 of this opinion.

4.2.6 **Sei Whale**

Sei whales, *Balaenoptera borealis*, are members of the baleen whale family and are considered one of the "great whales" or rorquals. Two subspecies of sei whales are recognized, B. b. borealis in the Northern Hemisphere and B. b. schlegellii in the Southern Hemisphere. These large animals can reach lengths of 40-60 feet (12-18 meters) and weigh 100,000 pounds (45,000 kilograms). Females may be slightly longer than males. Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath. The body is often covered in oval-shaped scars (probably caused from cookie-cutter shark and lamprey bites) and sometimes has subtle “mottling".

The sei is regarded as the fastest swimmer among the great whales, reaching bursts of speed in excess of 20 knots. When a sei whale begins a dive it usually submerges by sinking quietly below the surface, often remaining only a few meters deep, leaving a series of swirls or tracks as it move its flukes. When at the water's surface, sei whales can be sighted by a columnar or bushy blow that is about 10-13 feet (3-4 meters) in height. The dorsal fin usually appears at the same time as the blowhole, when the animal surfaces to breathe. This species usually does not arch its back or raise its flukes when diving.

Distribution

The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004).

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20-23°N (Gambell 1985b; Masaki 1977). Sasaki et al. (2013) demonstrated that sei whales in the North Pacific are strongly correlated with sea surface temperatures between 13.1-16.8 °C.

NMFS has designated three stocks of sei whale for management purposes under the MMPA in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2011). Little is known about the stock structure of sei whales in the action area.

Population Structure

The population structure of sei whales is not well defined, but presumed to be discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

Mark-recapture, catch distribution, and morphological research indicate more than one population may exist in the North Pacific – one between 155-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982; Nasu 1974). Sightings have also occurred in Hawaiian waters. In Navy-funded surveys 2007-2012, there were three confirmed sightings of sei whales for a total of five individuals, all made from vessels (HDR 2012). Two sightings were documented northeast of Oahu in 2007 (Smultea et al. 2007), while the third was encountered near Perret Seamount west of the Island of Hawaii in 2010 (HDR 2012). Bottom depths for the sei whale sightings were from 3,100-4,500 m. Smultea et al. (2010) noted that the lack of sightings of sei whales in the Hawaiian Islands may be due to misidentification and/or poor sighting conditions. Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and Demaster 1998). Whaling data suggest that sei whales do not venture north of about 55° N (Gregr et al. 2000). Harwood and Stirling (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea, and that 75-85 percent of the North Pacific population resides east of 180°. Considering the many British Columbia whaling catches in the early to mid-1900s, sei whales have clearly utilized this area in the past (Gregr et al. 2000; Pike and Macaskie 1969). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July through September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea.

Sei whales appear to prefer to forage in regions of steep bathymetric relief, such as continental shelf breaks, canyons, or basins situated between banks and ledges (Best and Lockyer 2002; Gregr and Trites 2001; Kenney and Winn 1987), where local hydrographic features appear to help concentrate zooplankton, especially copepods. In their foraging areas, sei whales appear to associate with oceanic frontal systems (Horwood 1987). More recently, sei whales have become known for an irruptive migratory habit in which they appear in an area then disappear for time periods that can extend to decades.

Reproduction

Very little is known regarding sei whale reproduction. Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at six to nine months, and the calving interval is about two to three years (Gambell 1985b; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). Sei whales become sexually mature at six to twelve years of age when they reach about 45 feet (13 meters) in length, and generally mate and give birth during the winter in lower latitudes. Females give birth to a single calf that is about 15 feet (4.6 meters) long and weighs about 1,500 pounds (680 kilograms). Sei whales have an estimated lifespan of 50-70 years.

Diving and Social Behavior

Generally, sei whales make 5-20 shallow dives of 20-30 second duration followed by a deep dive of up to 15 minutes (Gambell 1985b). The depths of sei whale dives have not been studied; however the composition of their diet suggests that they do not perform dives in excess of 300 meters.

Little is known about the actual social system of these animals. Sei whales are usually found in small groups of up to six individuals, but they commonly form larger groupings when they are on feeding grounds (Gambell 1985b). These large aggregations may not be dependent on food supply alone, as they often occur during times of migration. During mating season, males and females may form a social unit, but strong data on this issue are lacking.

Feeding

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2006). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009; Mizroch et al. 1984; Rice 1977). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95 percent of their diets (Calkins 1986). The dominant food for sei whales off California during June-August is northern anchovy, while in September-October whales feed primarily on krill (Rice 1977). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries. In the North Pacific, sei whales appear to prefer feeding along the cold eastern currents (Perry et al. 1999). Sei whales have the flexibility to skim or engulf prey (Brodie and Vikingsson 2009).

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hertz range with 1.5 second duration and tonal and upsweep calls in the 200-600 Hertz range of 1-3 second durations (McDonald et al. 2005). Differences may exist in vocalizations between ocean basins (Rankin et al. 2009). Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 seconds, separated by 0.4-1.0 seconds) of 10-20 short (4 millisecconds) FM sweeps between 1.5 to 3.5 Kilohertz (Richardson and Wursig 1995).

Recordings made in the presence of sei whales have shown that they produce sounds ranging from short, mid-frequency pulse sequences (Knowlton et al. 1991; Thompson et al. 1979) to low frequency broadband calls characteristic of mysticetes (Baumgartner et al. 2008; McDonald et al. 2005; Rankin and Barlow 2007). Off the coast of Nova Scotia, Canada, Knowlton et al. (1991) recorded two-phased calls lasting about 0.5-0.8 seconds and ranging in frequency from 1.5-3.5 Kilohertz in the presence of sei whales, data similar to that reported by Thompson et al. (1979). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recorded in later studies. For example, calls recorded in the Antarctic averaged 0.45 ± 0.3 seconds in duration at 433 ± 192 Hertz, with a maximum source level of 156 ± 3.6 dB re 1 μPa-m (McDonald et al. 2005). During winter months off Hawaii, Rankin and Barlow (2007) recorded down swept calls by sei whales that exhibited two distinct low frequency ranges of 100-44 Hertz and 39- 21 Hertz, with the former range usually shorter in duration. Similar sei whale calls were also found near the Gulf of Maine in the northwest Atlantic, ranging from 82.3-34.0 Hertz and averaging 1.38 seconds in duration (Baumgartner et al. 2008). These calls were primarily single occurrences, but some double or triple calls were noted as well. It is thought that the difference in call frequency may be functional, with the mid-frequency type serving a reproductive purpose and the low frequency calls aiding in feeding/social communication (McDonald et al. 2005). Sei whales have also been shown to reduce their calling rates near the Gulf of Maine at night, presumably when feeding, and increase them during the day, likely for social activity (Baumgartner and Fratantoni 2008).

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Results of studies on blue whales (Goldbogen et al. 2013; Southall et al. 2011), which have similar auditory physiology compared to sei whales, indicate that some individuals hear some sounds in the mid-frequency range and exhibit behavioral responses to sounds in this range depending on received level and context. In terms of functional hearing capability, sei whales belong to low-frequency cetaceans which have a hearing range of 7 Hertz to 22 Kilohertz (Southall et al. 2007). There are no tests or modeling estimates of specific sei whale hearing ranges.

Status and Trends

The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973.

Ohsumi and Wada (1974) estimate the pre-whaling abundance of sei whales to be 58,000-62,000 in the North Pacific. Later, Tillman (1977) used a variety of different methods to estimate the abundance of sei whales in the North Pacific and revised this pre-whaling estimate to 42,000.

From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987; Perry et al. 1999). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). This estimate does not account for over-reporting by Soviet whalers, who took approximately 3,700 fewer individuals than were reported (Ivashchenko et al. 2013). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). The most current population estimate for sei whales in the entire north Pacific is 9,110 (Calambokidis et al. 2008) and 25,000 individuals worldwide (Braham 1991).

Natural Threats

Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

Anthropogenic Threats

Human activities known to threaten sei whales include whaling, commercial fishing, and vessel strikes. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas. In 2009, 100 sei whales were killed during western North Pacific surveys (Bando et al. 2010).

Sei whales are occasionally killed in collisions with vessels. Of three sei whales that stranded along the U.S. Atlantic coast during 1975 to 1996, two showed evidence of collisions (Laist et al. 2001). Between 1999-2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada’s Maritime Provinces (Cole et al. 2005; Nelson et al. 2007b). Two of these ship strikes were reported as having resulted in death. New rules for seasonal (June through December) slowing of vessel traffic in the Bay of Fundy to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are predicted to reduce sei whale ship strike mortality by 17 percent.

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

Critical Habitat

NMFS has not designated critical habitat for sei whales.

4.2.7 Sperm Whale

Sperm whales, *Physeter macrocephalus*, are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males measuring considerably larger than females. Adult females may grow to lengths of 36 feet (11 meters) and weigh 15 tons (13,607 kilograms). Adult males, however, reach lengths of 52 feet (16 meters) and may weigh as much as 45 tons (40,823 kilograms).

The sperm whale is distinguished by its extremely large head, which takes up to 25-35 percent of its total body length. It is the only living cetacean that has a single blowhole asymmetrically situated on the left side of the head near the tip. Sperm whales have the largest brain of any animal (on average 17 pounds (7.8 kilograms) in mature males). However, compared to their large body size, the brain is not exceptional in size. Sperm whales are mostly dark gray, but oftentimes the interior of the mouth is bright white, and some whales have white patches on the belly. Their flippers are paddle-shaped and small compared to the size of the body, and their flukes are very triangular in shape. They have small dorsal fins that are low, thick, and usually rounded.

Distribution

Sperm whales are distributed in all of the world’s oceans, from equatorial to polar waters, and are highly migratory. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Perry et al. 1999; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed.

Population Structure

There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups(Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawaii) (Perry et al. 1999; Waring et al. 2004). Genetic studies have also indicated that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead 2008).

Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin and the Pribilof Islands in summer, and occur south of 40° N in winter (Carretta et al. 2005; Gosho et al. 1984; Miyashita et al. 1995; Rice 1974). Sperm whales are the most common large whale in the central and western Aleutian Islands and are present in the Gulf of Alaska year-round (Angliss and Outlaw 2008; Mellinger et al. 2004).

Occurrence in the Gulf of Alaska is higher from July through September than January through March (Mellinger et al. 2004; Moore et al. 2006). The vast majority of individuals in the region are likely male based upon whaling records and genetic studies; the area is a summer foraging area for these individuals (Reeves et al. 1985; Straley and O'Connell 2005; Straley et al. 2005). Mean group size has been reported to be 1.2 individuals (Wade et al. 2003b; Waite 2003). Groups of females are rare but have been known to occur in areas up to the central Aleutian Islands (Fearnbach et al. 2012).

Movement

Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead et al. 2008). No sperm whale in the Pacific has been known to travel to points over 5,000 kilometers apart and only rarely have been known to move over 4,000 kilometers within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred kilometers are common (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. General transit speed averages about 4 kilometers/hour. Movement of some individuals between ocean basins, such as Atlantic-Indian by way of the Cape of Good Hope and Pacific-Indian via passage along Tasmania or the Sunda Islands, is likely and can facilitate genetic exchange between otherwise discrete sperm whale populations (Klinowska 1990).

Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl et al. 1983; Forney et al. 1995; Lee 1993; Mobley Jr. et al. 2000; Rice 1960; Shallenberger 1981), but they reach peak abundance from April to mid-June and from the end of August to mid-November (Rice 1974). They are seen in every season except winter (December-February) in Washington and Oregon (Green et al. 1992). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly towards the middle of the tropical Pacific and northward towards the tip of Baja California (Carretta et al. 2006).

Whaling data suggests that sperm whales were found in large numbers near 40° N in the northeastern Pacific and around 30° N in the northwestern Pacific (Mizroch and Rice 2006).

Habitat

Sperm whales have a strong preference for waters deeper than 1,000 meters (Reeves and Whitehead 1997; Watkins 1977), although Berzin (1972) reported that they are restricted to waters deeper than 300 meters. While deep water is their typical habitat, sperm whales are occasionally found in waters less than 300 meters in depth (Clarke 1956; Klinowska 1990). Sperm whales have been observed near Long Island, New York, in water 40-55 meters deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf. Due to their preference for deeper pelagic waters, sperm whales generally remain offshore in the eastern Aleutian Islands and Gulf of Alaska.

Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000; Davis et al. 2002; Lawson et al. 2014). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993).

Reproduction

Female sperm whales become sexually mature at an average age of 9 years or 8.25-8.8 meters (Kasuya 1991). Males reach a length of 1012 meters at sexual maturity and take 9-20 years to become sexually mature, but require another 10 years to become large enough to successfully breed (Kasuya 1991; Wursig et al. 2000). Mean age at physical maturity is 45 years for males and 30 years for females (Waring et al. 2004). Adult females give birth after roughly 15 months of gestation and nurse their calves for two to three years (Waring et al. 2004). The calving interval is estimated to be every four to six years between the ages of 12-40 (Best et al. 1984; Kasuya 1991; Whitehead 2003; Whitehead et al. 2008). In the North Pacific, female sperm whales and their calves are usually found in tropical and temperate waters year round, while it is generally understood that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters off of the Aleutian Islands (Kasuya and Miyashita 1988). It has been suggested that some mature males may not migrate to breeding grounds annually during winter, and instead may remain in higher latitude feeding grounds for more than 1 year at a time (Whitehead and Arnbom 1987).

Sperm whale age distribution is unknown, but sperm whales are believed to live at least 60 years (Rice 1978b). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980).

During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Diving and Social Behavior

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals) versus the Pacific (25-30 individuals) (Jaquet and Gendron 2009). Groups may be stable for long periods, such as for 80 days in the Gulf of California (Jaquet and Gendron 2009). Males start leaving these family groups at about 6 years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age.

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 and therefore generates a lot of interest. Sperm whales are probably the deepest and longest diving mammalian species, with dives up to 3 kilometers down and durations in excess of 2 hours (Clarke 1976; Watkins et al. 1993; Watkins et al. 1985). Usually, dives are generally shorter (25-45 min) and shallower (400-1,000 meters). Dives are separated by 8-11 minute rests at the surface (Gordon 1987; Jochens et al. 2006; Papastavrou et al. 1989; Watwood et al. 2006; Wursig et al. 2000). Sperm whales typically travel approximately 3 kilometers horizontally and 0.5 kilometers vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

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 meters) of sperm whales in the Gulf of California overlapped with depth distributions (200-400 meters) of jumbo squid, based on data from satellite-linked dive recorders placed on both species, particularly during daytime hours. 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 meters, and utilize different strategies depending on position in the water column (Teloni et al. 2007).

Feeding

Sperm whales appear to feed regularly throughout the year (NMFS 2006d). It is estimated they consume about 3-3.5 percent of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Klinowska 1990). A large proportion of a sperm whale's diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1996; Clarke 1980b; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Klinowska 1990). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Klinowska 1990).

Vocalization and Hearing

Sound production and reception by sperm whales is better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hertz to 20 Kilohertz that can be extremely loud for a biological source (200-236 dB re 1µPa), although lower source level energy has been suggested at around 171 dB re 1 PPa (Goold and Jones 1995; Mohl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2-4 Kilohertz and 10-16 Kilohertz (Goold and Jones 1995; NMFS 2006d; Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972). Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intragroup interactions and may also aid in intra-specific communication (Weilgart and Whitehead 1993). Another class of sound, "squeals," are produced with frequencies of 100 Hertz to 20 Kilohertz (Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 Kilohertz. Behavioral responses of adult, free ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999b).

When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Recent research in the South Pacific suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects, similar to those of killer whales (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean and those in the Pacific (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these include codas associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Direct measures of sperm whale hearing have been conducted on a stranded neonate using the auditory brainstem response technique: the whale showed responses to pulses ranging from 2.5-60 Kilohertz and highest sensitivity to frequencies between 5-20 Kilohertz (Ridgway and Carder 2001). Other hearing information consists of indirect data. The anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992a). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992a). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. In the Caribbean, Watkins et al. (1985) observed that sperm whales exposed to 3.25-8.4 Kilohertz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial noise generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 Kilohertz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re 1 μPa2 between 250 Hertz and 1.0 Kilohertz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. The full range of functional hearing for the sperm whale is estimated to occur between approximately 150 Hertz and 160 Kilohertz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Status and Trends

Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is not well understood, several studies and estimates of abundance are available. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003).

The most comprehensive abundance estimate for sperm whales we are aware of is from Whitehead (2002), who estimated that there are approximately 76,803 sperm whales in the eastern tropical Pacific, eastern North Pacific, Hawaii, and western North Pacific, and a worldwide population of 360,000 individuals. The tropical Pacific is home to approximately 26,053 sperm whales and the western North Pacific has approximately 29,674 (Whitehead 2002).

Hill and Demaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947-1987. This estimate does not account for under-reporting by Soviet whalers, who took approximately 31,000 more individuals than were reported (Ivashchenko et al. 2013). Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths are unclear, the paucity of population data, uncertainly regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to kill up to 56 sperm whales per year.

NMFS has designated three stocks of sperm whale for management purposes under the MMPA in the north Pacific: (1) the Hawaii stock, (2) the California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2013).

Natural Threats

Sperm whales are known to be occasionally predated upon by killer whales (Jefferson et al. 1991; Pitman et al. 2001), large sharks (Best et al. 1984), and harassed by pilot whales (Arnbom et al. 1987; Klinowska 1990; Palacios and Mate 1996; Weller et al. 1996; Whitehead 1995). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes of strandings remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic Threats

Sperm whales historically faced severe depletion from commercial whaling operations. From 1800-1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910-1982 (IWC Statistics 1959 to 1983). Other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). All of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947-1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas

(Yablokov and Zemsky 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. Sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004). Japan maintains an active whaling fleet, killing up to 10 sperm whales annually (IWC 2008). In 2009, one sperm whale was killed during western North Pacific surveys (Bando et al. 2010).

Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006). In U.S. waters in the Pacific Ocean, sperm whales are known to have been incidentally captured only in drift gillnet operations, which killed or seriously injured an average of nine sperm whales per year from 1991-1995 (Barlow et al. 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Hill and Demaster 1998; Klinowska 1990). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on fish caught in longline gear in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and Demaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear. An individual was caught and released from gillnetting, although injured, on Georges Bank during 1990. A second individual was freed, but injured, from gillnetting on George's Bank in 1995. In 1994, a sperm whale was disentangled from gillnet along the coast of Maine. In August 1993, a dead sperm whale, with longline gear wound tightly around the jaw, was found floating approximately 32 km off Maine. Ten sperm whale entanglements have been observed in U.S. fisheries since 1990 in the Pacific (Carretta and Enriquez 2012). Two additional whales have been found to die from ingestion of fishing gear (Jacobsen et al. 2010). Overall, it is estimated that 3.8 sperm whales die annually along the U.S. west coast due to fisheries interaction (Carretta et al. 2013).

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and HCHs in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). Unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise Sr. et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 microgram Cr/grams tissue, with the mean (8.8 microgram Cr/grams tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise Sr. et al. 2009). Older or larger individuals do not appear to accumulate chromium at higher levels.

Ingestion of marine debris can have fatal consequences even for large whales. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract (Viale et al. 1992). A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). The stomach contents of two sperm whales that stranded separately in California included extensive amounts of discarded fishing netting (NMFS 2009). A fifth individual from the Pacific was found to contain nylon netting in its stomach when it washed ashore in 2004 (NMFS 2009). In March 2012, a sperm whale stranded dead, apparently dying as a result of plastic ingestion (De Stephanis et al. 2013).

There have not been any recent documented ship strikes involving sperm whales in the eastern North Pacific, although there are a few records of ship strikes in the 1990s. Two whales described as "possibly sperm whales" are known to have died in U.S. Pacific waters in 1990 after being struck by vessels (Barlow et al. 1997). There is an anecdotal record from 1997 of a fishing vessel that struck a sperm whale in southern Prince William Sound in Alaska, although the whale did not appear to be injured (Laist et al. 2001). More recently in the Pacific, two sperm whales were struck by a ship in 2005, but it is not known if these ship strikes resulted in injury or mortality (NMFS 2009). The lack of recent evidence should not lead to the assumption that no mortality or injury from collisions with vessels occurs as carcasses that do not drift ashore may go unreported, and those that do strand may show no obvious signs of having been struck by a ship (NMFS 2009). Worldwide, sperm whales are known to have been struck 17 times out of a total record of 292 strikes of all large whales, 13 of which resulted in mortality (Jensen and Silber 2004; Laist et al. 2001). Given the current number of reported cases of injury and mortality, it does not appear that ship strikes are a primary threat to sperm whales (Whitehead 2003).

Critical Habitat

NMFS has not designated critical habitat for sperm whales.

5 ENVIRONMENTAL BASELINE

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

5.1 Ambient and Anthropogenic Noise

Due to their use of sound in navigating, locating prey, mating, and communicating, marine organisms may be expected to choose their locations and modify their behavior based, in part, on natural and anthropogenic background noise. Noise in the ocean is the result of both natural and anthropogenic sources. Natural sources of noise include processes such as earthquakes, wind-driven waves, rainfall, bio-acoustic sound generation, and thermal agitation of the seawater. Anthropogenic noise is generated by a variety of activities, including shipping; oil and gas exploration, development, and production (e.g., air-guns, ships, oil drilling); naval operations (e.g., military sonars, communications, and explosions); fishing (e.g., commercial/civilian sonars, acoustic deterrent, and harassment devices); research (e.g., air-guns, sonars, telemetry, communication, and navigation); and other activities such as construction, icebreaking, and recreational boating. Sources of anthropogenic noise are becoming more pervasive, increasing oceanic background noise levels as well as peak sound intensity levels. Many anthropogenic sources of noise are located along shipping routes and encompass coastal and continental shelf waters, areas that represent important marine habitat.

5.2 Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean (e.g., offshore habitats below the surface). Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20-500 Hertz appear to be dominated by distant shipping noise. Above 300 Hertz, the level of wind-related noise occasionally exceeds shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500-50,000 Hertz. The frequency spectrum and level of ambient noise 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 frequencies between 100-500 Hertz, (Urick 1983) has estimated the average deep water ambient noise spectra to be 73-80 dB for areas of heavy shipping traffic and high sea states, and 46-58 dB for light shipping and calm seas. Underwater ambient noise within the Southern California Range Complex has higher than average noise (78-86 dB) at low frequencies (100-500 Hertz), owing to the dominance of ship noise at frequencies below 100 Hertz and local wind and waves above 100 Hertz (Hildebrand et al. 2012). In addition, there is monthly variation including noise peaks at 15-30 Hertz and also 47 Hertz related to the presence of blue and fin whale calls (Hildebrand et al. 2012).

5.3 Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters (i.e., surface waters, 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 shipping and industrial activities, wind and waves, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. 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 sound levels tend to be higher than when the bottom is absorptive.

5.4 Anthropogenic Sources

Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Jasny et al. 2005; NRC 2003b; Richardson and

Wursig 1995). McDonald et al. (2006a) observed an increase in low-frequency noise of 10-12 dB over 39 years at a site off the southern California coast. A variety of anthropogenic noise sources have been identified in the action area, including vessel noise from shipping and other activities, military training and testing, and seismic survey work associated with research and the oil and gas industry.

5.4.1 **Vessel Noise and Commercial Shipping**

Much of the increase in noise in the ocean environment is due to increased shipping as ships become more numerous and of larger tonnage (Hildebrand 2009; McKenna et al. 2012; NRC 2003b). Shipping constitutes a major source of low-frequency noise in the ocean, particularly in the Northern Hemisphere where the majority of ship traffic occurs. At frequencies below 300 Hertz, ambient noise levels are elevated by 15-20 dB when exposed to sounds from ships at a distance (McKenna et al. 2012). Analysis of noise from ships revealed that their propulsion systems are a dominant source of radiated underwater noise at frequencies <200 Hertz (Ross 1976). Additional sources of ship noise include rotational and reciprocating machinery that produces tones and pulses at a constant rate.

Individual vessels produce unique acoustic signatures, although these signatures may change with ship speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial ships are in the frequency band of 10-50 Hertz and range from 195 dB re µPa2 /Hertz at 1 meter for fast-moving (> 20 knots) supertankers to 140 dB re µPa2 /Hertz at 1 meter for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (1-5 Kilohertz) range and at moderate (150-180 dB re 1 µPa at 1 meter) source levels (Erbe 2002b; Gabriele et al. 2003; Kipple and Gabriele 2004). On average, noise levels are higher for the larger vessels, and increased vessel speeds resulted in higher noise levels.

Measurements made over the period 1950-1970 indicated low-frequency (50 Hertz) ship traffic noise in the eastern North Pacific and western North Atlantic Oceans was increasing by 0.55 dB per year. Data obtained in the northeast Pacific from 1978-1986 suggest the 0.55 dB/year increase seen in the early data continued to around 1980, but then slowed to about 0.2 dB/year (Chapman and Price 2011).

The scientific community recognizes the addition of anthropogenic sound to the marine environment as a stressor that could possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). The species considered in this opinion may be impacted by noise in various ways. Once detected, some sounds may produce a behavioral response, including but not limited to, changes in habitat to avoid areas of higher noise levels, changes in diving behavior, or changes in vocalization (MMC 2007).

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging and construction (Richardson and Wursig 1995). Most observations have been limited to short term behavioral responses, which included temporary cessation of feeding, resting, or social interactions, however, habitat abandonment can lead to more long-term effects which may have implications at the population level. Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for blue and fin whales. This could have a variety of implications for an animal's fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC 2007). Recent scientific evidence suggests that marine mammals, including blue and fin whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (McDonald et al. 2006b; Parks 2003; Parks 2009). Physical injury could also occur if an animal is exposed to high intensity sound of relatively short duration (e.g., exposure to airguns).

5.4.2 **Seismic Surveys**

Seismic surveys are the primary means for finding and monitoring fossil fuel reserves and are also used by the scientific community (MMC 2007). Seismic surveys use an array of airguns which emit low-frequency sound into the marine environment (Dragoset 2000; Hildebrand 2005). Numerous seismic surveys have been undertaken in the action area and its surrounding region over the past 35 years (Turner et al. 1987). ESA-listed cetaceans are long-lived individuals whose experience likely includes prior exposure to seismic sound sources. Prior exposure could lead to habituation, sensitization, or other changes to future exposure based upon prior experience. Significant attention has been paid to the potential impact of seismic airguns on ESA-listed species.

Gordon et al. (2004) found that marine mammals can be impacted by the intense, broadband pulses produced by seismic airguns through: hearing impairment (temporary threshold shift [TTS] or permanent threshold shift [PTS]); physiological changes such as stress responses; impacting their prey; behavioral alterations such as avoidance responses, displacement, or a change in vocalizations; or through masking (obscuring sounds of interest). Responses can differ according to context, sex, age class, or species.

Generally, only the area within 500 meters of the seismic vessel is observed, yet high noise levels can occur at much greater distances. Madsen et al. (2006) discovered that in the Gulf of Mexico received levels can be as high at a distance of 12 kilometers from a seismic survey as they are at 2 kilometers (in both cases >160 dB peak-to-peak). Received levels, as determined from acoustic tags on sperm whales, generally fell at distances up to 8 kilometers from the seismic survey, only to increase again at greater distances (Madsen et al. 2006).

5.4.3 **Potential Population-level Impacts of Anthropogenic Noise**

It is clear that impacts may result from increased levels of anthropogenic-induced background noise or high intensity, short-term anthropogenic sounds. The majority of impacts will likely be short-term behavioral responses, although more serious impacts are possible. Despite the potential for these impacts to affect individual animals, information is not currently available to determine the potential population level effect of anthropogenic sound levels in the marine environment (MMC 2007) on ESA-listed marine mammals and sea turtles. More information would be required including, but not limited to, empirical data on how sound impacts an individual's growth and vital rates, how these changes impact that individual's ability to reproduce successfully, and then the relative influence of that individual's reproductive success on the population being considered. As a result, the consequences of anthropogenic sound on threatened and endangered marine mammal and sea turtles at the population or species scale remain uncertain.

5.5 Climate Change

The latest Assessment Synthesis Report from the Working Groups on the Intergovernmental Panel on Climate Change (IPCC) concluded climate change is unequivocal (IPCC 2014). The Report concludes oceans have warmed, with ocean warming the greatest near the surface (e.g., the upper 75 meters have warmed by 0.11 °C per decade over the period 1971-2010) (IPCC 2014). Global mean sea level rose by 0.19 meters between 1901-2010, and the rate of sea-level rise since the mid-19th century has been greater than the mean rate during the previous two millennia (IPCC 2014). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, heat waves, and droughts (IPCC 2014). Climate change has the potential to impact species abundance, geographic distribution, migration patterns, timing of seasonal activities (IPCC 2014), and species viability into the future. Though predicting the precise consequences of climate change on highly mobile marine species, such as many of those considered in this opinion, is difficult (Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring.

Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. He predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, with 47 percent likely to be negatively affected.

Similarly, climate-mediated changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1990). Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have significant negative consequences for species such as sperm whales, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

Previous warming events (e.g., El Niño, the 1977-1998 warm phase of the Pacific Decadal Oscillation) may illustrate the potential consequences of climate change. Off the U.S. west coast, past warming events have reduced nutrient input and primary productivity in the California Current, which also reduced productivity of zooplankton through upper-trophic level consumers (Doney et al. 2012; Lee and Sydeman 2009). In the past, warming events have resulted in reduced food supplies for marine mammals along the U.S. west coast (Feldkamp et al. 1991; Hayward 2000; Le Boeuf and Crocker 2005). Some marine mammal distributions may have shifted northward in response to persistent prey occurrence in more northerly waters during El Niño events (Benson et al. 2002; Danil and Chivers 2005; Lusseau et al. 2004; Norman et al. 2004; Shane 1994; Shane 1995). Low reproductive success and body condition in humpback whales may have resulted from the 1997/1998 El Niño (Cerchio et al. 2005).

This is not an exhaustive review of all available literature regarding the potential impacts of climate change to the species considered in this opinion. However, this review provides some examples of impacts that may occur. While it is difficult to accurately predict the consequences of climate change to the species considered in this opinion, a range of consequences are expected, ranging from beneficial to catastrophic. Given a lack of available information within the context of the temporal scale of the action, specific climate change related impacts on the species evaluated in this opinion are speculative, cannot be meaningfully assessed, and will not be considered further.

5.6 Fisheries Interactions

Marine mammals may be impacted by fisheries through entrapment or entanglement in actively fished gear, or may be impacted through entanglement in, or ingestion of, derelict fishing gear.

Additionally, some marine mammals considered in this opinion have the potential to be impacted indirectly if a fishery reduces the available prey base for higher trophic level organisms. Due to their highly migratory nature, many species considered in this opinion have the potential to interact with fisheries both in and outside of the action area. Assessing the impact of fisheries on such species is difficult, due to the large number of fisheries that may interact with the animals, and the inadequate protected species monitoring that occurs in many of those fisheries. For a comprehensive list of U.S. commercial fisheries that may interact with marine mammals in the North Pacific Ocean (see NOAA 2014, Appendix 3).

The vast majority of documented cases of baleen whale entanglements with fishing gear are from actively fished gear (NOAA 2014). Entanglement in fishing gear can result in serious injury and mortality to cetaceans. From 2003-2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters (Allen and Angliss 2013). Mortality and serious injury numbers are minimum estimates as some interactions go unobserved. For example, whales may swim away with portions of the net, not allowing fishery observers or fishers to document the interaction (Carretta et al. 2014). Additionally, since cetaceans occurring in the action area are migratory, these populations are likely to interact with fisheries and derelict gear from outside the action area. For example, many of the humpback whales that occur in the action area migrate to and from Hawaii or the U.S. West coast. For example, between 2007-2011, 16 documented humpback whale interactions occurred with pot and trap fisheries off the U.S. West coast, and in all instances, the whale either died or was seriously injured. During the same time period and in the same area, gill nets and unidentified fisheries accounted for 10 documented interactions with humpback whales, with one mortality and nine serious injuries (Carretta et al. 2013). From November 2009 through April 2010, the Hawaii Whale Entanglement Response Network received 32 reports of entangled humpback whales from fishing gear including longline, monofilament (hook and line), and local crab pot (trap) gear (DoN 2013). Reports of fin whale entanglement are less common than for humpbacks off the U.S. West coast. Only one fin whale death has been observed in fisheries off the California coast (observed in the swordfish drift gillnet fishery) since 1990. In Hawaii, the two longline fisheries that may interact with large marine mammals (the deep-set longline fishery and the shallow-set longline fishery) did not document a fin whale interaction between 2007-2011 (Bradford and Forney 2014; McCracken 2013).

5.7 Marine Debris

Anthropogenic marine debris is prevalent throughout the action area, originating from a variety of oceanic and land-based sources. Debris can be introduced into the marine environment by its improper disposal, accidental loss, or natural disasters (Watters et al. 2010), and can include plastics, glass, derelict fishing gear, derelict vessels, or military expendable materials. Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it. Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced.

As noted above in the fisheries interactions section of the Environmental Baseline, entanglement or entrapment in derelict fishing gear can pose a threat to many of the species considered in this opinion. The vast majority of reported cases of entangled baleen whales in the U.S. are humpbacks, with most of these interactions likely involving actively fished, rather than derelict, gear (NOAA 2014). In Alaska, only 24 percent of documented entanglements were from unknown sources, possibly including marine debris, with the rest of the cases being from a known fishery and likely being actively fished (Jensen et al. 2009). As noted previously, it is likely that some animals interact with fishing gear outside of the action area, become entangled, and bring that gear with them when they migrate to the action area. For example, 10 humpbacks with entangled gear observed in Hawaii have also been sighted with entangled gear in Alaska, with one animal traveling over 2,450 nautical miles with gear attached (Lyman 2012).

Anthropogenic marine debris can also be accidentally consumed while foraging. Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items (Baird and Hooker 2000). This can have significant implications for an animal's survival, potentially leading to starvation or malnutrition, or internal injuries from consumption. In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impaction was the cause of both deaths. Jacobsen et al. (2010) speculated that the debris likely accumulated over many years, possibly in the North Pacific gyre that would carry derelict Asian fishing gear into eastern Pacific waters.

5.8 Scientific Research

Scientific research permits issued by the NMFS currently authorize studies on listed species in the North Pacific Ocean, some of which extend into portions of the action area. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, exposure to acoustic activities, and breath sampling. Research activities involve non-lethal "takes" of these whales. From 2009-2016, no lethal takes of the species considered in this opinion were authorized.

Table 3 describes the cumulative number of takes for each ESA-listed species in the action area authorized by scientific research permits.

Table 3. Authorized takes of listed whales in the Pacific Ocean under the Endangered Species Act and Marine Mammal Protection Act.

Species	2009-2016 sub-lethal take
Blue whale	151,037
Fin whale	222,093
Western North Pacific Gray whale	1,264
Humpback whale	472,963
North Pacific Right whale	12,762
Sei whale	63,784
Sperm whale	195,287

See Section 6 of this opinion for a discussion of the expected responses of large whales to exposure of non-lethal scientific research activities.

5.9 United States Navy Activities

The Navy has been conducting training exercises in the North Pacific Oceans and Gulf of Alaska for many years. Monitoring in conjunction with Navy training and testing exercises to determine the effects of active sonar and explosives on marine mammals is ongoing at many locations. Marine mammal responses to Navy training and testing range from no response, to hearing loss and possible death.

5.10 Vessel Strike

Though vessel strikes are a known source of injury and mortality for cetaceans worldwide, documenting such events is challenging, particularly in remote areas such as Alaska (Neilson et al. 2012). Vessel strikes may go unreported because operators may not report the strike or because they may not detect it. Vessel speed and size appears to be particularly important in predicting collision rates and their outcomes (Neilson et al. 2012). For example, Silber et al. (2010) determined that during close encounters with whales, reduced ship speeds decreased the probability of a collision. Laist et al. (2001) determined that most ship strikes resulting in death or serious injury involved ships traveling 14 knots or faster and ships greater than 80 meters in length. Neilson et al. (2012) evaluated documented whale vessel strikes in Alaskan waters that occurred from 1978-2011. During that time, a total of 108 collisions were documented. The majority of the documented strikes were of humpback whales (n=93) in southeastern Alaska. Fin whales (n=3), sperm (n=1), and gray whales (n=1) were also struck in Alaska during this time period. All sizes of vessels struck whales (ranging from < 15 meters to > 80 meters), but small vessel strikes were most common.

With the information available, we know interactions occur, but available literature does not allow us to determine what degree ship strikes impact the survival and recovery of cetaceans. This is particularly true given the lack of information on interactions between whales and vessels outside of U.S. waters in the North Pacific Ocean. The one exception is the blue whale. Monnahan et al. (2014) used a population dynamics model to assess the trends and status of Eastern North Pacific blue whales, and the effects of ship strikes. The authors estimate the Eastern North Pacific blue whale population is currently at 97 percent carrying capacity, and that it would take an 11- fold increase in the current number of vessels for the population to have a 50 percent chance of being below its maximum level of productivity, and thus depleted due to ship strike. Based on this information, we can conclude that ship strikes are not inhibiting the survival and recovery of Eastern North Pacific blue whales.

The potential effects of cetacean interactions with vessels that do not result in ship strike are discussed below (e.g., exposure to vessel noise, behavioral avoidance of vessel).

5.11 Whale Watching

As of 2010, commercial whale watching was a $1 billion global industry per year (Lambert et al. 2010). Private vessels may partake in this activity as well. Numerous commercial whale watching businesses operate in and around the marine waters off Kodiak Island. Additionally, as noted previously, many of the cetaceans considered in this opinion are highly migratory, so may also be exposed to whale watching activity occurring outside of the action area. 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. Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior or even injure them if the vessel gets too close or strikes the whale. Preferred habitats may be abandoned if disturbance levels are too high. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Several investigators have studied the short term effects of whale watch vessels on marine mammals (Amaral and Carlson 2005; Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005; Watkins 1986; Williams et al. 2002). The whale’s behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel noise, and the number of vessels. 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. Although numerous short-term behavioral responses to whale watching vessels are documented, little information is available on whether long-term negative effects result from whale watching (NMFS 2006b). Christiansen et al. (2014) estimated the cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, though some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was very low. The authors suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates (Christiansen et al. 2014). To our knowledge, similar studies have not been conducted in Alaska.

5.12 Whaling

Large whale population numbers in the action area have historically been impacted by commercial exploitation, mainly in the form of whaling. Prior to current prohibitions on whaling, most large whale species had been significantly depleted.

Table 4 lists the reported catches of all whale species considered in this opinion and the year in which the IWC issued a moratorium on harvest of that species.

Table 4. Reported catch of endangered whales considered in this opinion, in the North Pacific Ocean.

Species	Estimated total catch	Data years	Source	IWC moratorium
Blue whale	9,500	1910-1965	(Ohsumi and Wada 1972)	1966
Fin whale	46,000	1919-1945	(C. Allison, IWC, pers. comm.; cited in: Carretta et al. 2014)	1976
Humpback whale	15,000	1919-1987	(Tonnessen and Johnsen 1982; C. Allison, IWC unpubl. Data; cited in: Carretta et al. 2014)	1966
Sei whale	61,500	1947-1987	(C Allison, IWC, pers. comm.; Allison 2007)	1976
Sperm whale	258,000	1947-1987	(C. Allison, IWC, pers. comm.; cited in: Carretta et al. 2014)	1988

These whaling numbers represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialist Republics catch records indicate extensive illegal whaling activity between 1948-1979, with a harvest totaling 157,680 sperm whales in the North Pacific Ocean (Ivashchenko et al. 2014). Of these, only 132,505 were reported by the Union of Soviet Socialist Republics to the Bureau of International Whaling Statistics. Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Pacific Ocean whether it be under objection of the IWC, for aboriginal subsistence purposes, or under IWC special permit. From 1985-2013, 1089 sei whales and 444 sperm whales were harvested. Although these fisheries operate outside of the action area, some of the whales killed in these fisheries are likely part of the same populations of whales occurring within the action area for this consultation.

Historically, commercial whaling caused all of the large whale species to decline to the point where they faced extinction risks high enough to list them as endangered species. Since the end of large-scale commercial whaling, the primary threat to these species has been eliminated. However, as described in greater detail in the Status of the Species section of this opinion, all whale species have not recovered from those historic declines. Scientists cannot determine if those initial declines continue to influence current populations of most large whale species in the North Pacific. For example, the North Pacific right and Western North Pacific gray whales have not recovered from the effects of commercial whaling and continue to face very high risks of extinction because of their small population sizes and low population growth rates. In contrast, species such as humpback and blue whale have increased substantially from post-whaling population levels and appear to be recovering despite the impacts of ship strikes, interactions with fishing gear, and increased levels of ambient sound in the Pacific Ocean.

5.13 Large Whale Unusual Mortality Event 2015

Since May 2015, elevated large whale mortalities have occurred in the western Gulf of Alaska, encompassing the action area, particularly Kodiak Island (Figure 7). As of mid-August 2015, 11 fin, 14 humpback, 1 gray, and 4 unidentified cetaceans have stranded in the area. As of the signing of this opinion, no definitive cause has been determined for this event.

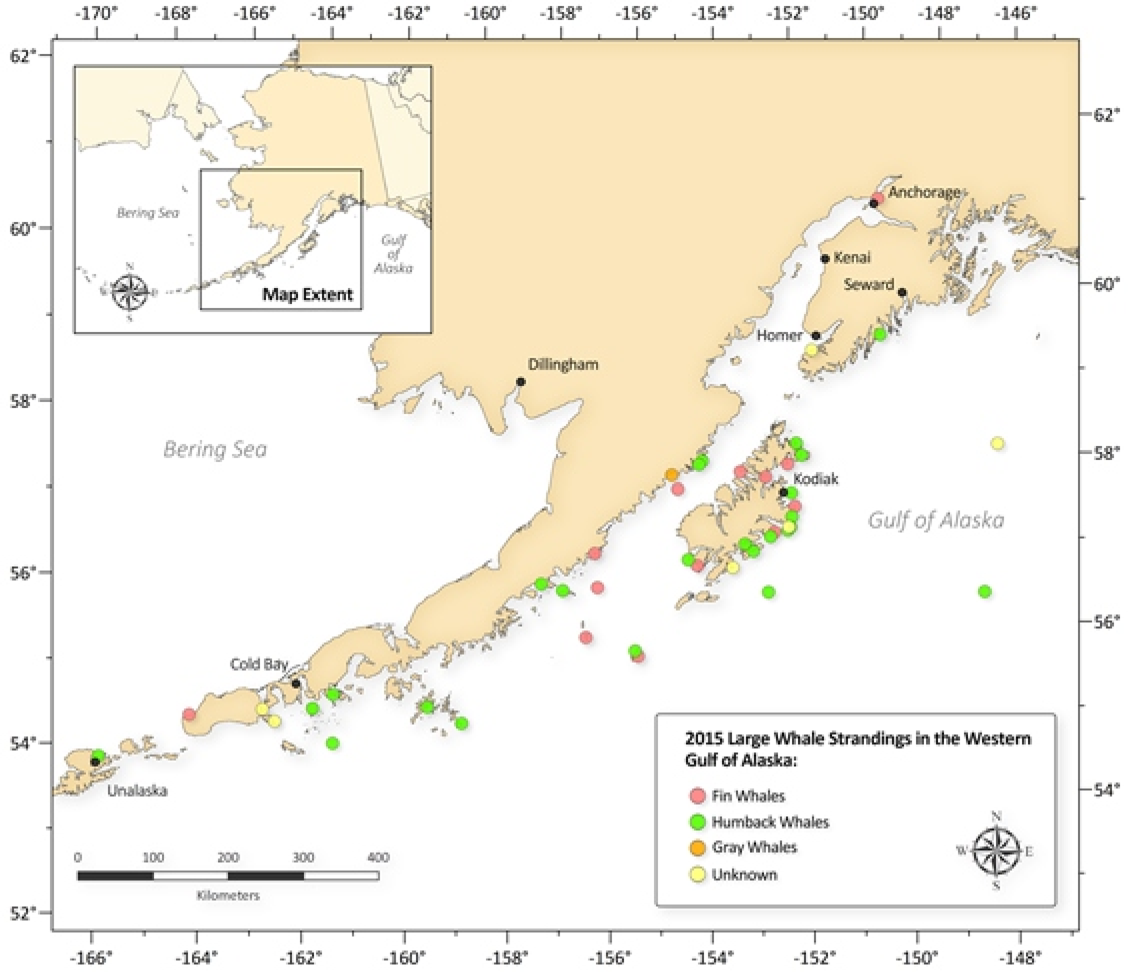

Figure 7. Large whale stranding locations in the Western Gulf of Alaska through December 1, 2015. Map sourced from http://www.nmfs.noaa.gov/pr/health/mmume/gulf_of_ak/ak_ume_map.jpg

5.14 Recovery Actions in the Action Area

Recovery is the process by which species' ecosystems are restored and threats to the species are minimized such that ESA-listed species can be self-sustaining. This section addresses ongoing recovery actions that may compensate for effects from stressors in the Environmental Baseline and the action assessed in this opinion. Ongoing conservation actions for ESA-listed cetaceans include, but are not limited to, the following:

- NOAA Fisheries Alaska Protected Resources Division large whale disentanglement efforts (https://alaskafisheries.noaa.gov/protectedresources/entanglement/whale_entanglement_factsheet.pdf).

- Marine Mammal Viewing Guidelines and Regulations (http://alaskafisheries.noaa.gov/protectedresources/mmv/guide.htm).
- Research on humpback population structure and abundance including the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project.

5.15 The Impact of the Baseline on Endangered Species Act listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed species considered in this opinion. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strike, whaling), whereas others result in more indirect (e.g., a fishery that impacts prey availability) or non-lethal (e.g., whale watching, anthropogenic sound) impacts. Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that most of the species in this opinion are wide ranging and subject to stressors in locations well beyond the action area.

We consider the best indicator of the aggregate impact of the Environmental Baseline on ESA-listed resources to be the status and trends of those species. The population abundance of the ESA-listed species noted in Table 2, may be increasing, decreasing, or the status remains unknown. Taken together, this indicates that the Environmental Baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the Environmental Baseline. Therefore, while the Environmental Baseline described previously may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the Environmental Baseline is preventing their recovery. It is also possible that their populations are at such low levels (e.g., due to historic commercial whaling) that even when the species’ primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself.

A thorough review of the status and trends of each species is discussed in the *Status of Listed Resources* section of this opinion.

6 EFFECTS OF THE ACTION ON ENDANGERED SPECIES ACT LISTED SPECIES AND CRITICAL HABITAT

Section 7 regulations define “effects of the action” as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

As was stated in Section 3, this biological opinion includes both a jeopardy analysis and an adverse modification analysis.

The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence of a listed species,” which is “to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts of the proposed action on the critical habitat features and conservation value of designated critical habitat. This opinion relies on the recently updated regulatory definition of “destruction or adverse modification” of critical habitat at 50 CFR §402.02: a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

Under Section 7(a) (2) of the ESA, Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed activities authorized by permit No. 18529 would expose ESA-listed species to close vessel approaches and photography, biological sampling, suction cup and satellite tagging, and subsequent research (e.g., focal follows, evaluation of acoustic pingers). In this section, we describe the:

- potential physical, chemical, or biotic stressors associated with the proposed action;
- the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available ; and,
- probable responses of those individuals (given probable exposures) based on the available evidence.

Any responses that would be expected to reduce an individual’s fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success) would be assessed to consider the risk posed to the viability of the listed population. The purpose of this assessment is to determine if it is reasonable to expect the proposed studies to have an effect on the listed population that could appreciably reduce their likelihood of surviving and recovering in the wild.

The proposed action involves non-lethal harassment of ESA-listed cetaceans and pinnipeds. The ESA does not define harassment nor has NMFS defined this term, pursuant to the ESA, through regulation. The MMPA defines harassment as “any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering" [16 USC 1362(18) (A)]. The latter portion of this definition ("...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the USFWS' regulatory definition of harassment. For the following sections, we define harassment as "an intentional or unintentional act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns essential to the animal's life history or its contribution to the population the animal represents." If we find that the proposed research causes behavioral disruptions that may result in animals that fail to feed or breed successfully, or die, then we will discuss the likely consequences of these disruptions for the population.

The assessment for this consultation identified the following possible stressors associated with the proposed permitted activities:

1) vessel traffic;
2) vessel close approaches to ESA-listed species;
3) passive acousting recording/monitoring;
4) fishing gear modifications;
5) hydroacoustic sampling for prey mapping;
6) suction-cup tagging;
7) dart/barb tagging;
8) tag instrument transmissions;
9) acoustic playbacks;
10) biopsy;
11) collection of sloughed skin, feces, blow, and prey remains;
12) collection and export of dead listed mammal parts.

All proposed activities will occur in the Gulf of Alaska, and will be focused in marine waters of the outer continental shelf, Prince William Sound, and southeastern Alaskan waters (Figure 6) and will occur annually from the date of the permit's issuance until its expiration (five years from the date of issuance).

6.1 Stressors Not Likely to Adversely Affect Endangered Species Act Listed Species

Based on a review of available information, we determined the following possible stressors that individual animals would be exposed to would not pose a risk to listed species: vessel traffic; fishing gear modifications; passive acoustic recording/monitoring; hydroacoustic sampling for prey mapping; tag instrument transmissions; collection of sloughed skin, feces, blow, and prey remains; and collection and export of dead listed mammal parts.

Vessel Traffic

Vessel traffic associated with the proposed research is not expected to pose a measurable risk to ESA-listed species (with the exception of close approach, as described in Section 6.2). Given the experience of the applicant in detecting the ESA-listed species considered in this opinion and conducting similar surveys to those proposed for this permit, the possibility of vessel strike is remote. We expect the applicant would be able to locate, identify, and avoid all ESA-listed cetaceans and pinnipeds during transit. Additionally, we expect the applicant to comply with the permit terms and conditions that require the applicant to exercise caution when approaching animals and require them to retreat from animals if behaviors indicate the approach may be interfering with reproduction, feeding or other vital functions. Further caution will be used when approaching females with calves. For these reasons, we consider the likelihood for a vessel strike of an ESA-listed species to be extremely unlikely to occur, and thus, discountable.

Noise from project vessels may be detectable to ESA-listed marine mammals in the action area; however, the infrequency of vessels associated with this project is not expected to substantially increase noise levels above background conditions. Any response elicited from ESA-listed species due to vessel noise is expected to be in the form of behavioral avoidance or interruption in behavior and of short duration. We believe any behavioral response of ESA-listed species to vessel noise will be of limited duration and magnitude such that it would not involve fitness consequences from the disruption of breeding, feeding, communication, or sheltering. Therefore, the effects of vessel noise on ESA-listed species are expected to be biologically insignificant.

We also evaluated the potential for a small fuel spill that could occur during project activities to impact ESA-listed species. Due to the open ocean environment in which the proposed action will occur, the duration and small spatial extent of such a spill, and the wide ranging life histories and mobility of ESA-listed species that may occur in the action area, the effects of a small fuel spill are deemed insignificant.

Tag Instrument Transmissions

During tagging activities, some whales could be exposed to sounds from tag attachments. The transmitters operate on the 401.650 Megahertz frequency, which is well outside the hearing range of odontocetes and mysticetes. As described in the Status of Listed Species section, we assume the species considered in this opinion hear best at frequencies at which they vocalize. Based on available information, this includes sounds in the low frequency (i.e., <1 Kilohertz) range. Therefore, the effects of VHF transmissions are considered insignificant and thus not considered further in this opinion.

Passive Acoustic Recording/Monitoring

Passive acoustic recording is not expected to pose a measurable risk to individuals of each listed species. Single hydrophones or hydrophone arrays would be used for passive acoustic recording. None of the hydrophone array components emit any sound into the air or water, and therefore this equipment does not pose a risk of acoustic exposure. However, because use of these hydrophone buoys involves equipment suspended on and into the water column, the possibility for interactions with listed whales was assessed. In the proposed permit, hydrophones are towed by the vessel as an array, attached to the vessel, or deployed as a single hydrophone near the vessel. In essence, the hydrophone or array would be an extension of the vessel itself. In this sense, effects to the target animals would be from the vessel close approach which is discussed in Section 6.2 of this opinion.

Fishing Gear Modifications

Modifications to normal longline fishing vessel operations would occur under the proposed research activities. These longline fishing vessels fish in areas where sperm whales are expected to be present. For specific modifications to longline fishing vessels see Section 2.1.2 of this opinion.

We expect no measurable effect to sperm whales as a result of these modifications. Passive acoustic recording was already analyzed above and determined to pose no measurable effect on listed species. Modifications to longline systems would only vary the sequence and would not add additional systems to each haul that would not already have existed without research activities.

Hydroacoustic Sampling for Prey Mapping

Focal follows will be the primary method used for prey mapping but occasionally hydroacoustics would be used to estimate prey biomass and track underwater movement of whales. Since individuals may be pursuing/chasing prey up to the surface, sonar activities would occasionally occur within one body length of a whale. Sonar would be operated at frequencies from 30-120 Kilohertz. These frequencies are above the known hearing range for listed mammals in proposed activities therefore, the effects of hydroacoustic sampling on ESA-listed species are expected to be biologically irrelevant and thus, insignificant.

Collection of Sloughed Skin, Feces, Blow, and Prey Remains

Sloughed skin from humpback whales will be collected following certain surface activities (i.e., breaching, tail slapping). Sloughed skin will be collected from the site of the surface activity only after the whale has moved greater than 90 meters from the location. Since whales will have either departed the area or passed a safe distance of 90 meters by the time the vessel retrieves sloughed skin, the effects of this action is insignificant and will not be considered further.

The collection of exhaled air would be authorized under proposed activities. Air is collected on close vessel approach with a sampling device that is held in the air in the path of the whale’s exhalation spray. The device itself is not likely to make contact with the whale, but it is possible. The effect of the device making contact with the whale would be less than that of tag attachment and would not pose a measurable risk to the whale, however, the close approach associated with air collection would be considered to pose a measurable risk and is analyzed further in this opinion below.

The collection of feces would be authorized under the proposed permit. Feces will be collected from the surface after defecation has been observed and the whale has moved a distance of 20 meters or more away therefore, the effects of this action is insignificant and will not be considered further.

Collection and Export of Dead Animal Parts and Prey Remains

The collection of prey remains and dead ESA-listed marine mammal parts would result in no effect to these species since the animals will have been removed from the population by other causes prior to the take of their parts.

6.2 Stressors Likely To Adversely Affect Endangered Species Act Listed Species

The exposure and response analysis of this opinion will focus on the following potential stressors: 1) vessel close approaches; 2) suction cup tagging; 3) dart/barb tagging; 4) biopsy; and, 5) acoustic playbacks.

6.2.1 Mitigation to Minimize or Avoid Exposure

Mitigation measures to minimize disturbance and impacts to target species were discussed after eash individual proposed research activity under Section 2.1 of this opinion.

6.2.2 Exposure Analysis

Exposure analyses identify the co-occurrence of ESA-listed species with the actions' effects in space and time, and identify the nature of that co-occurrence. The analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulations(s) those individuals represent. As discussed previously, blue, fin, gray, humpback, North Pacific right, sei, and sperm whales of either gender and any age class could be exposed to stressors associated with the proposed action.

We have assessed the action at the proposed levels for all research activities. It is possible that in any given year, not all proposed takes would occur since researchers ask for takes based on a desired sample size and account for potential (though not necessarily likely or expected) encounters with large numbers of whales that could occur while conducting field research. The take levels requested and analyzed in this opinion are above in Table 1. Under the proposed action, exposure to proposed activities would occur each year for five years until the permit's expiration.

The duration of each exposure depends on the duration of close approach and the methods performed after close approach. Tagging of target whales could last 5-10 minutes for close approach and then five seconds or less for the tag or biopsy application. Suction cup tags may remain attached up to 48 hours, but most will only remain attached for 6-8 hours. Following the application of a tag, whales will be monitored for varying amounts of time depending on the research objective.

6.2.3 **Response Analysis**

As discussed in the *Approach to the Assessment* section of this opinion, response analyses determine how listed resources are likely to respond after being exposed to an action's stressors. Below we discuss the expected response of ESA-listed whales to close vessel approaches, suction cup tagging, satellite tagging, biopsy, and acoustic playbacks.

Close Vessel Approaches

The procedure for close vessel approaches was described in Section 2.1.1 of this opinion. This section also described the minimization measures the applicant will use in order to minimize disturbance to animals including slowly approaching animals and terminating an approach if signs of disturbance are observed (e.g., changes in behavior, stress vocalizations, abrupt shifts in direction of movement).

The presence of vessels has the potential to induce behavioral and physiological changes in individuals being targeted, although the animals' reactions are generally short term and low impact. The degree to which individuals are disturbed is highly variable. Whales may respond differently depending upon what behavior the individual or group is engaged in before the vessel approaches (Hooker et al. 2001; Wursig et al. 1998) and the degree to which they have become accustomed to vessel traffic (Lusseau 2004; Richter et al. 2006); reactions may also vary by species or individuals within a species (Gauthier and Sears 1999). Overall, reactions range from little to no observable change in behavior to momentary changes in swimming speed, pattern, orientation, diving, time spent submerged, foraging, and respiratory patterns. Responses may also include aerial displays like tail flicks and lobtailing and may possibly influence distribution (Baker et al. 1983a; Bauer and Herman 1986; Clapham et al. 1993; Jahoda et al. 2003; Watkins et al. 1981). In a few cases, longer lasting responses have been documented. For example, Jahoda et al. (2003) found effects of more than a few minutes, with fin whales failing to return to baseline behaviors after one hour of observation in some cases. Baker et al. (1988) reported that changes in whale behavior corresponded to vessel speed, size, and distance from the whale, as well as the number of vessels operating in the proximity. Based on experiments conducted by Clapham and Mattila (1993), experienced, trained personnel approaching whales slowly would result in fewer whales exhibiting responses that might indicate stress.

Numerous studies have documented varied responses of humpback whales to vessel approaches, ranging from no response to approach to evasion (Goodyear 1993; Salden 1993). In response to vessel approach, Felix (2001) found that 27 of 86 individuals approached resulted in avoidance of the vessel (50 were indifferent and 9 approached vessels), including long dive, change in heading, tail splashes, altered swimming speed or breathing frequency, and group structure disruption. Approaching vessels may instigate aerial behavior, such as fluke slapping and breaching, behavior recently suggested to be a switch in communication from vocal to surface active signaling (Baker et al. 1983a; Baker et al. 1983b; Holt et al. 2009). Hall (1982) did not find social or feeding behavior to be disturbed by vessel traffic or close approaches; however, there is the possibility that humpback whales may habituate to vessel noise if given sufficient time and exposure (Clapham and Mattila 1993; Watkins 1986). Goodyear (1983) did not observe changes in behavior due to vessel approaches in most cases, although an increase in speed did occur on one occasion when a whale was approached within 10 meter. Cantor et al. (2010) generally found resting or socializing whales to switch to traveling upon approach of their research vessels. Watkins et al. (1981) found that humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startle reaction, or moving away from the vessel with strong fluke motions. Several authors found that humpbacks spent less time at the surface and altered their direction of travel in response to approaching vessels (Baker and Herman 1989; Baker et al. 1983a; Bauer 1986; Bauer and Herman 1986; Green and Green 1990). Increased time underwater and decreased swim speed persisted for up to 20 minutes after vessels left the area. Watkins and Goebel (1984) found humpbacks to be very difficult to approach. Norris (1994) documented changes in humpback song structure in response to passing vessels, with unit and phrase durations reduced versus control periods.

In Alaskan waters, increased dive durations have been observed along with a shift in orientation away from the path of moving boats, often at ranges up to 3-4 kilometers (Baker and Herman 1989; Baker et al. 1983a). Some approaches in Alaskan waters closer than 100 meters initiated evasive behavior (Hall 1982). Watkins (1986) found little response to approaches outside of 100 meters away, although humpbacks regularly reacted to outboard vessels on a collision course even from long distances.

Information on contextual responses is also relatively abundant for humpback whales. Responses by humpback whales likely depend upon a given individual’s prior experience and current situation (Clapham and Mattila 1993). The use of smaller, outboard-powered vessels (presumably louder) elicited more frequent and stronger responses to biopsy attempts than larger, inboard-powered vessels; sex was not a factor in response frequency or intensity (Cantor et al. 2010). Sudden changes in vessel speed and direction have been identified as contributors to humpback whale behavioral responses (Watkins 1981b). The more active the group, the more easily it was disturbed; however, Cantor et al. (2010) found structuring in the response rate of various individuals in mating groups, with male response becoming progressively less frequent with increasing degree of dominance in the mating group. Mother-calf pairs were the most easily disturbed group, followed by all adult groups, adult subadult mixes, and all subadult groups (Felix 2001). Several authors found feeding animals to be least responsive, although data from these studies was contradictory when evaluating responses while resting or on breeding grounds (Cantor et al. 2010; Krieger and Wing 1984; Weinrich et al. 1991; Weinrich et al. 1992). On several occasions, research trips conducted by Krieger and Wing (1984) had to actively avoid collisions with humpbacks, although whales presumably were aware of the vessel’s presence. Single or paired individuals may respond more than larger groups (Bauer and Herman 1986). Wursig et al. (1998) found milling or resting cetaceans to be more sensitive to vessel maneuvering.

Repeated exposure can have a cumulative effect that is greater than the sum of individual exposures, eliciting responses that are more significant for individuals and populations. Although Cantor et al. (2010) did not find a difference in response based upon re-exposure, humpback whales have vacated areas where relatively high boat traffic and human activity occurs (Herman 1979). Major declines and distributional shifts in Glacier Bay, Alaska were correlated with a rapid and significant increase in vessel traffic from 1976-1978, whereas humpback whales in other nearby areas with less traffic did not undergo such changes (Bauer and Herman 1986). Matkin and Matkin (1981) did not find a correlation between humpback whale behavior and recreational vessels.

Other large whale species have also been investigated for their responses to close vessel approaches. Pettis et al. (1999) found gray whales tended to disperse in the presence of boats and aggregate in their absence. When directly approached, individuals were more likely to change heading, do a fluke-down dive, or slip under water, whereas indirect approaches tended to result in fluke or flipper swishes and head raises. Calf presence did not appear to impact response, although calves tended to respond with bubble release from the blowholes, change their heading, or roll, whereas adults were more likely to dive or slip underwater. Gray whales vacated a wintering (breeding, non-feeding) lagoon apparently in response to increased commercial vessel traffic but reoccupied it after vessel traffic decreased (Reeves 1977). Fin whales were found to accelerate their speed upon vessel approach (Watkins 1981b). Fin whales were particularly evasive in a study published by Ray et al. (1978), exhibiting high-speed swimming, frequent changes in heading, separation of groups, and irregular breathing patterns. As with humpback whales, fin whales have been found to respond by rapid course change, accelerated dive, and speed increases to vessel noise, particularly throttle changes, such as reversing.

Based on the information presented above, we would expect most ESA-listed whales exposed to close vessel approaches under the proposed permit to exhibit either no visible reaction or short-term low-level to moderate behavioral responses. Although close approaches conducted under the proposed permit might still be stressful for some individuals, and might temporarily interrupt behaviors such as foraging, evidence from investigators and in the literature suggests that responses would be short-lived. Assuming an animal is no longer disturbed after it returns to preapproach behavior, we do not expect a negative fitness consequence for the individuals approached. Additionally, it’s worth noting that since the inception of the Applicant’s research program, they have successfully collected numerous biopsy samples and tagged several individuals, all of which required close vessel approach. The researchers have not documented a severe reaction to any of the close vessel approaches and they have never struck a cetacean or pinniped.

Close vessel approach could also result in incidental harassment of non-target ESA-listed whales if these animals are in close proximity to the target animal and therefore, close to the research vessel. We would expect these animals to at most, react in a similar manner to the research vessel as those animals that are being targeted. That is, we would expect non-target animals that may be incidentally harassed under the proposed permit to exhibit either no visible reaction or short-term low-level to moderate behavioral responses. We do not expect fitness consequences for individuals that may be incidentally harassed.

Suction cup tagging

Although suction cup tagging is not as invasive as implantable tagging, whales have demonstrated behavioral reactions to their attachment. Goodyear (1989) observed a quickened dive, high back arch, tail swish (31 percent) or no reaction (69 percent) to suction cup attachment, although one breach was observed in roughly 100 tagging's. In response to suction cup tagging, Baird et al. (2000) observed only low (e.g., tail arch or rapid dive) to medium (e.g., tail flick) level reactions. No long term or strong reactions were recorded (Baird et al. 2000). Regardless, pre-tagging behavior was observed in all cases within minutes. No damage to skin was found (Goodyear 1989). Baumgartner and Mate (2003) reported that strong reactions of North Atlantic right whales to suction-cup tagging were uncommon, and that 71 percent of the 42 whales closely approached for suction-cup tagging showed no observable reaction. Of the remaining whales, reactions included lifting of the head or flukes, rolling, back-arching, or performing head lunges were observed. No differences in dive patterns were found after two dives post-tagging. Goodyear (1989) noted that humpbacks monitored several days after being suction-cup tagged did not appear to exhibit altered behavior.

Walker et al. (2012) reviewed the effects of different marking and tagging techniques on marine mammals. In their review, they found that cetacean behavioral responses to suction-cup tagging could include changes in frequency of leaps and group speed, flinching, tail slapping, rapid swimming, and rapid surfacing attempts. In the studies they reviewed, only short-term behavioral responses were observed and no long term fitness consequences were documented from suction-cup tagging.

Based on the available information presented above, we expect responses to consist of brief, low-level to moderate behavioral responses. These are likely to include increased swimming speed, diving, change in direction, lobtail, forceful exhalation, submergence, tail and flipper movements, agonistic behavior, twitches, back arches, and/or defecation. Although behavioral modifications may be observed, we expect that individuals would return to baseline behavior within a few minutes, and thus no effects to fitness are expected.

Dart/barb tagging

Implantable tags are fully or partially implanted into the muscle below the hypodermis, or into the blubber, and are designed for long-term attachment. The dart/barb type tag proposed under this permit contains an electronics package that is attached to the dorsal fin or the body just below the fin with two barbed darts that implant into the skin and/or blubber (Andrews et al. 2005). For all types, the tag would remain external to the animal. These tags would be deployed from a crossbow or an air gun.

Responses of large whales to implantable satellite tags most often include head lifts, fluke lifts, exaggerated fluke beats on diving, quick dives, or increased swimming speeds; responses less often include fluke slaps, head lunges, fluke swishes, defecation, decreased surfacing rates, disaffiliation with a group of whales, evasive swimming behavior, or cessation of singing (humpbacks) (Mate et al. 2007). In addition, responses to implantable tagging seem to vary by species (Mate et al. 2007). In all cases where Mate et al. (2007) followed implantable-tagged whales, responses to tagging were short-term. For example, a humpback that stopped singing after tagging resumed singing 13 minutes later and a North Atlantic right whale tagged while sleeping went back to sleep within 5 minutes after tagging. Over 40 of Mate et al. (2007) tagged whales were resighted at the date of their publication and in no case did the animals appear to be in poor health nor did they behave differently than untagged whales. After their study, Mate et al. (2007) also hypothesized that lack of response to dermal tagging by many whales is because cetaceans have widely dispersed “pressure” sensors on their skin and a blunt object can stimulate many of these stressors while a sharp object would be akin to getting a shot from an experienced nurse (Mate et al. 2007). The implantable tag’s bladed entry tip provides a clean-cut wound, which usually heals faster than ragged wounds (Mate et al. 2007). Implantable tag sites produced swelling (localized and regional) among large whales and divots have been seen on humpbacks and North Atlantic right whales that lost their tags due to rupture of fat cells in the blubber layer where tags enter (Mate et al. 2007). Resight analysis of data (North Atlantic right whale consortium catalog) showed that the resighting rate of tagged versus untagged whales was identical, thus, there was no discernible difference in mortality rates between tagged and untagged whales (Mate et al. 2007).

Whales showed little or no obvious reaction to the dermal tag attachment by Mate et al. (1997). Often, whales would swim away from the vessel as did many of the whales they closely approached but did not tag (Mate et al. 1997). One whale resumed resting 10 minutes after tagging showing a return to normal behavior (Mate et al. 1997). Resightings of whales after tagging demonstrated that there was no apparent effect on the close association between mother and calf (Mate et al. 1997). Overall, Mate et al. (1997) observed no visible evidence of adverse health effects (heavy external parasite loads, skin sloughing, etc.) from tagging. Later, Mate et al. (1998) found humpback whales to exhibit no observable reaction to satellite tagging beyond that elicited by close approach of the boat.

Invasive tagging seems to have no bearing on reproductive output. Best and Mate (2007) satellite tagged southern right whales and found that 6 of 7, or 85.7 percent, of the cows tagged with calves gave birth to a subsequent calf within intervals comparable to those prior to tagging, which suggests their procedure had no major impact on reproductive output. After reviewing available information on the responses of whales to invasive tagging, we do not expect mortality to occur due to invasive tagging under proposed activities. Though we do not expect mortality, we do expect that invasive tags would produce an injury that would have to heal over time. Based on the available evidence we would expect most whales exposed under the proposed permits to exhibit either no visible reaction or short-term low-level to moderate behavioral responses, and would expect the prior behavior of the whales to influence their response. Disturbance of a tagged whale may occur during the approach of the researchers and during attachment of the tag.

Recognizing the conditions of the proposed permit and the evidence indicating that behavioral responses would be short-lived, we assume that the tagging activities would produce short-term stress responses in some individuals, but would not lead to reduced foraging opportunities or negatively affect an individual's fitness.

Acoustic Playbacks

Acoustic playback studies would be conducted to gain insight into whether an acoustic decoy can be used to attract sperm whales away from fishing gear. Sound levels received by target species would not exceed 190 dB re 1µPa at 1 meter (rms pressure). Total playback would be 3-4 hours in length during actual fishing hauls and will be simultaneously recorded. Observers will be present and if they note any signs of major disturbance (i.e. breaching, tail slaps, or underwater bubble cloud releases) a disable signal would be sent to the playback device to halt the trial. For a more detailed explaination of the procedures for acoustic playback experimentation see Section 2.1.5 of this opinion.

Previous playbacks of various sources to humpback whales in waters off Hawaii indicate only transient effects to whales ranging from rapid approach to the playback vessel, to slight avoidance, to no reaction (Frankel and Clark 1998; Frankel and Clark 2000; Frankel and Clark 2002; Frankel et al. 1995; Mobley Jr. et al. 1988).

Although researchers have documented local movements by whales in response to sounds, humpbacks continue to return to known feeding and calving grounds year after year suggesting that playbacks occurring there have not resulted in a permanent shift in habitat use. The NMFS expects that the proposed playback sessions would likewise result in no more than local, temporary reactions (via behavior and movements) by targeted whales. No prolonged or permanent shift in habitat use would be expected.

Based on the proposed source levels and received levels, source levels of vocalizations produced by live sperm and killer whales whales, the design of the experiments, reports from the permit holder, and published literature, the NMFS does not expect that whales (individuals, populations or species) would be significantly impacted by the proposed playback sessions. No mortality or serious injury would be expected as a result of playback sessions. Individuals targeted for acoustic playbacks would be expected to display behavioral responses, as the goals of playbacks are to determine the effects of these sounds on behavior. NMFS does not expect that cetacean hearing would be harmed or injured. Any behavioral impacts to target or non-target animals would likely be short-term and negligible. Consequently, the proposed research activities are not expected to adversely affect the survival, longevity, or lifetime reproductive success of large whales.

Biopsy

We reviewed the literature assessing the impacts of biopsy sampling to various cetacean species. Gauthier and Sears (1999) summarized data for several species, including blue, fin, and humpback whales. Their data show that blue whales respond by submerging, accelerating, and/or diving. They found humpback whales to accelerate, change direction, dive, lobtail, exhale forcefully, submerge, and display tail and flipper movements (the most common response); "moderate" responses were the most common category of response. Inadvertent repeated biopsy within a week did not appear to cause a difference in reaction in three blue whales and five fin whales. Group size does not appear to impact the likelihood or severity of response. Female fin whales appear to respond to biopsy more often than males (66 percent versus 44 percent) and more strongly. Individuals generally return to baseline behavior within a few minutes (Gauthier and Sears 1999).

An IWC working group reviewed biopsy sampling and concluded long-term effects are unlikely, although short-term responses frequently occur (IWC 1991). Clapham and Mattila (1993) found 44 percent of humpback whales sampled showed no immediate response, while 22.5 percent reacted in subtle or minor ways. Cerchio (2003) found similar results in 350 biopsy events. Cantor et al. (2010) found that 46 percent of 542 biopsy attempts on adult or subadult humpback whales from 10-25 meters away resulted in a behavioral response (most commonly fluke movement). Neither the use of a tether, the duration of vessel contact with the target individual, nor region of the body hit influenced the likelihood of response, although responses were more frequent and intense from smaller vessels (likely due to their additional noise) than from larger vessels. Weinrich et al. (1992) found that of 71 humpback whales biopsied, 7 percent had no response, 27 percent exhibited a "low" response, 61 percent had a "moderate" response, and 6 percent had a "strong" response. Brown et al. (1994) found 41 percent of 203 humpbacks biopsied to respond in some way, including fluke movements, tail slaps, and disrupted dives. Humpbacks rarely display tail flicks, but frequently do so in response to biopsy (Weinrich et al. 1992). Repeated sampling was not found to influence the likelihood of subsequent biopsy responses (Brown et al. 1994). Fin whales were found to either not respond at all, or exhibit low- to moderate-level behavioral responses (Marsili and Focardi 1996).

The behavioral state of individuals pre-biopsy may also influence the probability of response, with foraging, traveling, or socializing individuals less likely to respond than resting individuals (Cantor et al. 2010; Weinrich et al. 1991). Clapham and Mattila (1993) found that evasion was the most common behavioral change and that response was less likely on breeding grounds. Demographic factors do not appear to influence biopsy response in humpback whales; individual age, gender, group size, geographic location, and repeated sampling have not been found to influence the likelihood of biopsy responses (Cantor et al. 2010; Gauthier and Sears 1999; Weinrich et al. 1991). Of individuals that do respond, return to baseline behavior occurs within a few minutes (Gauthier and Sears 1999). Mothers and males in competitive groups reacted less frequently than other individuals (Cerchio 2003; Clapham and Mattila 1993); however, calves tend to be more evasive than any other group. Females with calves responded more frequently than did non-lactating females (60 percent versus 43 percent) (Cantor et al. 2010).

Biopsy misses can also cause behavioral responses (Gauthier and Sears 1999). Strong behavioral responses were found by Weinrich et al. (1992) when a line attached to the biopsy dart snagged on an individual's flukes. Brown et al. (1994) reported that 16 percent of missed Australian humpbacks responded, suggesting that these animals reacted to the sound of the dart hitting the water. Similarly, Clapham and Mattila (1993) reported that a total of 375 (87.7 percent) misses on breeding grounds involved no reaction. Gauthier and Sears (1999) found four out of five misses of individuals in a feeding area did not involve a response, although four out of five other individuals did respond until freed from biopsy darts that stuck in their blubber. Significantly stronger reactions were displayed when biopsy darts actually hit humpback whales than when they missed (Weinrich and Kuhlberg 1991).

We are not aware of any direct studies of the effect of biopsying on North Pacific right whales. However, North Atlantic right whales have been shown to exhibit immediate, minor behavioral response to biopsy darting 19 percent of the time in 241 attempts and no reaction in 81 percent of hits and misses (Brown et al. 1991). Reactions include twitches, increased swimming speed and dives, back arches and dives, tail flicks, lobtails, and turning away from the tagging vessel (Brown et al. 1991). More than 50 percent of individuals had a hard tail flick, an unusual behavior for this species. Dives also became longer relative to surface times. However, return to baseline behavior generally occurred after the vessel approach was complete (Brown et al. 1991). Reeb and Best (2006) also documented no or low- to moderate-level responses of right whales to pole biopsy techniques. Demographic differences in responses have been identified in southern right whales, with greater response in singletons versus groups and cow/calf pairs responding more strongly than other groups (Best et al. 2005).

We identified only one study that has reported on the response of sperm whales to biopsy attempts. Whitehead et al. (1990) reported responses from sperm whales off Nova Scotia as well as the Azores, finding that every biopsy hit and roughly half of the misses caused a startle response. Startling was associated with flexing the body, raising the back, and/or increasing swimming speed. Other responses occasionally observed included short dives of up to five minutes and defecation. In all cases, individuals were observed to return to baseline behavior within minutes.

We know of only one published report of a cetacean death following biopsy sampling, when the dart penetrated the muscle mass of a female common dolphin (*Delphinus delphis*), which may have resulted in vertebral trauma and severe shock (Bearzi 2000). The individual had relatively thin blubber, permitting deeper penetration than was desired and sticking of the dart. Additionally, there is no evidence of infection at the point of penetration or elsewhere among the many whales sighted in the days following biopsy sampling (Weller 2005). The risk of infection is thought to be minimized by sterilizing dart tips before sampling occurs. In general, healing is rapid, roughly one week, scarring thereafter (Noren and Mocklin 2012).

We expect responses to consist of brief, low-level to moderate behavioral responses. These responses may include increased swimming speed, diving, change in direction, lobtail, forceful exhalation, submergence, tail and flipper movements, agonistic behavior, twitches, back arches, or defecation. As a result, individuals may temporarily leave the immediate area or cease feeding, resting, or other activities. However, we expect that individuals would return to baseline behavior within a few minutes. Additionally, because the applicant will be cleaning and sanitizing all biopsy darts prior to each subsequent use, we do not expect any infections to result from this activity. Based on the available literature and the applicant's previous experience collecting biopsy sampling with no significant reactions observed, we do not expect biopsy sampling to impact the fitness of any individuals.

6.3 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, the NMFS searched for information on future state, tribal, local, or private actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the Environmental Baseline, which we expect will continue into the future. Anthropogenic effects include commercial fishing, vessel traffic, ocean noise, pollution, discharged contaminants, and coastal development. An increase in these activities could result in an increased effect on ESA-listed species; however, the magnitude and significance of any anticipated effects remain unknown at this time.

6.4 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 6.3) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 4).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered species and critical habitat that are likely to be exposed. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment.

The *Status of Listed Resources* section described the factors that have contributed to the reduction in population size for the species considered in this opinion. Threats to the survival and recovery of these species include, but are not limited to, fisheries interactions, ship strikes, noise, and scientific research. The NMFS expects that the current natural and anthropogenic threats described in the *Environmental Baseline* will continue. We did not find any likely future actions that could affect the species considered in this opinion beyond those described in the *Environmental Baseline*.

Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from the issuance of permit No. 18529 to Jan Straley for research on marine mammals in the Gulf of Alaska would not be expected to appreciably reduce the likelihood of the survival or recovery of blue, fin, gray (Western North Pacific DPS), humpback (range-wide), North Pacific right, sei, or sperm whales in the wild by reducing the reproduction, numbers, or distribution of those species. The issuance of permit No. 18529 would also not be expected to appreciably reduce the likelihood of the survival or recovery of the proposed threatened Western North Pacific DPS. As described in Section 6 of this opinion, stressors associated with the proposed action will not affect the population dynamics, behavioral ecology, and social dynamics of individual ESA-listed whales in ways or to a degree that would reduce their fitness. Under the proposed permit, listed whales would be exposed to the following potential stressors:

1) vessel traffic;
2) vessel close approaches to ESA-listed species;
3) passive acousting recording/monitoring;
4) fishing gear modifications;
5) hydroacoustic sampling for prey mapping;
6) suction-cup tagging;
7) dart/barb tagging;
8) tag instrument transmissions;

9) acoustic playbacks;
10) biopsy;
11) collection of sloughed skin, feces, blow, and prey remains;
12) collection and export of dead listed mammal parts.

Of those potential stressors, we determined that only vessel close approaches, suction-cup tagging, dart/barb tagging, biopsy, and acoustic playbacks were likely to adversely affect ESA-listed whales. We believe short-lived behavioral reactions are possible, but we do not expect these responses to lead to reduced opportunities for foraging, reproduction or other essential life functions for target or non-target individuals. Overall, no individual whale is expected to experience a fitness reduction from the proposed action. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent (that is, we would not expect reductions in the reproduction, numbers, or distribution of those populations). For these reasons, we do not anticipate any reductions in survival rate or trajectory of recovery of the whale species considered in this opinion.

7 CONCLUSION

During the consultation, we reviewed the current status of ESA-listed blue, fin, gray (Western North Pacific DPS), humpback (rangewide and the proposed threatened Western North Pacific DPS), North Pacific right, sei, and sperm whales as well as the status of North Pacific right whale critical habitat. We also assessed the *Environmental Baseline* within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects.

Our regulations require us to consider, using the best available scientific data, effects of the action that are “likely” and “reasonably certain” to occur rather than effects that are speculative or uncertain (see 50 C.F.R. § 402.02 defining to “jeopardize the continued existence of” and “effects of the action”). For the reasons set forth above, and taking into consideration the best available scientific evidence documented throughout this opinion, we conclude that the issuance of permit No. 18529 to Jan Straley for research on marine mammals in the Gulf of Alaska is unlikely to lead to any fitness consequences to any individuals or affected species. Therefore, it is the NMFS’ biological opinion that the issuance of permit No. 18529 is likely to adversely affect, but is not likely to jeopardize the continued existence of blue, fin, gray (Western North Pacific DPS), humpback (rangewide), North Pacific right, sei, and sperm whales or the North Pacific right whale critical habitat. It is the NMFS’ conference opinion that the proposed action is not likely to jeopardize the continued existence of the proposed threatened Western North Pacific DPS of humpback whales.

8 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this Incidental Take Statement.

As discussed in the accompanying opinion, only the species targeted by the proposed research activities would be harassed as part of the intended purpose of the proposed action. Therefore, the NMFS does not expect the proposed action would incidentally take threatened or endangered species.

9 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, help implement recovery plans, or develop information (50 CFR 402.02).

We recommend the following conservation recommendations, which would provide information for future consultations involving the issuance of permits that may affect listed whales as well as reduce harassment related to the authorized activities:

- We recommend that the Permits Conservation Division continue to develop a programmatic approach to research permit consultations on a taxa-specific, geographic basis, or other programmatic approach. A programmatic approach to research permit consultations would allow for a better understanding of all proposed research efforts and their effects to populations and would expedite issuance of individual research permits.

In order for the NMFS’ Office of Protected Resources Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Permits and Conservation Division should notify the Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

10 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed issuance of permit No. 18529 to Jan Straley to conduct research on marine mammals in the Gulf of Alaska. As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat that was not considered in this opinion, or (4) a new species is ESA-listed or critical habitat designated that may be affected by the action.

11 REFERENCES

Aburto, A., D. J. Rountry, and J. L. Danzer. 1997. Behavioral response of blue whales to active signals. Naval Command, Control and Ocean Surveilance Center, RDT&E Division.

Agler, B. A., and coauthors. 1990. Fin whale (*Balaenoptera physalus*) photographic identification: Methodology and preliminary results from the western North Atlantic. Report of the International Whaling Commission Special Issue 12:349-356.

Agler, B. A., R. L. Schooley, S. E. Frohock, S. K. Katona, and I. E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. Journal of Mammalogy 74(3):577-587.

Aguilar, A. 1983. Organochlorine pollution in sperm whales, *Physeter macrocephalus*, from the temperate waters of the eastern North Atlantic. Marine Pollution Bulletin 14(9):349-352.

Aguilar, A., and A. Borrell. 1988. Age- and sex-related changes in organochlorine compound levels in fin whales (*Balaenoptera physalus*) from the Eastern North Atlantic. Marine Environmental Research 25:195-211.

Aguilar, A., and C. H. Lockyer. 1987. Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. Canadian Journal of Zoology 65:253-264.

Alava, J. J., M. J. Barragan, and J. Denkinger. 2012. Assessing the impact of bycatch on Ecuadorian humpback whale breeding stock: A review with management recommendations. Ocean and Coastal Management 57:34-43.

Allen, B. M., and R. P. Angliss. 2010. Humpback whale (*Megaptera novaeangliae*): Western North Pacific stock. Pages 179-187 *in* Alaska Marine Mammal Stock Assessments, 2010, volume Technical Memorandum-AFSC-223. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, Washington.

Allen, B. M., and R. P. Angliss. 2013. Alaska marine mammal stock assessments, 2012. NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center.

Alter, S. E., E. Rynes, and S. R. Palumbi. 2007. DNA evidence for historic population size and past ecosystem impacts of gray whales. Proceedings of the National Academy of Sciences of the United States of America 104(38):15162-15167.

Amaral, K., and C. Carlson. 2005. Summary of non-lethal research techniques for the study of cetaceans. Pages 3 *in* Regional Workshop of Experts on the Development of the Marine

Mammal Action Plan for the Wider Caribbean Region. United Nations Environment Programme, Bridgetown, Barbados.

Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. Ecological Monographs 70(3):445-470.

André, M., M. Terada, and Y. Watanabe. 1997. Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. Report of the International Whaling Commission 47:499-504.

Andrews, R. C. 1916. The sei whale (*Balaenoptera borealis* Lesson). Memoirs of the American Museum of Natural History, New Series 1(6):291-388.

Andrews, R. D., C. O. Matkin, and L. Mazzuca. 2005. Satellite tags and attachment techniques for killer whales. Pages 15 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Angliss, R. P., and K. L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, NMFS-AFSC-144.

Angliss, R. P., and R. B. Outlaw. 2008. Alaska marine mammal stock assessments, 2007. National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, NMFS-AFSC-180.

Arnbom, T., V. Papastavrou, L. S. Weilgart, and H. Whitehead. 1987. Sperm whales react to an attack by killer whales. Journal of Mammalogy 68(2):450-453.

Ashe, E., J. Wray, C. R. Picard, and R. Williams. 2013. Abundance and survival of Pacific humpback whales in a proposed critical habitat area. PLoS ONE 8(9):e75228.

Au, W., J. Darling, and K. Andrews. 2001. High-frequency harmonics and source level of humpback whale songs. Journal of the Acoustical Society of America 110(5 Part 2):2770.

Au, W. W. L., and M. Green. 2000. Acoustic interaction of humpback whales and whale-watching boats. Marine Environmental Research 49(5):469-481.

Au, W. W. L., and coauthors. 2006. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America 120(2):1103.

Au, W. W. L., A. N. Popper, and R. R. Fay. 2000. Hearing by Whales and Dolphins. Springer-Verlag, New York.

Bacon, C., M. A. Smultea, B. Würsig, K. Lomac-MacNair, and J. Black. 2011. Comparison of blue and fin whale behavior, headings and group characteristics in the southern California Bight during summer and fall 2008-2010. Pages 23 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Baier, C. T., and J. M. Napp. 2003. Climate-induced variability in *Calanus marshallae* populations. Journal of Plankton Research 25(7):771-782.

Bailey, H., and coauthors. 2010. Behavioural estimation of blue whale movements in the northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research 10(1):93-106.

Baird, R. W., and S. K. Hooker. 2000. Ingestion of plastic and unusual prey by a juvenile harbour porpoise. Marine Pollution Bulletin 40(8):719-720.

Baird, R. W., A. D. Ligon, and S. K. Hooker. 2000. Sub-surface and night-time behavior of humpback whales off Maui, Hawaii: A preliminary report. Hawaiian Islands Humpback Whale National Marine Sanctuary.

Baker, C. S., and L. M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: Experimental and opportunistic observations. Kewalo Basin Marine Mammal Lab, Honolulu, Hawaii.

Baker, C. S., L. M. Herman, B. G. Bays, and G. B. Bauer. 1983a. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.

Baker, C. S., L. M. Herman, W. Stifel, B. G. Bays, and A. Wolman. 1983b. The migratory movement of humpback whales between Hawaii and Alaska. Pages 5-6 *in* Fifth Biennial Conference on the Biology of Marine Mammals, New England Aquarium, Boston, Massachusetts.

Baker, C. S., A. Perry, and G. Vequist. 1988. Humpback whales of Glacier Bay, Alaska. Whalewatcher 22(3):13-17.

Baker, C. S., and coauthors. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Marine Ecology Progress Series 494:291-306.

Ban, S. S. 2005. Modelling and characterization of Steller sea lion haulouts and rookeries using oceanographic and shoreline type data. University of British Columbia.

Bando, T., and coauthors. 2010. Cruise Report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2009 (part I) - Offshore component. International Whaling Commission Scientific Committee.

Baraff, L., and M. T. Weinrich. 1993. Separation of humpback whale mothers and calves on a feeeding ground in early autumn. Marine Mammal Science 9(4):431-434.

Barendse, J., P. B. Best, I. Carvalho, and C. Pomilla. 2013. Mother knows best: Occurrence and associations of resighted humpback whales suggest maternally derived fidelity to a Southern Hemisphere coastal feeding ground. PLoS ONE 8(12):e81238.

Barlow, J. 1995. Abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin 93(1):1-14.

Barlow, J., and coauthors. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science 27(4):793-818.

Barlow, J., and coauthors. 1997. U.S. Pacific marine mammal stock assessment -1996. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS-SWFSC-248, La Jolla, California.

Barrett-Lennard, L. G., T. G. Smith, and G. M. Ellis. 1996. A cetacean biopsy system using lightweight pneumatic darts, and its effect on the behavior of killer whales. Marine Mammal Science 12(1):14-27.

Bauer, G. B. 1986. The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions. University of Hawaii.

Bauer, G. B., and L. M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Honolulu, Hawaii.

Baumgartner, M. F., and D. M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. Limnology and Oceanography 53(5 Part 2):2197-2209.

Baumgartner, M. F., and coauthors. 2013. Associations between North Pacific right whales and their zooplanktonic prey in the southeastern Bering Sea. Marine Ecology Progress Series 490:267-284.

Baumgartner, M. F., and B. R. Mate. 2003. Summertime foraging ecology of North Atlantic right whales. Marine Ecology Progress Series 264:123-135.

Baumgartner, M. F., and coauthors. 2008. Low frequency vocalizations attributed to sei whales (*Balaenoptera borealis*). Journal of the Acoustical Society of America 124(2):1339-1349.

Bearzi, G. 2000. First report of a common dolphin (*Delphinus delphis*) death following penetration of a biopsy dart. Journal of Cetacean Research and Management 2(3):217-221.

Benjamins, S., W. Ledwell, J. Huntington, and A. R. Davidson. 2012. Assessing changes in numbers and distribution of large whale entanglements in Newfoundland and Labrador, Canada. Marine Mammal Science 28(3):579-601.

Bennet, D. H., C. M. Falter, S. R. Chipps, K. Niemela, and J. Kinney. 1994. Effects of Underwater Sound Simulating the Intermediate Scale Measurement System on Fish and Zooplankton of Lake Pend Orielle, Idaho.

Benson, S. R., D. A. Croll, B. B. Marinovic, F. P. Chavez, and J. T. Harvey. 2002. Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Niño 1997-98 and La Niña 1999. Progress in Oceanography 54(1-4):279-291.

Berchok, C. L., D. L. Bradley, and T. B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. Journal of the Acoustical Society of America 120(4):2340-2354.

Berzin, A. A. 1972. The sperm whale. Pacific Scientific Research Institute of Fisheries and Oceanography, Moscow, Russia.

Berzin, A. A., and A. A. Rovnin. 1966. Distribution, and migration of whales in the northeastern part of the Pacific Ocean, Bering, and Chukchi seas. Izvestiya Tinro 58:179-207.

Berzin, A. A., and A. V. Yablokov. 1978. Abundance and population structure of important exploited cetacean species of the world ocean. Zoologicheskii Zhurnal 7(12):1771-1785.

Best, P. B. 1987. Estimates of the landed catch of right (and other whalebone) whales in the American fishery, 1805-1909. Fishery Bulletin 85(3):403-418.

Best, P. B., J. Bannister, R. L. Brownell, and G. Donovan. 2001. Right whales: Worldwide status.

Best, P. B., P. A. S. Canham, and N. Macleod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report of the International Whaling Commission Special Issue 6:51-79.

Best, P. B., and C. H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. South African Journal of Marine Science 24:111-133.

Best, P. B., and B. Mate. 2007. Sighting history and observations of southern right whales following satellite tagging off South Africa. Journal of Cetacean Research and Management 9(2):111.

Best, P. B., and coauthors. 2005. Biopsying southern right whales: Their reactions and effects on reproduction. Journal of Wildlife Management 69(3):1171-1180.

Bickham, J. W., J. C. Patton, and T. R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: Implications for conservation and biogeography of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 77(1):95-108.

Biedron, I. S., C. W. Clark, and F. Wenzel. 2005. Counter-calling in North Atlantic right whales (*Eubalaena glacialis*). Pages 35 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Biggs, D. C., R. R. Leben, and J. G. Ortega-Ortiz. 2000. Ship and satellite studies of mesoscale circulation and sperm whale habitats in the northeast Gulf of Mexico during GulfCet II. Gulf of Mexico Science 18(1):15-22.

Blokhin, S. A., N. V. Doroshenko, and I. P. Marchenko. 2003. The abundance, distribution, and movement patterns of gray whales (*Eschrichtius robustus*) in coastal waters off the northeast Sakhalin Island coast in 2002 based on the aerial survey data. Russian Federations State Committee on Fisheries, Federal Unitarian Enterprise TINRO.

Borrell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. Marine Pollution Bulletin 26(3):146.

Borrell, A., and A. Aguilar. 1987. Variations in DDE percentage correlated with total DDT burden in the blubber of fin and sei whales. Marine Pollution Bulletin 18(2):70-74.

Bort, J. E., S. Todd, P. Stevick, S. Van Parijs, and E. Summers. 2011. North Atlantic right whale (*Eubalaena glacialis*) acoustic activity on a potential wintering ground in the Central Gulf of Maine. Pages 38 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Boyd, I. L., C. Lockyer, and H. D. Marsh. 1999. Reproduction in marine mammals. Pages 218-286 *in* J. E. R. III, and S. A. Rommel, editors. Biology of Marine Mammals. Smithsonian Institution Press, Washington.

Boye, T. K., M. Simon, and P. T. Madsen. 2010. Habitat use of humpback whales in Godthaabsfjord, West Greenland, with implications for commercial exploitation. Journal of the Marine Biological Association of the United Kingdom in press(in press):in press.

Bradford, A. L., and K. A. Forney. 2014. Injury determinations for cetaceans observed interacting with Hawaii and American Samoa longline fisheries during 2008-2012. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

Bradford, A. L., and coauthors. 2003. Survival estimates of western gray whales (*Eschrichtius robustus*) incorporating individual heterogeneity and temporary emigration. International Whaling Commission Scientific Committee, Berlin.

Bradford, A. L., and coauthors. 2006a. Survival estimates of western gray whales *Eschrichtius robustus* incorporating individual heterogeneity and temporary emigration. Marine Ecology Progress Series 315:293-307.

Bradford, A. L., D. W. Weller, A. M. Burdin, Y. V. Ivashchenko, and J. R. L. Brownell. 2006b. Anthropogenic scarring of western gray whales (*Eschrichtius robustus*): A preliminary report. IWC Scientific Committee, St Kitts and Nevis, West Indies.

Bradford, A. L., D. W. Weller, Y. V. Ivashchenko, A. M. Burdin, and R. L. Brownell. 2007. Seasonal and annual variation in body condition of western gray whales off northeastern Sakhalin Island, Russia: A preliminary report. IWC Scientific Committee, Anchorage, AK.

Bradford, A. L., D. W. Weller, Y. V. Ivashchenko, A. M. Burdin, and R. L. Brownell. 2008a. Seasonal and annual variation in body condition of western gray whales off northeastern Sakhalin Island, Russia. IWC Scientific Committee, Santiago, Chile.

Bradford, A. L., D. W. Weller, Y. V. IVashchenko, A. M. Burdin, and J. Robert L. Brownell. 2009. Anthropogenic scarring of western gray whales (*Eschrichtius robustus*). Marine Mammal Science 25(1):161-175.

Bradford, A. L., and coauthors. 2010. Comparing observations of age at first reproduction in western gray whales to estimates of age at sexual maturity in eastern gray whales. IWC Scientific Committee, Agadir, Morocco.

Bradford, A. L., and coauthors. 2012. Leaner leviathans: Body condition variation in a critically endangered whale population. Journal of Mammalogy 93(1):251-266.

Bradford, A. L., D. W. Weller, P. R. Wade, A. M. Burdin, and R. L. B. Jr. 2008b. Population abundance and growth rate of western gray whales *Eschrichtius robustus*. Endangered Species Research 6(1):1-14.

Braham, H. W. 1984. Distribution and migration of gray whales in Alaska. Pages 249-266 *in* M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Braham, H. W. 1991. Endangered whales: A status update. A report on the 5-year status of stocks review under the 1978 amendments to the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory, Seattle, Washington.

Braham, H. W., and D. W. Rice. 1984. The right whale, *Balaena glacialis*. Marine Fisheries Review 46(4):38-44.

Brandon, R. 1978. Adaptation and evolutionary theory. Studies in the History and Philosophy of Science 9:181-206.

Brodie, P., and G. Vikingsson. 2009. On the feeding mechanisms of the sei whale (*Balaenoptera borealis*). Journal of Northwest Atlantic Fishery Science 42(5):49-54.

Brown, M. R., P. J. Corkeron, P. T. Hale, K. W. Schultz, and M. M. Bryden. 1994. Behavioral-responses of east Australian humpback whales *Megaptera novaeangliae* to biopsy sampling. Marine Mammal Science 10(4):391-400.

Brown, M. W., S. D. Kraus, and D. E. Gaskin. 1991. Reaction of North Atlantic right whales (*Eubalaena glacialis*) to skin biopsy sampling for genetic and pollutant analysis. Report of the International Whaling Commission Special Issue 13:81-89.

Brownell Jr., R. L. 2007. Entrapment of western gray whales in Japanese fishing gear: Population threats. International Whaling Commission Scientific Committee, Anchorage, Alaska.

Brownell Jr., R. L., P. J. Clapham, T. Miyashita, and T. Kasuya. 2001. Conservation status of North Pacific right whales. Journal of Cetacean Research and Management (Special Issue 2):269-286.

Brownell Jr., R. L., and T. Kasuya. 1999. Western gray whale captured off western Hokkaido, Japan. IWC Scientific Committee, Grenada, West Indies.

Brownell Jr., R. L., A. R. Lang, A. M. Burdin, A. B. Bradford, and D. W. Weller. 2009. The western gray whale population is distinct: A response to SC/61/BRG22. International Whaling Commission Scientific Committee, Madeira, Portugal.

Brownell, R. L. 2004. Oil development threats to western gray whales off Sakhalin Island. International Whaling Commission Scientific Committee, Sorrento, Italy.

Buck, J. R., and P. L. Tyack. 2000. Response of gray whales to low-frequency sounds. Journal of the Acoustical Society of America 107(5):2774.

Burdin, A. M., A. L. Bradford, G. A. Tsidulko, and M. Sidorenko. 2011. Status of western gray whales off northeastern Sakhalin Island and eastern Kamchatka, Russia in 2010. International Whaling Commission Scientific Committee, Tromso, Norway.

Burdin, A. M., O. A. Sychenko, and M. M. Sidorenko. 2013. Status of western gray whales off northeastern Sakhalin Island, Russia in 2012. IWC Scientific Committee, Jeju, Korea.

Burdin, A. M., G. A. Tsidulko, M. Sidorenko, and E. Dzhikiya. 2010. Status of western gray whales off northeastern Sakhalin Island, Russia in 2009. International Whaling Commission Scientific Committee, Agadir, Morocco.

Burdin, A. M., D. W. Weller, G. A. Tsidulko, and R. L. Brownell. 2003. Russia-US research program on western gray whales off northeastern Sakhalin Island in 2003. International Whaling Commission Scientific Committee, Berlin.

Burgess, W. C. 2000. The bioacoustic probe: A general-purpose acoustic recording tag. Journal of the Acoustical Society of America 105(5):2583.

Burnell, S. R. 2001. Aspects of the reproductive biology, movements and site fidelity of right whales off Australia. Journal of Cetacean Research and Management Special Issue 2:89-102.

Burtenshaw, J. C., and coauthors. 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. Deep Sea Research Part II: Topical Studies in Oceanography 51(10-11):967-986.

Calambokidis, J. 1997. The humpbacks of Costa Rica. Pages 4–7 *in* The Whale. Oceanic Society.

Calambokidis, J., J. Barlow, J. K. B. Ford, T. E. Chandler, and A. B. Douglas. 2009a. Insights into the population structure of blue whales in the eastern North Pacific from recent sightings and photographic identification. Marine Mammal Science 25(4):816-832.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Jessie Huggins. 2009b. Photographic identification of humpback and blue whales off the US West Coast: Results and updated abundance estimates from 2008 field season. Cascadia Research, Olympia, Washington.

Calambokidis, J., and coauthors. 2008. SPLASH: Structure of populations, levels of abundance and status of humpback whales in the North Pacific U.S. Department of Commerce, Western Administrative Center, Seattle, Washington.

Calambokidis, J., and coauthors. 2003. Feeding and vocal behavior of blue whales determined through simultaneous visual-acoustic monitoring and deployment of suction-cup attached tags. Pages 1 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Calambokidis, J., G. H. Steiger, D. K. Ellifrit, B. L. Troutman, and C. E. Bowlby. 2004. Distribution and abundance of humpback whales (*Megaptera novaeangliae*) and other marine mammals off the northern Washington coast. Fishery Bulletin 102(4):563-580.

Calambokidis, J., and coauthors. 1996. Interchange and isolation of humpback whales off California and other North Pacific feeding grounds. Marine Mammal Science 12(2):215-226.

Calambokidis, J., and coauthors. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17(4):769-794.

Calambokidis, J., and coauthors. 1997. Abundance and population structure of humpback whales in the North Pacific basin. National Oceanic and Atmospheric Administration, National

Marine Fisheries Service, Southwest Fisheries Science Center, 50ABNF500113, La Jolla, California.

Calkins, D. G. 1986. Marine Mammals. Pages 527−558 *in* D. W. Hood, and S. T. Zimmerman, editors. The Gulf of Alaska, Physical Environment and Biological Resources. Government Printing Office, Washington, D. C.

Call, K. A., and T. R. Loughlin. 2005. An ecological classification of Alaskan Steller sea lion (*Eumetopias jubatus*) rookeries: A tool for conservation/management. Fisheries Oceanography 14(Supplement 1):212-222.

Canese, S., and coauthors. 2006. The first identified winter feeding ground of fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 86(4):903-907.

Cantor, M., T. Cachuba, L. Fernandes, and M. H. Engel. 2010. Behavioural reactions of wintering humpback whales (*Megaptera novaeangliae*) to biopsy sampling in the western South Atlantic. Journal of the Marine Biological Association of the United Kingdom 90(8):1701-1711.

Carder, D. A., and S. H. Ridgway. 1990. Auditory brainstem response in a neomatal sperm whale, *Physeter* spp. Journal of the Acoustical Society of America 88(Supplement 1):S4.

Carretta, J. V., and L. Enriquez. 2012. Marine mammal and seabird bycatch in California gillnet fisheries in 2010. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2007. U.S. Pacific marine mammal stock assessments: 2007. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2010. U. S. Pacific marine mammal stock assessments: 2009. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California.

Carretta, J. V., and coauthors. 2005. U.S. Pacific marine mammal stock assessments: 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2006. U.S. Pacific marine mammal stock assessments: 2005. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2012. U.S. Pacific marine mammal stock assessments: 2011.

Carretta, J. V., and coauthors. 2011. U.S. Pacific marine mammal stock assessments: 2010. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., M. S. Lynn, and C. A. LeDuc. 1994. Right whale (*Eubalaena glacialis*) sighting off San Clemente Island, California. Marine Mammal Science 10(1):101-105.

Carretta, J. V., and coauthors. 2013. U.S. Pacific marine mammal stock assessments: 2012. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., and coauthors. 2014. U. S. Pacific marine mammal stock assessments, 2013. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carroll, G. M., J. C. George, L. M. Philo, and C. W. Clark. 1989. Ice entrapped gray whales near Point Barrow, Alaska: Behavior, respiration patterns, and sounds. Pages 10 *in* Eighth

Biennial Conference on the Biology of Marine Mammals, Asilomar Conference Center, Pacific Grove, California.

Castellote, M., C. Clark, and M. O. Lammers. 2012. Acoustic and behavioral changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147:115-122.

Cerchio, S. 2003. Paternity, polygyny and alternative mating tactics in humpback whales (*Megaptera novaeangliae*). University of Michigan.

Cerchio, S., J. K. Jacobsen, D. M. Cholewiak, and E. A. Falcone. 2005. Reproduction of female humpback whales off the Revillagigedo Archipelago during a severe El Niño event. Pages 55 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Chapman, N. R., and A. Price. 2011. Low frequency deep ocean ambient noise trend in the Northeast Pacific Ocean. Journal of the Acoustical Society of America 129(5):EL161-EL165.

Charif, R. A., D. K. Mellinger, K. J. Dunsmore, K. M. Fristrup, and C. W. Clark. 2002. Estimated source levels of fin whale (*Balaenoptera physalus*) vocalizations: Adjustments for surface interference. Marine Mammal Science 18(1):81-98.

Cherfas, J. 1989. The Hunting of the Whale. Viking Penguin Inc., New York, New York.

Christal, J., and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galápagos Islands breeding ground. Marine Mammal Science 13(1):59-69.

Christal, J., H. Whitehead, and ErlLettevall. 1998. Sperm whale social units: Variation and change. Canadian Journal of Zoology 76(8):1431-1440.

Christensen, I., T. Haug, and N. Oien. 1992. A review of feeding and reproduction in large baleen whales (Mysticeti) and sperm whales (*Physeter macrocephalus*) in Norwegian and adjacent waters. Fauna Norvegica Series A 13:39-48.

Christiansen, F., M. H. Rasmussen, and D. Lusseau. 2014. Inferring energy expenditure from respiration rates in minke whales to measure the effects of whale watching boat interactions. Journal of Experimental Marine Biology and Ecology 459:96-104.

Clapham, P., K. Sheldon, and P. Wade. 2005. Review of information relating to possible critical habitat for eastern North Pacific right whales. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, National Marine Mammal Laboratory.

Clapham, P. J. 1994. Maturational changes in patterns of association in male and female humpback whales, *Megaptera novaeangliae*. Journal of Zoology 234(2):265-274.

Clapham, P. J. 1996. The social and reproductive biology of humpback whales: An ecological perspective. Mammal Review 26(1):27-49.

Clapham, P. J., and coauthors. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71(2):440-443.

Clapham, P. J., and coauthors. 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. Journal of Cetacean Research and Management 6(1):1-6.

Clapham, P. J., and D. K. Mattila. 1993. Reactions of humpback whales to skin biopsy sampling on a West-Indies breeding ground. Marine Mammal Science 9(4):382-391.

Clapham, P. J., and C. A. Mayo. 1987. Reproduction and recruitment of individually identified humpback whales, *Megaptera novaeangliae*, observed in Massachusetts Bay, 1979-1985. Canadian Journal of Zoology 65(12):2853-2863.

Clapham, P. J., S. B. Young, and R. L. Brownell Jr. 1999. Baleen whales: Conservation issues and the status of the most endangered populations. Mammal Review 29(1):35-60.

Clark, C. 2006. Acoustic communication in the great whales: The medium and the message. Eighty-Sixth Annual Conference of the American Society of Mammalogists.

Clark, C. W., J. F. Borsani, and G. Notarbartolo-di-Sciara. 2002. Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. Marine Mammal Science 18(1):286-295.

Clark, C. W., and P. J. Clapham. 2004. Acoustic monitoring on a humpback whale (*Megaptera novaeangliae*) feeding ground shows continual singing into late spring. Proceedings of the Royal Society of London Series B Biological Sciences 271(1543):1051-1057.

Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Pages 564-582 *in* J. A. Thomas, C. F. Moss, and M. Vater, editors. Echolocation in Bats and Dolphins. University of Chicago Press.

Clark, C. W., and G. J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics 52(3):48.

Clarke, C. W., and R. A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997. JNCC.

Clarke, J. T., and S. E. Moore. 2002. A note on observations of gray whales in the southern Chukchi and northern Bering Seas, August-November, 1980-89. Journal of Cetacean Research and Management 4(3):283-288.

Clarke, M. R. 1976. Observations on sperm whale diving. Journal of the Marine Biological Association of the United Kingdom 56(3):809-810.

Clarke, M. R. 1977. Beaks, nets and numbers. Symposia of the Zoological Society of London 38:89-126.

Clarke, M. R. 1980a. Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Reports 37:1-324.

Clarke, M. R. 1996. Cephalopods as prey. III. Cetaceans. Philosophical Transactions of the Royal Society of London B Biological Sciences 351(1343):1053-1065.

Clarke, R. 1956. Sperm whales of the Azores. Discovery Reports 28:237-298.

Clarke, R. 1980b. Catches of sperm whales and whalebone whales in the southeast Pacific between 1908 and 1975. Report of the International Whaling Commission 30:285-288.

Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005. Mortality and serious injury determinations for large whales stocks along the eastern seaboard of the United States, 1999-2003. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Commission, I. W. 2004. Report of the Workshop on the Western Gray Whale: Research and Monitoring Needs, 22-25 October 2002, Ulsan, Korea. Journal of Cetacean Research and Management 6(Supplement):487-500.

Cooke, J., D. W. Weller, A. L. Bradford, A. M. Burdin, and J. R. L. Brownell. 2005. Estimates and projections of the western gray whale population using an individuallybased population model. Unpublished paper to the IWC Scientific Committee. 14 pp. Ulsan, Korea, June (SC/57/BRG22).

Cooke, J. G., D. W. Weller, A. L. Bradford, A. M. Burdin, and R. L. Brownell. 2008. Population assessment of western gray whales in 2008. IWC Scientific Committee, Santiago, Chile.

Cooke, J. G., D. W. Weller, A. L. Bradford, A. M. Burdin, and J. R. L. Brownell. 2007. Population assessment of western gray whales in 2007. Unpublished paper to the IWC Scientific Committee. 10 pp. Anchorage, AK, May (SC/59/BRG41).

Cooke, J. G., D. W. Weller, A. L. Bradford, A. M. Burdin, and J. Robert L. Brownell. 2006. Population assessment of western gray whales in 2006. (Eschrichtius robustus). IWC Scientific Committee, St Kitts and Nevis, West Indies.

Cooke, J. G., and coauthors. 2013. Population assessment of the Sakhalin gray whale aggregation. IWC Scientific Committee, Jeju, Korea.

Corkeron, P., P. Ensor, and K. Matsuoka. 1999. Observations of blue whales feeding in Antarctic waters. Polar Biology 22(3):213-215.

Corkeron, P. J. 1995. Humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. Canadian Journal of Zoology 73(7):1290-1299.

COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale *Balaenoptera musculus* (Atlantic population, Pacific population) in Canada.vi + 32.

COSEWIC. 2005. COSEWIC assessment and update status report on the fin whale *Balaenoptera physalus* (Pacific population, Atlantic population) in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Canada.

COSEWIC. 2011. COSEWIC assessment and status report on the humpback whale *Megaptera novaeangliae* North Pacific population in Canada. COSEWIC Committee on the Status of Endangered Wildlife in Canada.

Cotte, C., C. Guinet, I. Taupier-Letage, B. Mate, and E. Petiau. 2009. Scale-dependent habitat use by a large free-ranging predator, the Mediterranean fin whale. Deep Sea Research Part I: Oceanographic Research Papers 56(5):801-811.

Crane, N. L., and K. Lashkari. 1996. Sound production of gray whales, Eschrichtius robustus, along their migration route: A new approach to signal analysis. Journal of the Acoustical Society of America 100(3):1878-1886.

Cranford, T. W. 1992. Functional morphology of the odontocete forehead: Implications for sound generation. University of California, Santa Cruz.

Cranford, T. W., and P. Krysl. 2015. Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. PLoS ONE 10(1):e116222.

Croll, D., and coauthors. 1999a. From wind to whales: Foraging ecology of rorquals in the California Current. Pages 41 *in* Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii.

Croll, D. A., A. Acevedo-Gutierrez, B. R. Tershy, and J. Urban-Ramirez. 2001a. 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(4):797-809.

Croll, D. A., and coauthors. 2002. Only male fin whales sing loud songs. Nature 417:809.

Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison, and B. R. Tershy. 2001b. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4(1):13-27.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999b. Marine vertebrates and low frequency sound. University of California Santa Cruz, Institute of Marine Sciences, Marine Mammal and Seabird Ecology Group.

Cummings, W. C., and P. O. Thompson. 1971a. Gray whales, *Eschrichtius robustus*, avoid the underwater sounds of killer whales, *Orcinus orca*. Fishery Bulletin 69(3):525-530.

Cummings, W. C., and P. O. Thompson. 1971b. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America 50(4B):1193-1198.

Cummings, W. C., and P. O. Thompson. 1994. Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. Journal of the Acoustical Society of America 95:2853.

Cummings, W. C., P. O. Thompson, and R. Cook. 1968. Underwater sounds of migrating gray whales, Eschrichtius glaucus (Cope). Journal of the Acoustical Society of America 44(5):1278-1281.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Scientific Reports of the Whales Research Institute 36:41-47.

Dahlheim, M. E., H. D. Fisher, and J. D. Schempp. 1984. Sound production by the gray whale and ambient noise levels in Laguna San Ignacio, Baja California Sur, Mexico. Pages 511-542 *in* M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Dahlheim, M. E., and D. K. Ljungblad. 1990. Preliminary hearing study on gray whales (*Eschrichtius robustus*) in the field. Pages 335-346 *in* J. A. Thomas, and R. A. Kastelein, editors. Sensory Abilities of Cetaceans: Laboratory and Field Evidence. Plenum Press, New York.

Danil, K., and S. J. Chivers. 2005. Habitat-based spatial and temporal variability in life history characteristics of female common dolphins (*Delphinus delphis*) in the eastern tropical Pacific. Pages 67 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Danilewicz, D., M. Tavares, I. B. Moreno, P. H. Ott, and C. C. Trigo. 2009. Evidence of feeding by the humpback whale (*Megaptera novaeangliae*) in mid-latitude waters of the western South Atlantic. Journal of the Marine Biological Association II - Biodiversity Records:3.

Darling, J. D., and S. Cerchio. 1993. Movement of a humpback whale (*Megaptera novaeangliae*) between Japan and Hawaii. Marine Mammal Science 9(1):84-89.

Davis, R. W., W. E. Evans, and B. Wursig. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region.

Davis, R. W., and coauthors. 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 Ecology Progress Series 333:291-302.

Davis, R. W., and coauthors. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers 49(1):121-142.

De Stephanis, R., J. Gimenez, E. Carpinelli, C. Gutierrez-Exposito, and A. Canadas. 2013. As main meal for sperm whales: Plastics debris. Marine Pollution Bulletin 69(1-2):206-214.

De Vos, A., T. Wu, and R. L. Brownell Jr. 2013. Recent blue whale deaths due to ship strikes around Sri Lanka. IWC Scientific Committee, Jeju, Korea.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of central and northern California, 1980-1983: Status, abundance, and distribution. MMS, 14-12-0001-29090.

Dolphin, W. F. 1987. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65(1):83-90.

DoN. 2001. Final environmental impact statement for the North Pacific Acoustic Laboratory. U.S. Department of the Navy, Arlington, Virginia.

DoN. 2006. Marine resources accessment for the Gulf of Alaska Operating Area. Naval Facilities Engineering Command, Pacific, Pearl Harbor, Hawaii.

DoN. 2012. Marine species monitoring for the U.S. Navy's Southern California Range Complex-annual report 2012. U.S. Department of the Navy, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, Hawaii.

DoN. 2013. Hawaii-Southern California Training and Testing Draft Environmental Impact Statement/Overseas Environmental Impact Statement.

Doney, S. C., and coauthors. 2012. Climate change impacts on marine ecosystems. Marine Science 4.

Donovan, G. 2005. Report on Secretariat activities with respect to western North Pacific gray whales (Resolution 2004-1). International Whaling Commission.

Doroshenko, N. V. 2000. Soviet whaling for blue, gray, bowhead, and right whales in the North Pacific Ocean, 1961-1979. Pages 96-103 *in* Soviet Whaling Data (1949-1979). Center for Russian Environmental Policy Marine Mammal Council, Moscow.

Douglas, A. B., and coauthors. 2008. Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom 88(06):1121-1132.

Dragoset, B. 2000. Introduction to air guns and air-gun arrays. Leading Edge 19(8):892-897.

Dufault, S., H. Whitehead, and M. Dillon. 1999. An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus*) worldwide. Journal of Cetacean Research and Management 1:1-10.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). Marine Mammal Science 24(3):613-629.

Edds-Walton, P. L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics 8:47-60.

Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence Estuary. Bioacoustics 1(2/3):131-149.

Eldredge, L. G. 1991. Annotated checklist of the marine mammals of Micronesia. Micronesica 24(2):217-230.

Eldredge, L. G. 2003. The marine reptiles and mammals of Guam. Micronesica 35(36):653-660.

Elfes, C. T., and coauthors. 2010. Geographic variation of persistent organic pollutant levels in humpback whale (*Megaptera novaeangliae*) feeding areas of the North Pacific and North Atlantic. Environmental Toxicology and Chemistry 29(4):824-834.

Elvin, S. S., and C. T. Taggart. 2008. Right whales and vessels in Canadian waters. Marine Policy 32(3):379-386.

Erbe, C. 2002a. Hearing abilities of baleen whales. Defence R&D Canada.

Erbe, C. 2002b. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Evans, K., M. Hindell, and G. Hince. 2004. Concentrations of orgranochlorines in sperm whales (*Physeter macrocephalus*) from Southern Australian waters. Marine Pollution Bulletin 48(5-6):486-503.

Fadeev, V. I. 2009. Benthos studies in feeding grounds of western gray whales off the northeast coast of Sakhalin Island (Russia), 2004-2008. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Fadeev, V. I. 2011. Benthos studies in feeding grounds of western gray whales off the northeast coast of Sakhalin Island (Russia), 2002-2010. International Whaling Commission Scientific Committee, Tromso, Norway.

Fadely, B. S., B. W. Robson, J. T. Sterling, A. Greig, and K. A. Call. 2005. Immature Steller sea lion (*Eumetopias jubatus*) dive activity in relation to habitat features of the eastern Aleutian Islands. Fisheries Oceanography 14(Supplement 1):243-258.

Fay, F. H., R. A. Dieterich, L. M. Shults, and B. P. Kelly. 1978. Morbidity and mortality of marine mammals. Pages 39-79 *in* Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators for the Year Ending March 1978. Volume 1. Receptors--Mammals-Birds, volume 1. U.S. Department of Commerce, NOAA and U.S. Department of the Interior, Bureau of Land Management, Boulder, CO.

Fearnbach, H., J. W. Durhan, S. A. Mizroch, S. Barbeaux, and P. R. Wade. 2012. Winter observations of a group of female and immature sperm whales in the high-latitude waters near the Aleutian Islands, Alaska. Marine Biodiversity Records 5: e13.

Feldkamp, S. D., R. L. Delong, and G. A. Antonelis. 1991. Effects of El Niño 1983 on the foraging patterns of California sea lions (*Zalophus californianus*) near San Miguel Island, California. Pages 146-155 *in* F. Trillmich, and K. A. Ono, editors. Pinnipeds and El Niño: Responses to Environmental Stress. Springer-Verlag, Berlin.

Felix, F. 2001. Observed changes of behavior in humphack whales during whalewatching encounters off Ecuador. Pages 69 *in* Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Fischer, J. B. 1829. Synopsis Mammalium. J. G. Cottae, Stuttgart.

Ford, J. K. B., and coauthors. 2009. An assessment of the potential for recovery of humpback whales off the Pacific Coast of Canada. Canadian Science Advisory Secretariat.

Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: Antipredator strategies of baleen whales. Mammal Review 38(1):50-86.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fisheries Bulletin 93(1):15-26.

Forney, K. A., and R. L. Brownell Jr. 1996. Preliminary report of the 1994 Aleutian Island marine mammal survey. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Paper SC/48/011, La Jolla, California.

Frankel, A., and C. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, *Megaptera novaeangliae*, in Hawai. Canadian Journal of Zoology 76(3):15.

Frankel, A. S., and C. W. Clark. 2000. Behavioral responses of humpback whales (*Megaptera novaeangliae*) to full-scale ATOC signals. Journal of the Acoustical Society of America 108(4):1930-1937.

Frankel, A. S., and C. W. Clark. 2002. ATOC and other factors affecting the distribution and abundance of humpback whales (*Megaptera novaeangliae*) off the north shore of Kauai. Marine Mammal Science 18(3):644-662.

Frankel, A. S., J. R. Mobley, and L. M. Herman. 1995. Estimation of auditory response thresholds in humpback whales using biologically meaningful sounds. Pages 55-70 *in* R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall, editors. Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden.

Frantzis, A., and P. Alexiadou. 2008. Male sperm whale (*Physeter macrocephalus*) coda production and coda-type usage depend on the presence of conspecifics and the behavioural context. Canadian Journal of Zoology 86(1):62-75.

Frazer, L. N., and E. Mercado III. 2000. A sonar model for humpback whale song. IEEE Journal of Oceanic Engineering 25(1):160-182.

Friday, N. A., A. N. Zerbini, J. M. Waite, S. E. Moore, and P. J. Clapham. 2013. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf, June and July of 2002, 2008, and 2010. Deep Sea Research Part II: Topical Studies in Oceanography 94:244-256.

Friedlaender, A. S., R. B. Tyson, A. K. Stimpert, A. J. Read, and D. P. Nowacek. 2013. Extreme diel variation in the feeding behavior of humpback whales along the western Antarctic Peninsula during autumn. Marine Ecology Progress Series 494:281-289.

Fritz, L., and coauthors. 2013. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) conducted in Alaska in June-July 2008 through 2012, and an ppdate on the status and trend of the Western Distinct population segment in Alaska. NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center.

Fulling, G. L., P. H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65(3):321-343.

Futuymda, D. J. 1986. Evolutionary Biology, Second edition. Sinauer Associates, Inc., Sunderland, Massachusetts.

Gabriele, C., B. Kipple, and C. Erbe. 2003. Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska. Pages 56-57 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Gabriele, C. M., and A. S. Frankel. 2002. Surprising humpback whale songs in Glacier Bay National Park. Pages 17-21 *in* Alaska Park Science: Connections to Natural and Cultural Resource Studies in Alaska's National Parks.

Gabriele, C. M., J. M. Straley, and J. L. Neilson. 2007. Age at first calving of female humpback whales in southeastern Alaska. Pages 159-162 *in* Fourth Glacier Bay Science Symposium.

Gailey, G., B. Wursig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):75-91.

Gambell, R. 1976. World whale stocks. Mammal Review 6(1):41-53.

Gambell, R. 1979. The blue whale. Biologist 26:209-215.

Gambell, R. 1985a. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pages 171-192 *in* Handbook of Marine Mammals, volume 3: The Sirenians and Baleen Whales. Academic Press, London, United Kingdom.

Gambell, R. 1985b. Sei whale, *Balaenoptera borealis* Lesson, 1828. Pages 155-170 *in* S. H. Ridway, and S. R. Harrison, editors. Handbook of Marine Mammals, volume 3: The Sirenians and Baleen Whales. Academic Press, London.

Gardner, S. C., and S. Chavez-Rosales. 2000. Changes in the relative abundance and distribution of gray whales (*Eschrichtius robustus*) in Magdalena Bay, Mexico during an El Nino event. Marine Mammal Science 16(4):728-738.

Gaskin, D. E. 1972. Whales, Dolphins, and Seals; with Special Reference to the New Zealand Region. Heinemann, London.

Gauthier, J., and R. Sears. 1999. Behavioral response of four species of balaenopterid whales to biopsy sampling. Marine Mammal Science 15(1):85-101.

Gauthier, J. M., C. D. Metcalfe, and R. Sears. 1997. Chlorinated organic contaminants in blubber biopsies northwestern Atlantic balaenopterid whales summering in the Gulf of St. Lawrence. Marine Environmental Research 44(2):201-223.

Gero, S., D. Engelhaupt, L. Rendell, and H. Whitehead. 2009. Who Cares? Between-group variation in alloparental caregiving in sperm whales. Behavioral Ecology 20(4):838-843.

Gillespie, D., and R. Leaper. 2001. Report of the Workshop on Right Whale Acoustics: Practical Applications in Conservation, Woods Hole, 8-9 March 2001. International Whaling Commission Scientific Committee, London.

Gilpatrick Jr., J. W., and W. L. Perryman. 2009. Geographic variation in external morphology of North Pacific and Southern Hemisphere blue whales (*Balaenoptera musculus*). Journal of Cetacean Research and Management 10(1):9-21.

Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, *Megaptera novaeangliae,* in Hawaii. Marine Mammal Commission.

Glockner, D. A., and S. C. Venus. 1983. Identification, growth rate, and behavior of humpback whale (*Megaptera novaeangliae*) cows and calves in the waters off Maui, Hawaii, 1977-79. Pages 223-258 *in* R. Payne, editor. Communication and Behavior of Whales. Westview Press, Boulder, CO.

Goddard, P. D., and D. J. Rugh. 1998. A group of right whales seen in the Bering Sea in July 1996. Marine Mammal Science 14(2):344-349.

Goldbogen, J. A., and coauthors. 2013. Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society of London Series B Biological Sciences 280(1765):Article 20130657.

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Canadian Journal of Zoology 72(8):1528-1530.

Goodyear, J. 1989. Continuous-transmitting depth of dive tag for deployment and use of free swimming whales. Pages 23 *in* Eighth Biennial Conference on the Biology of Marine Mammals, Asilomar Conference Center, Pacific Grove, California.

Goodyear, J. D. 1983. Night behavior of humpback whales in the Gulf of Maine as determined by radio tracking. Pages 38-39 *in* Fifth Biennial Conference on the Biology of Marine Mammals, New England Aquarium, Boston, Massachusetts.

Goodyear, J. D. 1993. A sonic/radio tag for monitoring dive depths and underwater movements of whales. Journal of Wildlife Management 57(3):503-513.

Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98(3):1279-1291.

Goold, J. C., H. Whitehead, and R. J. Reid. 2002. North Atlantic sperm whale, *Physeter macrocephalus*, strandings on the coastlines of the British Isles and Eastern Canada. Canadian Field-Naturalist 116:371–388.

Gordon, J., and coauthors. 2004. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34.

Gordon, J. C. D. 1987. Sperm whale groups and social behaviour observed off Sri Lanka. Report of the International Whaling Commission 37:205-217.

Gosho, M. E., D. W. Rice, and J. M. Breiwick. 1984. The sperm whale, *Physeter macrocephalus*. Marine Fisheries Review 46(4):54-64.

Grebmeier, J. M., L. W. Cooper, H. M. Feder, and B. I. Sirenko. 2006a. Ecosystem dynamics of the Pacific-influenced Northern Bering and Chukchi Seas in the Amerasian Arctic. Progress in Oceanography 71(2-4):331-361.

Grebmeier, J. M., and coauthors. 2006b. A major ecosystem shift in the northern Bering Sea. Science 311(5766):1461-1464.

Green, G. A., and coauthors. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 100 *in* J. J. Brueggeman, editor. Oregon and Washington Marine Mammal and Seabird Surveys, volume OCS Study MMS 91-0093. Minerals Management Service, Los Angeles, California.

Green, M. L., and R. G. Green. 1990. Short-term impact of vessel traffic on the Hawaiian humpback whale (*Megaptera novaeangliae*). Pages 4 *in* Annual Meeting of the Animal Behavior Society. Ocean Mammal Institute, SUNew York, Buffalo, New York.

Gregr, E. J., and K. O. Coyle. 2009. The biogeography of the North Pacific right whale (*Eubalaena japonica*). Progress in Oceanography 203(3-4):188-198.

Gregr, E. J., L. Nichol, J. K. B. Ford, G. Ellis, and A. W. Trites. 2000. Migration and population structure of northeastern Pacific whales off coastal British Columbia: An analysis of commercial whaling records from 1908-1967. Marine Mammal Science 16(4):699-727.

Gregr, E. J., and A. W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 58(7):1265-1285.

Griffin, R. B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15(1):33-51.

Gunnlaugsson, T., G. A. Vikingsson, and S. D. Halldorsson. 2013. Recent changes in biological parameters of North Atlantic fin whales. IWC Scientific Committee, Jeju, Korea.

Hain, J. H. W., G. R. Carter, S. D. Kraus, C. A. Mayo, and H. E. Winn. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. Fishery Bulletin 80(2):259-268.

Hain, J. H. W., and coauthors. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. Marine Mammal Science 11(4):464-479.

Hain, J. H. W., M. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the Northeastern United States. Marine Fisheries Review 47(1):13-17.

Hain, J. H. W., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-670.

Hall, J. D. 1982. Prince William Sound, Alaska: Humpback whale population and vessel traffic study. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, Juneau Management Office, Contract No. 81-ABG-00265., Juneau, Alaska.

Hamilton, P. K., G. S. Stone, and S. M. Martin. 1997. Note on a deep humpback whale (*Megaptera novaeangliae*) dive near Bermuda. Bulletin of Marine Science 61(2):491-494.

Harwood, L. A., and I. Stirling. 1987. Patterns of aggregation in ringed seals, bearded seals and bowhead whales in the Beaufort Sea during late summer. Pages 29 *in* Seventh Biennial Conference on the Biology of Marine Mammals, Miami, Florida.

Hashagen, K. A., G. A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. Northwestern Naturalist 90(2):160-162.

Hayward, T. L. 2000. El Niño 1997-98 in the coastal waters of southern California: A timeline of events. CalCOFl Reports 41:98-116.

Hazen, E. L., and coauthors. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change 3(3):234-238.

HDR. 2012. Guam and Saipan marine species monitoring: Winter-spring survey 15-29 March. HDR.

Helweg, D. A., A. S. Frankel, J. R. Mobley Jr., and L. M. Herman. 1992. Humpback whale song: Our current understanding. Pages 459-483 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine Mammal Sensory Systems. Plenum Press, New York.

Henderson, D. 1990. Gray whales and whalers on the China coast in 1869. (Eschrichtius robustus). Whalewatcher 24(4):14-16.

Hendrix, A. N., J. Straley, C. M. Gabriele, and S. M. Gende. 2012. Bayesian estimation of humpback whale (*Megaptera novaeangliae*) population abundance and movement patterns in southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences 69(11):1783-1797.

Henry, J., and P. B. Best. 1983. Organochlorine residues in whales landed at Durban, South Africa. Marine Pollution Bulletin 14(6):223-227.

Herman, L. M. 1979. Humpback whales in Hawaiian waters: A study in historical ecology. Pacific Science 33(1):1-16.

Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinoja. 1980. Right whale (*Balaena glacialis*) sightings near Hawaii: A clue to the wintering grounds? Marine Ecology Progress Series 2:271-275.

Herman, L. M., and coauthors. 2011. Resightings of humpback whales in Hawaiian waters over spans of 10–32 years: Site fidelity, sex ratios, calving rates, female demographics, and the dynamics of social and behavioral roles of individuals. Marine Mammal Science 27(4):736-768.

Highsmith, R. C., and K. O. Coyle. 1992. Productivity of Arctic amphipods relative to gray whale energy requirements. (Eschrichtius robustus). Marine Ecology Progress Series 83:141-150.

Highsmith, R. C., and K. O. Coyle. 1990. High productivity of northern Bering Sea benthic amphipods. Nature 344(6269):862-864.

Hildebrand, J. A. 2005. Impacts of anthropogenic sound. Pages 101-124 *in* J. E. Reynolds, editor. Marine Mammal Research: Conservation Beyond Crisis. The John Hopkins University Press.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Hildebrand, J. A., and coauthors. 2012. Passive acoustic monitoring for marine mammals in the SOCAL naval training area 2011-2012. University of California San Diego, Scripps Institution of Oceanography, Marine Physical Laboratory, San Diego, California.

Hill, P. S., and D. P. Demaster. 1998. Alaska marine mammal stock assessments, 1998. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Hill, P. S., and D. P. Demaster. 1999. Alaska marine mammal stock assessments, 1999. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Hodge, R. P., and B. L. Wing. 2000. Occurrences of marine turtles in Alaska Waters: 1960-1998. Herpetological Review 31(3):148-151.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):El27-El32.

Hooker, S. K., R. W. Baird, S. Al-Omari, S. Gowans, and H. Whitehead. 2001. Behavioral reactions of northern bottlenose whales (*Hyperoodon ampullatus*) to biopsy darting and tag attachment procedures. Fishery Bulletin 99(2):303-308.

Horwood, J. 1987. The Sei Whale: Population Biology, Ecology and Management. Croom Helm, London, England.

Hotchkin, C. F., S. E. Parks, and C. W. Clark. 2011. Source level and propagation of gunshot sounds produced by North Atlantic right whales (*Eubalanea glacialis*) in the Bay of Fundy during August 2004 and 2005. Pages 136 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Hucke-Gaete, R., L. P. Osman, C. A. Moreno, K. P. Findlay, and D. K. Ljungblad. 2004. Discovery of a blue whale feeding and nursing ground in southern Chile. Proceedings of the Royal Society of London Series B Biological Sciences 271(Supplement 4):S170-S173.

Ilangakoon, A. D. 2012. Exploring anthropogenic activities that threaten endangered blue whales (*Balaenoptera musculus)* off Sri Lanka. Journal of Marine Animals and their Ecology 5(1):3-7.

Ilyashenko, V. Y. 2009. How isolated is the 'western' gray whale population? International Whaling Commission Scientific Committee, Madeira, Portugal.

IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5. Intergovernmental Panel on Climate Change.

IUCN. 2010. IUCN red list of threatened species. Version 2010.4. International Union for Conservation of Nature and Natural Resources.

Ivashchenko, Y. V., R. L. Brownell Jr., and P. J. Clapham. 2014. Distribution of Soviet catches of sperm whales *Physeter macrocephalus* in the North Pacific. Endangered Species Research 25(3):249-263.

Ivashchenko, Y. V., and P. J. Clapham. 2012. Soviet catches of right whales *Eubalaena japonica* and bowhead whales *Balaena mysticetus* in the North Pacific Ocean and the Okhotsk Sea. Endangered Species Research 18(3):201-217.

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell Jr. 2013. Soviet catches of whales in the North Pacific: Revised totals. Journal of Cetacean Research and Management 13(1):59-71.

Ivashin, M. V., and A. A. Rovnin. 1967. Some results of the Soviet whale marking in the waters of the North Pacific. Norsk Hvalfangst-Tidende 56(6):123-135.

IWC. 1980. Sperm Whales. International Whaling Commission.

IWC. 1991. Report of the sub-committee on small cetaceans. International Whaling Commission.

IWC. 2003. Report of the workshop on the western gray whale: Research and monitoring needs. International Whaling Commission.

IWC. 2005. Chair's Report of the 57th Annual Meeting. International Whaling Commission, Ulsan, Korea.

IWC. 2006. Scientific permit whaling: Information on scientific permits, review procedure guidelines, and current permits in effect. International Whaling Commission.

IWC. 2008. Catch limits & catches taken. International Whaling Commission.

IWC. 2012. Extracts from the IWC64 Scientific Committee report relevant to the WGWAP. International Whaling Commission.

Jacobsen, J. K., L. Massey, and F. Gulland. 2010. Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). Marine Pollution Bulletin 60(5):765-767.

Jahoda, M., and coauthors. 2003. Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessels and biopsy sampling assessed through passive tracking and timing of respiration. Marine Mammal Science 19(1):96-110.

Jaquet, N., and D. Gendron. 2009. The social organization of sperm whales in the Gulf of California and comparisons with other populations. Journal of the Marine Biological Association of the United Kingdom 89(5):975-983.

Jaquet, N., H. Whitehead, and M. Lewis. 1996. Coherence between 19th century sperm whale distributions and satellite-derived pigments in the tropical Pacific. Marine Ecology Progress Series 145:1-10.

Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler. 2005. Sounding the depths II: The rising toll of sonar, shipping and industrial ocean noise on marine life. Natural Resources Defense Council, New York, New York.

Jefferson, T. A., P. J. Stacey, and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21(4):151-180.

Jefferson, T. A., M. A. Webber, and R. L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to their Identification. Elsevier, London, UK.

Jensen, A., M. Williams, L. Jemison, and K. Raum-Suryan. 2009. Somebody Untangle Me! Taking a closer look at marine mammal entanglement in marine debris. Alaska Sea Grant Report:63-69.

Jensen, A. S., and G. K. Silber. 2004. Large whale ship strike database. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

Jochens, A. E., and coauthors. 2006. Sperm whale seismic study in the Gulf of Mexico; Summary report 2002-2004. U.S. Department of the Interior, Minerals Management

Service, Gulf of Mexico OCS Region, OCS Study MMS 2006-034, New Orleans, Louisiana.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Marine Fisheries Review 46(4):30-37.

Johnson, M. P., and P. L. Tyack. 2003. A digital acoustic recording tag for measuring the response of wild marine mammals to sound. IEEE Journal of Oceanic Engineering 28(1):3-12.

Johnson, S. R., and coauthors. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):1-19.

Jones, M. L., and S. L. Swartz. 1984. Demography and phenology of gray whales and evaluation of whale-watching activities in Laguna San Ignacio, Baja California Sur, Mexico. Pages 309-374 *in* M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Jones, M. L., and S. L. Swartz. 2002. Gray whale, *Eschrichtius robustus*. Pages 524-536 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, California.

Josephson, E., T. D. Smith, and R. R. Reeves. 2008. Historical distribution of right whales in the North Pacific. Fish and Fisheries 9(2):155-168.

Jurasz, C. M., and V. P. Jurasz. 1979. Feeding modes of the humpback whale, *Megaptera novaeangliae*, in southeast Alaska, USA. Scientific Reports of the Whales Research Institute 31:69-83.

Kanda, N., M. Goto, V. Y. Ilyashenko, and L. A. Pastene. 2010. Preliminary mtDNA analysis of gray whales from Japan and Russia. International Whaling Commission.

Kasuya, T. 1991. Density dependent growth in North Pacific sperm whales. Marine Mammal Science 7(3):230-257.

Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Scientific Reports of the Whales Research Institute 39:31-75.

Kato, H., H. Ishikawa, T. Bando, T. Mogoe, and H. Moronuki. 2006. Status report of conservation and researches on the Western gray whales in Japan, June 2005-May 2006. Unpublished paper to the IWC Scientific Committee. 11 pp. St Kitts and Nevis, West Indies, June (SC/58/O14).

Kato, H., H. Ishikawa, M. Goto, T. Miyashita, and H. Moronuki. 2007. Status report of conservation and researches on the western gray whales in Japan, June 2006-April 2007. Unpublished paper to the IWC Scientific Committee. 10 pp. Anchorage, AK, May (SC/59/O18).

Kato, H., and T. Kasuya. 2002. Some analyses on the modern whaling catch history of the western North Pacific stock of gray whales (Eschrichtius robustus), with special reference to the Ulsan whaling ground. Journal of Cetacean Research and Management 4(3):277-282.

Katona, S. K., and H. P. Whitehead. 1981. Identifying humpback whales using their natural markings. Polar Record 20(128):439-444.

Kaufman, G. D., and M. Osmond. 1987. Aspects of population dynamics of East Australian humpback whales. Pages 36 *in* Seventh Biennial Conference on the Biology of Marine Mammals, Miami, Florida.

Kawamura, A. 1980. Food habits of the Brydes whales taken in the South Pacific and Indian Oceans. Scientific Reports of the Whales Research Institute 32:1-23.

Kawamura, A. 1982a. Food habits and prey distributions of three rorqual species in the North Pacific Ocean. Scientific Reports of the Whales Research Institute 34:59-91.

Kawamura, A. 1982b. A review of food of balaenopterid whales. Scientific Reports of the Whales Research Institute 32:155–197.

Kennedy, A. S., D. R. Salden, and P. J. Clapham. 2012. First high- to low-latitude match of an eastern North Pacific right whale (*Eubalaena japonica*). Marine Mammal Science 28(4):E539-E544.

Kenney, R. D. 2001. Anomalous 1992 spring and summer right whale (*Eubalaena glacialis*) distributions in the Gulf of Maine. Journal of Cetacean Research and Management Special Issue 2:209-223.

Kenney, R. D. 2002. North Atlantic, North Pacific, and southern right whales - *Eubalaena glacialis, E. japonica*, and *E. australis*. Pages 806-813 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego.

Kenney, R. D., and H. E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. Continental Shelf Research 7(2):107-114.

Ketten, D. R. 1992a. The cetacean ear: Form, frequency, and evolution. Pages 53-75 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine Mammal Sensory Systems. Plenum Press, New York.

Ketten, D. R. 1992b. The marine mammal ear: Specializations for aquatic audition and echolocation. Pages 717-750 *in* D. B. Webster, R. R. Fay, and A. N. Popper, editors. The Evolutionary Biology of Hearing. Springer-Verlag, New York.

Ketten, D. R. 1997. Structure and function in whale ears. Bioacoustics 8:103-135.

Ketten, D. R. 1998. Marine mammal auditory systems: A summary of audiometroc and anatomical data and its implications for underwater acoustic impacts. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Ketten, D. R., and D. C. Mountain. 2014. Inner ear frequency maps: First stage audiograms of low to infrasonic hearing in mysticetes. Pages 41 *in* Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

Kim, H. W., and coauthors. 2013. Report of gray whale sighting survey off Korean waters from 2003 to 2011. IWC Scientific Committee, Jeju, Korea.

Kim, S. L., and J. S. Oliver. 1989. Swarming benthic crustaceans in the Bering and Chukchi Seas and their relation to geographic patterns in gray whale feeding. Canadian Journal of Zoology 67(6):1531-1542.

Kipple, B., and C. Gabriele. 2004. Underwater noise from skiffs to ships. J. F. Piatt, and S. M. Gende, editors. Fourth Glacier Bay Science Symposium.

Kjeld, M., O. Olafsson, G. A. Vikingsson, and J. Sigurjonsson. 2006. Sex hormones and reproductive status of the North Atlantic fin whales (*Balaenoptera physalus*) during the feeding season. Aquatic Mammals 32(1):75-84.

Klinowska, M. 1990. Book Review - Handbook of Marine Mammals Volume 4: River Dolphins and the Larger Toothed Whales. S. H. Ridgway & Sir. Richard Harrison (eds). Academic

Press, New York. 442pp. ISBN 0-122-588504-0. $49.50. 1989. Aquatic Mammals 16(1):4-5.

Klumov, S. K. 2001. The right whales in the Pacific Ocean. Proceedings of the Institute of Oceanography 58:202-297.

Knowlton, A. R., C. W. Clark, and S. D. Kraus. 1991. Sounds recorded in the presence of sei whales, *Balaenoptera borealis*. Pages 40 *in* Ninth Biennial Conference on the Biology of Marine Mammals, Chicago, Illinois.

Knowlton, A. R., S. D. Kraus, and R. D. Kenney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). Canadian Journal of Zoology 72(7):1297-1305.

Konishi, K., and coauthors. 2009. Feeding strategies and prey consumption of three baleen whale species within the Kuroshio-Current Extension. Journal of Northwest Atlantic Fishery Science 42(3):27-40.

Krieger, K., and B. L. Wing. 1984. Hydroacoustic surveys and identifications of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick Sound, southeastern Alaska, Summer 1983. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Center.

Ladrón de Guevara P., P., B. E. Lavaniegos, and G. Heckel. 2008. Fin whales (*Balaenoptera physalus*) foraging on daytime surface swarms of the euphausiid *Nyctiphanes simplex* in Ballenas Channel, Gulf of California, Mexico. Journal of Mammalogy 89(3):559-566.

Lafortuna, C. L., M. Jahoda, A. Azzellino, F. Saibene, and A. Colombini. 2003. Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (Balaenoptera physalus). European Journal of Applied Physiology 303(3-4):387-395.

Lagerquist, B. A., K. M. Stafford, and B. R. Mate. 2000. Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the Central California coast. Marine Mammal Science 16(2):375-391.

Laidre, K. L., K. E. W. Shelden, D. J. Rugh, and B. A. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. Marine Fisheries Review 62(3):27-36.

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(1):35-75.

Lambert, E., C. Hunter, G. J. Pierce, and C. D. Macleod. 2010. Sustainable whale-watching tourism and climate change: Towards a framework of resilience. Journal of Sustainable Tourism 18(3):409-427.

Lambertsen, R. H. 1986. Disease of the common fin whale (*Balaenoptera physalus*): Crassicaudiosis of the urinary system. Journal of Mammalogy 67(2):353-366.

Lambertsen, R. H. 1987. A biopsy system for large whales and its use for cytogenetics. Journal of Mammalogy 68(2):443-445.

Lambertsen, R. H. 1990. Disease biomarkers in large whale populations of the North Atlantic and other oceans. Pages 395-417 *in* J. E. Mccarthy, and L. R. Shugart, editors. Biomarkers of Environmental Contamination. Lewis Publishers, Boca Raton, Florida.

Lambertsen, R. H. 1992. Crassicaudosis: A parasitic disease threatening the health and population recovery of large baleen whales. Revue Scientifique et Technique Office International des Epizooties 11(4):1131-1141.

Lambertsen, R. H., B. A. Kohn, J. P. Sundberg, and C. D. Buergelt. 1987. Genital papillomatosis in sperm whale bulls. Journal of Wildlife Diseases 23(3):361-367.

Lammers, M. O., A. A. Pack, E. G. Lyman, and L. Espiritu. 2013. Trends in collisions between vessels and North Pacific humpback whales (*Megaptera novaeangliae*) in Hawaiian waters (1975-2011). Journal of Cetacean Research and Management 13(1):73-80.

Lang, A. R., and coauthors. 2011. Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. International Whaling Commission.

Lang, A. R., and coauthors. 2004. Genetic differentiation between western and eastern gray whale populations using microsatellite markers. International Whaling Commission Scientific Committee, Sorrento, Italy.

Lang, A. R., D. W. Weller, R. G. Leduc, A. M. Burdin, and J. R. L. Brownell. 2005. Genetic assessment of the western gray whale population. Current research and future directions. Unpublished paper to the IWC Scientific Committee. 13 pp. Ulsan, Korea, June (SC/57/BRG14).

Lang, A. R., D. W. Weller, R. G. Leduc, A. M. Burdin, and J. Robert L. Brownell. 2010a. Delineating patterns of male reproductive success in the western gray whale (Eschrichtius robustus) population. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.

Lang, A. R., D. W. Weller, R. G. Leduc, A. M. Burdin, and J. Robert L. Brownell. 2010b. Genetic differentiation between western and eastern (Eschrichtius robustus) gray whale populations using microsatellite markers. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.

Law, R. J., R. L. Stringer, C. R. Allchin, and B. R. Jones. 1996. Metals and organochlorines in sperm whales (*Physeter macrocephalus*) stranded around the North Sea during the 1994/95 winter. Marine Pollution Bulletin 32(1):72-77.

Lawson, G. L., A. O. C. Lavery, and P. H. Wiebe. 2014. Zooplankton and micronekton distribution and interaction with predators at the Northwest Atlantic Shelf Break and its canyons. Office of Naval Research.

Le Boeuf, B. J., and D. E. Crocker. 2005. Ocean climate and seal condition. BMC Biology 3(9):10.

Leatherwood, S., D. K. Caldwell, and H. E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: A guide to their identification. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins and porpoises of the eastern North Pacific and adjacent Arctic waters: A guide to their identification. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Leduc, R. G., and coauthors. 2012. Genetic analysis of right whales in the eastern North Pacific confirms severe extirpation risk. Endangered Species Research 18(2):163-167.

Leduc, R. G., and coauthors. 2002. Genetic differences between western and eastern gray whales (Eschrichtius robustus). Journal of Cetacean Research and Management 4(1):1-5.

Lee, D. E., and W. J. Sydeman. 2009. North Pacific climate mediates offspring sex ratio in northern elephant seals. Journal of Mammalogy 90(1):1-8.

Lee, T. 1993. Summary of cetacean survey data collected between the years of 1974 and 1985. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). Report of the International Whaling Commission Special Issue 15:149–157.

Lockyer, C. 1972. The age at sexual maturity of the southern fin whale (*Balaenoptera physalus*) using annual layer counts in the ear plug. ICES Journal of Marine Science 34(2):276-294.

Lockyer, C. 1981. Estimates of growth and energy budget for the sperm whale, *Physeter catodon*. Pages 489-504 *in* J. Gordon Clark, editor. Mammals in the Seas volume 3: General papers and large cetaceans. Food and Agriculture Organization of the United Nations, Rome.

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. Molecular Genetics of Marine Mammals Special Publication 3:159-171.

Loughlin, T. R. 2002. Steller's sea lion *Eumetopias jubatus*. Pages 1181-1185 *in* W. F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press San Diego.

Loughlin, T. R., J. T. Sterling, R. L. Merrick, J. L. Sease, and A. E. York. 2003. Diving behavior of immature Steller's sea lions (*Eumetopias jubatus*). Fishery Bulletin 101(3):566-582.

Lusseau, D. 2004. The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. Ecology and Society 9(1):2.

Lusseau, D., and coauthors. 2004. Parallel influence of climate on the behaviour of Pacific killer whales and Atlantic bottlenose dolphins. Ecology Letters 7(11):1068-1076.

Lyman, E. 2012. Large whale entanglement threat and reports received around the Main Hawaiian Islands. Hawaiian Islands Humpback Whale National Marine Sanctuary.

Lyrholm, T., and U. Gyllensten. 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. Proceedings of the Royal Society of London Series B Biological Sciences 265(1406):1679-1684.

Lyrholm, T., O. Leimar, and U. Gyllensten. 1996. Low diversity and biased substitution patterns in the mitochondrial DNA control region of sperm whales: Implications for estimates of time since common ancestry. Molecular Biology and Evolution 13(10):1318-1326.

Lyrholm, T., O. Leimar, B. Johanneson, and U. Gyllensten. 1999. Sex-biased dispersal in sperm whales: Contrasting mitochondrial and nuclear genetic structure of global populations. Transactions of the Royal Society of London, Series B: Biological Sciences 266(1417):347-354.

MacLeod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endangered Species Research 7(2):125-136.

Macleod, K., M. P. Simmonds, and E. Murray. 2006. Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management 8(3):247-254.

Madsen, P. T., and coauthors. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4):2366-2379.

Magalhaes, S., and coauthors. 2002. Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. Aquatic Mammals 28(3):267-274.

Malme, C. I., B. Wursig, J. E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling. Final Report for the Outer Continental Shelf Environmental Assessment Program, Research Unit 675. 207pgs.

Marcoux, M., H. Whitehead, and L. Rendell. 2006. Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (*Physeter macrocephalus*). Canadian Journal of Zoology 84(4):609-614.

Marini, L., C. Consiglio, B. Catalano, T. Valentini, and G. Villetti. 1996. Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean sea. Marine Mammal Science 12(3):489-495.

Marshall, G. 1998. CRITTERCAM: An animal-borne imaging and data logging system. Marine Technical Society Journal 32:11-17.

Marsili, L., and S. Focardi. 1996. Organochlorine levels in subcutaneous blubber biopsies of fin whales (*Balaenoptera physalus*) and striped dolphins (*Stenella coeruleoalba*) from the Mediterranean Sea. Environmental Pollution 91(1):1-9.

Martin, A. R., and M. R. Clarke. 1986. The diet of sperm whales (*Physeter macrocephalus*) between Iceland and Greenland. Journal of the Marine Biological Association of the United Kingdom 66:779-790.

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. Bulletin of the Far Seas Fisheries Research Laboratory 14:1-104 +1pl.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Report of the International Whaling Commission Special Issue 1:71-79.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural history of Oregon coast mammals. U.S. Department of Agriculture, Forest Service, PNW-133, Portland, Oregon.

Mate, B., A. Bradford, G. Tsidulko, V. Vertyankin, and V. Ilyashenko. 2011. Late-feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the eastern North Pacific. International Whaling Commission Scientific Committee, Tromso, Norway.

Mate, B., R. Mesecar, and B. Lagerquist. 2007. The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. Deep Sea Research Part II: Topical Studies in Oceanography 54(3-4):224-247.

Mate, B. R., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76(5):863-868.

Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4):12.

Mate, B. R., S. L. Nieukirk, and S. D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393-1405.

Matkin, C., and D. Matkin. 1981. Marine mammal survey of southwestern Prince William Sound 1979-1980. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Matthews, J. N., and coauthors. 2001. Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). Journal of Cetacean Research and Management 3(3):271-282.

Maury, M. F. 1852. Whale chart of the world, series F (wind, and current charts), sheet 1 (Washington, D.C. 1852), sheets 2–4 (no date).

Maury, M. F. 1853. A chart showing the favourite resort of the sperm and right whale.

Maybaum, H. L. 1990. Effects of 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. EOS Transactions of the American Geophysical Union 71(2):92.

McCracken, M. L. 2013. Estimation of incidental interactions with sea turtles and seabirds in the 2012 Hawaii longline deep-set fishery. NOAA, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. Journal of the Acoustical Society of America 109(4):1728-1735.

McDonald, M. A., and C. G. Fox. 1999. Passive acoustic methods applied to fin whale population density estimation. Journal of the Acoustical Society of America 105(5):2643-2651.

McDonald, M. A., J. A. Hildebrand, and S. Mesnick. 2009. Worldwide decline in tonal frequencies of blue whale songs. Endangered Species Research 9(1):13-21.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006a. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America 120(2):711-718.

McDonald, M. A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6):3941-3945.

McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006b. Biogeographic characterization of blue whale song worldwide: Using song to identify populations. Journal of Cetacean Research and Management 8(1):55-66.

McDonald, M. A., and S. E. Moore. 2002. Calls recorded from North Pacific right whales (*Eubalaena japonica*) in the eastern Bering Sea. Journal of Cetacean Research and Management 4(3):261-266.

McKenna, M. F. 2011. Blue whale response to underwater noise from commercial ships. University of California, San Diego.

McKenna, M. F., D. Ross, S. M. Wiggins, and J. A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. Journal of the Acoustical Society of America 131(2):92-103.

Meier, S. K., and coauthors. 2007. Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. Environmental Monitoring and Assessment 134(1-3):107-136.

Mellinger, D. K., and C. W. Clark. 2003. Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. Journal of the Acoustical Society of America 114(2):1108-1119.

Mellinger, D. K., K. M. Stafford, S. E. Moore, L. Munger, and C. G. Fox. 2004. Detection of North Pacific right whale (*Eubalaena japonica*) calls In the Gulf of Alaska. Marine Mammal Science 20(4):872-879.

Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. Canadian Journal of Zoology 75(5):776-786.

Metcalfe, C., B. Koenig, T. Metcalfe, G. Paterson, and R. Sears. 2004. Intra- and inter-species differences in persistent organic contaminants in the blubber of blue whales and humpback whales from the Gulf of St. Lawrence, Canada. Marine Environmental Research 57:245–260.

Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fishes. Philosophy of Science 46(2):263-286.

Miyashita, T., H. Kato, and T. Kasuya. 1995. Worldwide Map of Cetacean Distribution Based on Japanese Sighting Data (Volume 1). National Research Institute of Far Seas Fisheries, Shizuoka.

Mizroch, S. A., and D. W. Rice. 2006. Have North Pacific killer whales switched prey species in response to depletion of the great whale populations? Marine Ecology Progress Series 310:235-246.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The sei whale, *Balaenoptera borealis*. Marine Fisheries Review 46(4):25-29.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman. 1999. Distribution and movements of fin whales (*Balaenoptera physalus*) in the Pacific Ocean. Pages 127 *in* Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii.

MMC. 2007. Marine mammals and noise: A sound approach to research and management. Marine Mammal Commission.

Mobley Jr., J. R., L. M. Herman, and A. S. Frankel. 1988. Responses of wintering humpback whales (*Megaptera novaeangliae*) to playback of recordings of winter and summer vocalizations and of synthetic sound. Behavioral Ecology and Sociobiology 23(4):211-223.

Mobley Jr., J. R., S. S. Spitz, K. A. Forney, R. Grotefendt, and P. H. Forestell. 2000. Distribution and abundance of odontocete species in Hawaiian waters: Preliminary results of 1993-98 aerial surveys. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Mohl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. Journal of the Acoustical Society of America 114(2):1143-1154.

Monnahan, C. C., T. A. Branch, K. M. Stafford, Y. V. Ivashchenko, and E. M. Oleson. 2014. Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. PLoS ONE 9(6):e98974.

Moore, S. E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982-91. Arctic 53(4):448-460.

Moore, S. E., and J. T. Clark. 2002. Potential impact of offshore human activities on gray whales (*Eschrichtius robustus*). Journal of Cetacean Research and Management 4(1):19-25.

Moore, S. E., J. T. Clarke, and D. K. Ljungblad. 1986a. A comparison of gray whale (Eschrichtius robustus) and bowhead whale (Balaena mysticetus) distribution, abundance, habitat preference and behavior in the northeastern Chukchi Sea, 1982-84. Report of the International Whaling Commission 36:273-279.

Moore, S. E., J. M. Grebmeier, and J. R. Davies. 2000a. Gray whale foraging habitat in the northern Bering Sea: A GIS-based retrospective summary. International Whaling Commission Scientific Committee, Adelaide, Australia.

Moore, S. E., J. M. Grebmeier, and J. R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: Current conditions and retrospective summary. Canadian Journal of Zoology 81(4):734-742.

Moore, S. E., D. K. Ljungblad, and D. R. V. Schoik. 1986b. Annual patterns of gray whale (Eschrichtius robustus) distribution, abundance and behavior in the northern Bering and eastern Chukchi Seas, July 1980-83. Report of the International Whaling Commission Special Issue 8:231-242.-Sc/36/Ps2).

Moore, S. E., K. M. Stafford, D. K. Mellinger, and J. A. Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. BioScience 56(1):49-55.

Moore, S. E., J. M. Waite, L. L. Mazzuca, and R. C. Hobbs. 2000b. Mysticete whale abundance and observations of prey associations on the central Bering Sea shelf. Journal of Cetacean Research and Management 2(3):227-234.

Morano, J. L., and coauthors. 2012. Acoustically detected year-round presence of right whales in an urbanized migration corridor. Conservation Biology 26(4):698-707.

Munger, L. M., S. M. Wiggins, S. E. Moore, and J. A. Hildebrand. 2008. North Pacific right whale (*Eubalaena japonica*) seasonal and diel calling patterns from long-term acoustic recordings in the southeastern Bering Sea, 2000-2006. Marine Mammal Science 24(4):795-814.

Mussoline, S. E., and coauthors. 2012. Seasonal and diel variation in North Atlantic right whale up-calls: Implications for management and conservation in the northwestern Atlantic Ocean. Endangered Species Research 17(1):17-26.

Napp, J. M., and G. L. Hunt Jr. 2001. Anomalous conditions in the southeastern Bering Sea, 1997: Linkages among climate, weather, ocean, and biology. Fisheries Oceanography 10:61-68.

Nasu, K. 1974. Movement of baleen whales in relation to hydrographic conditions in the northern part of the North Pacific Ocean and the Bering Sea. Pages 345-361 *in* Oceanography of the Bering Sea, with Emphasis on Renewable Resources. Institute of Marine Science, University of Alaska, Fairbanks.

Neilson, J., C. Gabriele, J. Straley, S. Hills, and J. Robbins. 2005. Humpback whale entanglement rates in southeast Alaska. Pages 203-204 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012. Summary of reported whale-vessel collisions in Alaskan waters. Journal of Marine Biology:106282.

Nelson, M., M. Garron, R. Merrick, R. Pace, and T. Cole. 2007a. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian maritimes, 2001-2005. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Nelson, W. G., R. Brock, H. Lee II, J. O. Lamberson, and F. Cole. 2007b. Condition of Estuaries and Bays of Hawaii for 2002: A statistical summary. U.S. Environmental Protection Agency, Washington, D. C.

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Scientific Reports of the Whales Research Institute 12:33-89.

Nemoto, T. 1970. Feeding pattern of baleen whales in the oceans. Pages 241-252 *in* J. H. Steele, editor. Marine Food Chains. University of California Press, Berkeley, California.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. Pages 171-191 *in* Whales, Dolphins and Porpoises. University of California Press, Berkeley.

Nishiwaki, S., and coauthors. 2006. Cruise report of the second phase of the Japanese whale research program under special permit in the Antarctic (JARPA II) in 2005/2006 - feasibility study. International Whaling Commission Scientific Committee, St. Kitts and Nevis, West Indies.

NMFS. 1991. Final recovery plan for the northern right whale *Eubalaena glacialis*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS. 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

NMFS. 2005. Biological opinion on the issuance of scientific research permits (batched) in the North Pacific Ocean for research on large whales and pinnipeds (permit nos. 545-1761, 587-1767, 1071-1770, 731-1774, 393-1772, 945-1776, 1000-1617, 774-1719-02, 774-1714). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2006a. Biological opinion on sinking exercises (SINKEX) in the western North Atlantic Ocean. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2006b. Biological opinion on the issuance of Section 10(a)(1)(A) permits to conduct scientific research on the southern resident killer whale (*Orcinus orca*) distinct population segment and other endangered or threatened species. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS. 2006c. Draft recovery plan for the fin whale (*Balaenoptera physalus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2006d. Draft recovery plan for the sperm whale (*Physeter macrocephalus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2006e. Review of the status of the right whales in the North Atlantic and North Pacific Oceans. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS. 2008. Final programmatic biological opinion on U.S. Navy activities in the Hawaii Range Complex 2008-2013. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS. 2009. Sperm whale (*Physeter macrocephalus*): 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2011. Hawaii pelagic longline fishery regulation summary. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Regional Office.

NOAA. 2014. 2014 report on the entanglement of marine species in marine debris with an emphasis on species in the United States. National Oceanic and Atmospheric Administration, Marine Debris Program, Silver Spring, Maryland.

Noren, D. P., and J. A. Mocklin. 2012. Review of cetacean biopsy techniques: Factors contributing to successful sample collection and physiological and behavioral impacts. Marine Mammal Science 28(1):154-199.

Norman, S. A., and coauthors. 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management 6(1):87-99.

Norris, K. S., and G. W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale (*Physeter catodon* L.). Pages 397-417 *in* S. R. Galler, K. Schmidt-Koenig, G. J. Jacobs, and R. E. Belleville, editors. Animal Orientation and Navigation. National Air and Space Administration, Washington, D. C.

Norris, T. F. 1994. Effects of boat noise on the acoustic behavior of humpback whales. Journal of the Acoustical Society of America 95(5 Part 2):3251.

Northrop, J., W. C. Cummings, and M. F. Morrison. 1970. Underwater 20-Hz signals recorded near Midway Island. Journal of the Acoustical Society of America 49:1909-1910.

Notarbartolo-Di-Sciara, G., C. W. Clark, M. Zanardelli, and S. Panigada. 1999. Migration patterns of fin whales, *Balaenoptera physalus*: Shaky old paradigms and local anomalies. Pages 118 *in* P. G. H. Evan, and E. C. M. Parsons, editors. Twelfth Annual Conference of the European Cetacean Society, Monaco.

Nowacek, D., P. Tyack, and M. Johnson. 2003. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm signal. Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, Texas

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 Series B Biological Sciences 271(1536):227-231.

Nowacek, D. P., A. Vedenev, B. L. Southall, and R. Racca. 2012. Development and implementation of criteria for exposure of western gray whales to oil and gas industry noise. Pages 6 *in* A. N. Popper, and A. Hawkings, editors. The Effects of Noise on Aquatic Life. Springer Science.

NRC. 2003a. Decline of the Steller Sea Lion in Alaskan Waters. National Academies Press, Washington, D. C.

NRC. 2003b. Ocean Noise and Marine Mammals. National Academies Press.

NRC. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academy of Sciences, Washington, D. C.

Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Report of the International Whaling Commission 24:114-126.

Oleson, E. M., J. Calambokidis, J. Barlow, and J. A. Hildebrand. 2007a. Blue whale visual and acoustic encounter rates in the Southern California Bight. Marine Mammal Science 23(3):574-597.

Oleson, E. M., S. M. Wiggins, and J. A. Hildebrand. 2007b. Temporal separation of blue whale call types on a southern California feeding ground. Animal Behaviour 74(4):881-894.

Omura, H. 1958. North Pacific right whale. Scientific Reports of the Whales Research Institute 13:1-52.

Omura, H. 1988. Distribution and migration of the western Pacific stock of the gray whale (Eschrichtius robustus). Scientific Reports of the Whales Research Institute 39:1-10.

Omura, H., S. Ohsumi, K. N. Nemoto, and T. Kasuya. 1969. Black right whales in the north Pacific. Scientific Reports of the Whales Research Institute 21.

Pace III, R. M., and R. L. Merrick. 2008. Northwest Atlantic ocean habitats important to the conservation of North Atlantic right whales (*Eubalaena glacialis*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Pack, A. A., and coauthors. 2012. Size-assortative pairing and discrimination of potential mates by humpback whales in the Hawaiian breeding grounds. Animal Behaviour 84(4):983-993.

Pack, A. A., and coauthors. 2009. Male humpback whales in the Hawaiian breeding grounds preferentially associate with larger females. Animal Behaviour 77(3):653-662.

Palacios, D. M., and B. R. Mate. 1996. Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Galápagos Islands. Marine Mammal Science 12(4):582-587.

Panigada, S., and coauthors. 2006. Mediterranean fin whales at risk from fatal ship strikes. Marine Pollution Bulletin 52(10):1287-1298.

Panigada, S., M. Zanardelli, S. Canese, and M. Jahoda. 1999. How deep can baleen whales dive? Marine Ecology Progress Series 187:309-311.

Panigada, S., and coauthors. 2008. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (western Mediterranean Sea) with physiographic and remote sensing variables. Remote Sensing of Environment 112(8):3400-3412.

Papastavrou, V., S. C. Smith, and H. Whitehead. 1989. Diving behaviour of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands. Canadian Journal of Zoology 67(4):839-846.

Parks, S. E. 2003. Acoustic communication in the North Atlantic right whale (*Eubalaena glacialis*). Massachusetts Institute of Technology and Woods Hole Oceanographic Institution.

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.

Parks, S. E., and C. W. Clark. 2007. Acoustic communication: Social sounds and the potential impacts of noise. Pages 310-332 *in* S. D. Kraus, and R. Rolland, editors. The Urban Whale: North Atlantic Right Whales at the Crossroads. Harvard University Press, Cambridge, Massahusetts.

Parks, S. E., C. W. Clark, and P. L. Tyack. 2005a. North Atlantic right whales shift their frequency of calling in response to vessel noise. Pages 218 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Parks, S. E., C. W. Clark, and P. L. Tyack. 2007a. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3725-3731.

Parks, S. E., P. K. Hamilton, S. D. Kraus, and P. L. Tyack. 2005b. The gunshot sound produced by male North Atlantic right whales (*Eubalaena glacialis*) and its potential function in reproductive advertisement. Marine Mammal Science 21(3):458-475.

Parks, S. E., C. F. Hotchkin, K. A. Cortopassi, and C. W. Clark. 2012a. Characteristics of gunshot sound displays by North Atlantic right whales in the Bay of Fundy. Journal of the Acoustical Society of America 131(4):3173-3179.

Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2011. Individual right whales call louder in increased environmental noise. Biology Letters 7(1):33-35.

Parks, S. E., M. Johnson, and P. Tyack. 2010. Changes in vocal behavior of individual North Atlantic right whales in increased noise. Journal of the Acoustical Society of America 127(3 Part 2):1726.

Parks, S. E., M. P. Johnson, D. P. Nowacek, and P. L. Tyack. 2012b. Changes in vocal behavior of North Atlantic right whales in increased noise. Pages 4 *in* A. N. Popper, and A. Hawkings, editors. The Effects of Noise on Aquatic Life. Springer Science.

Parks, S. E., D. R. Ketten, J. T. O'Malley, and J. Arruda. 2007b. Anatomical predictions of hearing in the North Atlantic right whale. Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology 290(6):734-744.

Parks, S. E., K. M. Kristrup, S. D. Kraus, and P. L. Tyack. 2003. Sound production by North Atlantic right whales in surface active groups. Pages 127 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Parks, S. E., S. E. Parks, C. W. Clark, and P. L. Tyack. 2006. Acoustic communication in the North Atlantic right whale (*Eubalaena glacialis*) and potential impacts of noise. EOS Transactions of the American Geophysical Union 87(36).

Parks, S. E., and P. L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. Journal of the Acoustical Society of America 117(5):3297-3306.

Parks, S. E., I. Urazghildiiev, and C. W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustical Society of America 125(2):1230-1239.

Pavan, G., and coauthors. 2000. Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. Journal of the Acoustical Society of America 107(6):3487-3495.

Payne, K. 1985. Singing in humpback whales. Whalewatcher 19(1):3-6.

Payne, K., P. Tyack, and R. Payne. 1983. Progressive changes in the songs of humpback whales (*Megaptera novaeangliae*): A detailed analysis of two seasons in Hawaii. Pages 9-57 *in* R. Payne, editor. Communication and Behavior of Whales. Westview Press, Boulder, CO.

Payne, P. M., and coauthors. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in prey abundance. Fishery Bulletin 88(4):687-696.

Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences 188(1):110-141.

Payne, R. S., and S. McVay. 1971. Songs of humpback whales. Humpbacks emit sounds in long, predictable patterns ranging over frequencies audible to humans. Science 173(3997):585-597.

Pecl, G. T., and G. D. Jackson. 2008. The potential impacts of climate change on inshore squid: Biology, ecology and fisheries. Reviews of Fish Biology and Fisheries 18:373-385.

Perkins, J. S., and P. C. Beamish. 1979. Net entanglements of baleen whales in the inshore fishery of Newfoundland. Journal of the Fisheries Research Board of Canada 36:521-528.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Perryman, W. L., R. LeDuc, and R. L. Brownell Jr. 1999. Progress report on eastern North Pacific right whale research during July 1998. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Petrochenko, S. P., A. S. Potapov, and V. V. Pryadko. 1991. Sounds, souce levels, and behavior of gray whales in the Chukotskoe Sea. Sov. Phys. Acoust. 37(6):622-624.

Pettis, J., F. Ollervides, and J. Packard. 1999. Gray whale *Eschrichtius robustus* behavior as an indicator of boat harassment. Pages 147 *in* Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii.

Pike, G. C., and I. B. Macaskie. 1969. Marine mammals of British Columbia. Bulletin of the Fisheries Research Board of Canada 171:54.

Pinela, A. M., and coauthors. 2009. Population genetics and social organization of the sperm whale (*Physeter macrocephalus*) in the Azores inferred by microsatellite analyses. Canadian Journal of Zoology 87(9):802-813.

Pinto de Sa Alves, L. C., A. Andriolo, A. N. Zerbini, J. L. A. Pizzorno, and P. J. Clapham. 2009. Record of feeding by humpback whales (*Megaptera novaeangliae*) in tropical waters off Brazil. Marine Mammal Science 25(2):416-419.

Pitcher, K. W., and coauthors. 2005. Ontogeny of dive performance in pup and juvenile Steller sea lions in Alaska. Canadian Journal of Zoology 83(9):1214-1231.

Pitman, R. L., L. T. Ballance, S. I. Mesnick, and S. J. Chivers. 2001. Killer whale predation on sperm whales: Observations and implications. Marine Mammal Science 17(3):494-507.

Poole, M. M. 1984. Migration corridors of gray whales along the central California coast, 1980-1982. Pages 389-408 *in* M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Punt, A. E. 2010. Further analyses related to the estimation of the rate of increase for an unknown stock using a Bayesian meta-analysis. International Whaling Commission Scientific Committee, Agadir, Morocco.

Ramp, C., W. Hagen, P. Palsboll, M. Berube, and R. Sears. 2010. Age-related multi-year associations in female humpback whales (*Megaptera novaeangliae*). Behavioral Ecology and Sociobiology 64(10):1563-1576.

Rankin, C. H., and coauthors. 2009. Habituation revisited: An updated and revised description of the behavioral characteristics of habituation. Neurobiology of Learning and Memory 92(2):135-138.

Rankin, S., and J. Barlow. 2007. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. Bioacoustics 16(2):137-145.

Rankin, S., D. Ljungblad, C. Clark, and H. Kato. 2005. Vocalisations of Antarctic blue whales, *Balaenoptera musculus intermedia*, recorded during the 2001/2002 and 2002/2003 IWC/SOWER circumpolar cruises, Area V, Antarctica. Journal of Cetacean Research and Management 7(1):13-20.

Ray, G. C., E. D. Mitchell, D. Wartzok, V. M. Kozicki, and R. Maiefski. 1978. Radio tracking of a fin whale (*Balaenoptera physalus*). Science 202(4367):521-524.

Reeb, D., and P. B. Best. 2006. A biopsy system for deep-core sampling of the blubber of southern right whales, *Eubalaena australis*. Marine Mammal Science 22(1):206-213.

Reeves, R., and coauthors. 2005. Report of the independent scientific review panel on the impacts of Sakhalin II phase 2 on western North Pacific gray whales and related biodiversity. International Union for the Conservation and Nature and Natural Resources (IUCN), Gland, Switzerland.

Reeves, R. C., Plus Panel Of Various Other Authors. 2005. Impacts of Sakhalin II Phase 2 on western North Pacific gray whales and related biodiversity. Independent Scientific Review Panel.

Reeves, R. R. 1977. The problem of gray whale (*Eschrichtius robustus*) harassment: At the breeding lagoon and during migration. Marine Mammal Commission.

Reeves, R. R., S. Leatherwood, S. A. Karl, and E. R. Yohe. 1985. Whaling results at Akutan (1912-39) and Port Hobron (1926-37), Alaska. Report of the International Whaling Commission 35:441-457.

Reeves, R. R., B. D. Smith, E. A. Crespo, and G. N. D. Sciara. 2003. Dolphins, whales, and porpoises: 2002-2010 conservation action plan for the world's cetaceans. International

Union for Conservation of Nature and Natural Resources, Survival Service Commission Cetacean Specialist Group.

Reeves, R. R., T. D. Smith, and E. A. Josephson. 2008. Observations of western gray whales by ship-based whalers in the 19th century. IWC Scientific Committee, Santiago, Chile.

Reeves, R. R., T. D. Smith, E. A. Josephson, P. J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20(4):774-786.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell. 2002. National Audubon Society Guide to Marine Mammals of the World. Alfred A. Knopf, New York.

Reeves, R. R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. Canadian Field-Naturalist 111(2):15.

Rehberg, M. J., K. L. Raum-Suryan, K. W. Pitcher, and T. S. Gelatt. 2001. Development of juvenile Steller sea lion (*Eumetopias jubatus*) diving behaviour in Alaska. Pages 177 *in* Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Reilly, S. B., and V. G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. Marine Mammal Science 6(4):265-277.

Rendell, L., and H. Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. Animal Behaviour 67(5):865-874.

Reynolds III, J. E., D. P. DeMaster, and G. K. Silber. 2002. Endangered species and populations. Pages 373-382 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, California.

Rice, D. W. 1960. Distribution of the bottle-nosed dolphin in the Leeward Hawaiian Islands. Journal of Mammalogy 41(3):407-408.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. Pages 170-195 *in* W. E. Schevill, editor. The Whale Problem. Harvard University Press, Cambridge, Massahusetts.

Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission Special Issue 1:92-97.

Rice, D. W. 1978a. The humpback whale in the North Pacific: Distribution, exploitation, and numbers. Pages 29–44 *in* K. S. Norris, and R. R. Reeves, editors. Workshop on Problems Related to Humpback Whales (*Megaptera novaeangliae*) in Hawaii. Marine Mammal Commission.

Rice, D. W. 1978b. Sperm whales. Pages 82-87 *in* D. Haley, editor. Marine Mammals of Eastern North Pacific and Arctic Waters. Pacific Search Press, Seattle, Washington.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Society for Marine Mammology, Lawrence, Kansas.

Rice, D. W., and A. A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). American Society of Mammologists.

Rice, D. W., A. A. Wolman, and H. W. Braham. 1984. The gray whale, Eschrichtius robustus. Marine Fisheries Review 46(4):7-14.

Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, California.

Richardson, W. J., and B. Wursig. 1995. Significance of responses and noise impacts. Pages 387-424 *in* W. J. Richardson, C. R. Greene Jr., C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

Richter, C., S. Dawson, and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science 22(1):46-63.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Science for Conservation 219.

Ridgway, S. H., and D. A. Carder. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. Aquatic Mammals 27(3):267-276.

Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

Rohrkasse-Charles, S., B. Würsig, and F. Ollervides. 2011. Social context of gray whale *Eschrichtius robustus* sound activity. Pages 255 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Rone, B. K., and coauthors. 2010. Results from the April 2009 Gulf of Alaska Line Transect Survey (GOALS) in the Navy Training Exercise Area. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Rosenbaum, H. C., and coauthors. 2000. World-wide genetic differentiation of *Eubalaena*: Questioning the number of right whale species. Molecular Ecology 9(11):1793-1802.

Ross, D. 1976. Mechanics of Unterwater Noise. Pergamon Press, New York.

Ryan, C., and coauthors. 2014. Levels of persistent organic pollutants in eastern North Atlantic humpback whales. Endangered Species Research 22(3):213-223.

Salden, D. R. 1993. Effects of research boat approaches on humpback whale behavior off Maui, Hawaii, 1989-1993. Pages 94 *in* Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.

Samaran, F., C. Guinet, O. Adam, J.-F. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. Journal of the Acoustical Society of America 127(6):3800-3808.

Saracco, J. F., C. M. Gabriele, and J. L. Neilson. 2013. Population dynamics and demography of humpback whales in Glacier Bay and Icy Strait, Alaska. Northwestern Naturalist 94(3):187-197.

Sasaki, H., and coauthors. 2013. Habitat differentiation between sei (*Balaenoptera borealis*) and Bryde's whales (*B. brydei*) in the western North Pacific. Fisheries Oceanography 22(6):496-508.

Scarff, J. E. 1986. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50°N and east of 180°W. Report of the International Whaling Commission Special Issue 10:43-63.

Scarff, J. E. 1991. Historic distribution and abundance of the right whale (*Eubalaena glacialis*) in the North Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan from the Maury whale charts. Report of the International Whaling Commission 41:467-489.

Scheidat, M., C. Castro, J. Gonzalez, and R. Williams. 2004. Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la

Plata, Machalilla National Park, Ecuador. Journal of Cetacean Research and Management 6(1):63-68.

Schevill, W. E., W. A. Watkins, and R. H. Backus. 1964. The 20-cycle signals and *Balaenoptera* (fin whales). Pages 147-152 *in* W. N. Tavolga, editor Marine Bio-acoustics. Pergamon Press, Lerner Marine Laboratory, Bimini, Bahamas.

Scott, T. M., and S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Marine Mammal Science 13(2):4.

Sears, R., C. Ramp, A. B. Douglas, and J. Calambokidis. 2014. Reproductive parameters of eastern North Pacific blue whales *Balaenoptera musculus*. Endangered Species Research 22(1):23-31.

Sears, R., and coauthors. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Report of the International Whaling Commission Special Issue 12:335-342.

Sergeant, D. E. 1977. Stocks of fin whales *Balaenoptera physalus* L. in the North Atlantic Ocean. Report of the International Whaling Commission 27:460-473.

Shallenberger, E. W. 1981. The status of Hawaiian cetaceans. Marine Mammal Commission.

Shane, S. H. 1994. Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-1991. Bulletin of the Southern California Academy of Sciences 93(1):13-29.

Shane, S. H. 1995. Behavior patterns of pilot whales and Risso's dolphins off Santa Catalina Island, California. Aquatic Mammals 21(3):195-197.

Shelden, K. E. W. 2006. Habitat requirements and extinction risks of eastern North Pacific right whales. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Shelden, K. E. W., S. E. Moore, J. M. Waite, P. R. Wade, and D. J. 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.

Shelden, K. E. W., D. J. Rugh, and A. Schulman-Janiger. 2004. Gray whales born north of Mexico: Indicator of recovery or consequence of regime shift? Ecological Applications 14(6):1789-1805.

Shirihai, H. 2002. A Complete Guide to Antarctic Wildlife. Alula Press, Degerby, Finland.

Silber, G., J. Slutsky, and S. Bettridge. 2010. Hydrodynamics of a ship/whale collision. Journal of Experimental Marine Biology and Ecology 391:10-19.

Silber, G. K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64(10):2075-2080.

Simao, S. M., and S. C. Moreira. 2005. Vocalizations of a female humpback whale in Arraial do Cabo (Rj, Brazil). Marine Mammal Science 21(1):150-153.

Simmonds, M. P. 2005. Whale watching and monitoring: Some considerations. International Whaling Commission Scientific Committee, Ulsan, Korea.

Simmonds, M. P., and W. J. Eliott. 2009. Climate change and cetaceans: Concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1):203-210.

Simmonds, M. P., and S. J. Isaac. 2007. The impacts of climate change on marine mammals: Early signs of significant problems. Oryx 41(1):19-26.

Simon, M., K. M. Stafford, K. Beedholm, C. M. Lee, and P. Madsen. 2010. Singing behavior of fin whales in the Davis Strait with implications for mating, migration and foraging. Journal of the Acoustical Society of America 128(5):3200-3210.

Sirovic, A., J. A. Hildebrand, and S. M. Wiggins. 2007. Blue and fin whale call source levels and propagation range in the Southern Ocean. Journal of the Acoustical Society of America 122(2):1208-1215.

Sirovic, A., L. N. Williams, S. M. Kerosky, S. M. Wiggins, and J. A. Hildebrand. 2012. Temporal separation of fin whale calls across the eastern North Pacific. Pages 9 *in* 2012 Southern California Marine Mammal Workshop, Pacific Life, Newport Beach, California.

Slikas, B., and coauthors. 2013. The right whale for next-generation sequencing - worldwide phylogenetic relationships and oceanic diversity. Pages 193-194 *in* Twentieth Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand.

Smith, A. W., and A. B. Latham. 1978. Prevalence of vesicular exanthema of swine antibodies among feral animals associated with the southern California coastal zones. American Journal of Veterinary Research 39:291–296.

Smith, J. N., A. W. Goldizen, R. A. Dunlop, and M. J. Noad. 2008. Songs of male humpback whales, *Megaptera novaeangliae*, are involved in intersexual interactions. Animal Behaviour 76(2):467-477.

Smith, T. D., and D. G. Pike. 2009. The enigmatic whale: The North Atlantic humpback. Pages 161-178 *in* C. Lockyer, and D. Pike, editors. North Atlantic Sightings Surveys: Counting Whales in the North Atlantic, 1987-2004, volume NAMMCO Scientific Publications Volume 7.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis. 2007. Marine mammal visual survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in support of Navy training exercises in the Hawai'i Range Complex, January 27 – February 2, 2007. Department of the Navy, NAVFAC Pacific, Oakland, California.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis. 2010. Rare sightings of a bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of Oʻahu, Hawaiʻi. Pacific Science 64(3):449-457.

Southall, B. L., and coauthors. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-521.

Southall, B. L., and coauthors. 2011. Biological and behavioral response studies of marine mammals in southern California (SOCAL-10). Pages 279 *in* Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Stafford, K. M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. Marine Mammal Science 19(4):12.

Stafford, K. M., C. G. Fox, and D. S. Clark. 1998. Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean. Journal of the Acoustical Society of America 104(6):3616-3625.

Stafford, K. M., D. K. Mellinger, S. E. Moore, and C. G. Fox. 2007. Seasonal variability and detection range modeling of baleen whale calls in the Gulf of Alaska, 1999-2002. Journal of the Acoustical Society of America 122(6):3378-3390.

Stafford, K. M., and S. E. Moore. 2005. Atypical calling by a blue whale in the Gulf of Alaska (L). Journal of the Acoustical Society of America 117(5):2724-2727.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. Journal of Cetacean Research and Management 3(1):65-76.

Stearns, S. C. 1992. The Evolution of Life Histories. Oxford Press, Oxford.

Steiger, G. H., and coauthors. 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: Implications for predation pressure. Endangered Species Research 4(3):247-256.

Stewart, B. S., S. A. Karl, P. K. Yochem, S. Leatherwood, and J. L. Laake. 1987. Aerial surveys for cetaceans in the former Akutan, Alaska, whaling grounds. Arctic 40(1):33-42.

Stimpert, A. K., D. N. Wiley, W. W. L. Au, M. P. Johnson, and RolArsenault. 2007. 'Megapclicks': Acoustic click trains and buzzes produced during night-time foraging of humpback whales (*Megaptera novaeangliae*). Biology Letters 3(5):467-470.

Stone, G. S., S. K. Katona, A. Mainwaring, J. M. Allen, and H. D. Corbett. 1992. Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. Report of the International Whaling Commission 42:739-745.

Straley, J., and T. O'Connell. 2005. Sperm whale interactions with longline fisheries in the Gulf of Alaska. Oncorhynchus 15(1):1-2.

Straley, J., T. O'Connell, L. Behnken, and A. Thode. 2005. Southeast Alaska sperm whale avoidance project: Fishermen and scientists working to reduce whale depredation on longlines.

Strong, C. S. 1990. Ventilation patterns and behavior of balaenopterid whales in the Gulf of California, Mexico. San Francisco State University.

Swartz, S. L., B. L. Taylor, and D. J. Rugh. 2006. Gray whale Eschrichtius robustus population and stock identity. Mammal Review 36(1):66-84.

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.

Tarpy, C. 1979. Killer whale attack! National Geographic Magazine 155(4):542-545.

Teloni, V., W. M. X. Zimmer, M. Wahlberg, and P. T. Madsen. 2007. Consistent acoustic size estimation of sperm whales using clicks recorded from unknown aspects. Journal of Cetacean Research and Management 9(2):127-136.

Ternullo, R., and N. Black. 2002. Predation behavior of transient killer whales in Monterey Bay, Calirornia. Pages 156-159 *in* Fourth International Orca Symposium, Chize, France.

Thode, A., J. Straley, C. O. Tiemann, K. Folkert, and V. O'Connell. 2007. Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. Journal of the Acoustical Society of America 122(2):1265-1277.

Thompson, P. O., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. Journal of the Acoustical Society of America 92(6):3051-3057.

Thompson, P. O., L. T. Findley, O. Vidal, and W. C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. Marine Mammal Science 12(2):288-293.

Thompson, P. O., and W. A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Thompson, T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete sounds. Pages 403-431 *in* H. E. Winn, and B. L. Olla, editors. Behavior of Marine Animals: Current Perspectives in Research, volume 3 Cetaceans. Plenum Press, New York.

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. Report of the International Whaling Commission Special Issue 1:98-106.

Tomilin, A. G. 1967. Mammals of the U.S.S.R. and Adjacent Countries, volume Volume 9, Cetacea. Izdatel'stvo Akademiya Nauk SSSR, Moscow.

Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19(1):1-50.

Trumble, S. J., E. M. Robinson, M. Berman-Kowalewski, C. W. Potter, and S. Usenko. 2013. Blue whale earplug reveals lifetime contaminant exposure and hormone profiles. Proceedings of the National Academy of Sciences 110(42):16922-16926.

Tsidulko, G. A., Q. Zhu, E. Sun, and M. A. Vorontsova. 2005. Scammon Lagoon for the western North Pacific gray whales? Pages 285 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Turner, R. F., and coauthors. 1987. Geological and operational summary, Kodiak shelf stratigraphic test wells, western Gulf of Alaska. United States Department of the Interior, Minerals Management Service, Alaska OCS Region.

Tyack, P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology 8(2):105-116.

Tyack, P. 1983. Differential response of humpback whales, *Megaptera novaeangliae*, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, P. L. 1999. Communication and cognition. Pages 287-323 *in* J. E. R. III, and S. A. Rommel, editors. Biology of Marine Mammals. Smithsonian Institution Press, Washington.

Tynan, C. T., and coauthors. 2005. Cetacean distributions relative to ocean processes in the northern California Current System. Deep Sea Research Part II: Topical Studies in Oceanography 52(1-2):145-167.

Tynan, C. T., D. P. Demaster, and W. T. Peterson. 2001. Endangered right whales on the southeastern Bering Sea shelf. Science 294(5548):1894.

Tyson, R. B., and D. P. Nowacek. 2005. Nonlinear dynamics in North Atlantic right whale (*Eubalaena glacialis*) vocalizations. Pages 286 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Tyurneva, O. Y., Y. M. Yakovlev, V. V. Vertyankin, G. Gailey, and O. Sychenko. 2011. Discovering a new feeding area for cow-calf pairs of western gray whales (*Eschrichtius robustus*) on the south-east shelf of Kamchatka and their utilizing different feeding regions within one season. Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.

Tyurneva, O. Y., and coauthors. 2010. Photographic identification of the Korean-Okhotsk gray whale (Eschrichtius robustus) offshore northeast Sakhalin Island and southeast Kamchatka Peninsula (Russia), 2009. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.

Tyurneva, O. Y., Y. M. Yakovlev, and V. V. Vertyankin. 2009. Photographic identification of the Korean-Okhotsk gray whale (Eschrichtius robustus) offshore northeast Sakhalin

Island and southeast Kamchatka Peninsula (Russia), 2008. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Urban R., J., and coauthors. 2013. Report on the photographic comparison of the Sakhalin Island and Kamchatka Peninsula with the Mexican gray whale catalogue. IWC Scientific Committee, Jeju, Korea.

Urick, R. J. 1983. Principles of Underwater Sound, 3rd edition. Peninsula Publishing, Los Altos, California.

Van Opzeeland, I., S. V. Parijs, L. Kindermann, E. Burkhardt, and O. Boebel. 2013. Calling in the cold: Pervasive acoustic presence of humpback whales (*Megaptera novaeangliae*) in Antarctic coastal waters. PLoS ONE 8(9):e73007.

Vanderlaan, A. S. M., A. E. Hay, and C. T. Taggart. 2003. Characterization of North Atlantic right whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. IEEE Journal of Oceanic Engineering 28(2):164-173.

Vanderlaan, A. S. M., C. T. Taggart, A. R. Serdynska, R. D. Kenney, and M. W. Brown. 2008. Reducing the risk of lethal encounters: Vessels and right whales in the Bay of Fundy and on the Scotian Shelf. Endangered Species Research 4(3):283-283.

Viale, D., and coauthors. 1992. Successful tracking of a fin whale by an ARGOS equipped satellite. International Whaling Commission Scientific Committee, Glasgow, Scotland.

Vladimirov, A. V. 2005. An attack of killer whales (*Orcinus orca*) on a mother-calf pair of western gray whales in the waters of northeastern Sakhalin Island, Russia. Pages 294 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

Vladimirov, V. A., and coauthors. 2006. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2005. Unpublished paper to the IWC Scientific Committee. 12 pp. St Kitts and Nevis, West Indies, June (SC/58/BRG29).

Vladimirov, V. A., and coauthors. 2005. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2004. Unpublished paper to the IWC Scientific Committee. 6 pp. Ulsan, Korea, June (SC/57/BRG23).

Vladimirov, V. A., and coauthors. 2008. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2007. IWC Scientific Committee, Santiago, Chile.

Vladimirov, V. A., S. P. Starodymov, A. G. Afanasyev-Grigoryev, and V. V. Vertyankin. 2009. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island, Russia, 2008. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Vladimirov, V. A., S. P. Starodymov, and A. V. Kalachev. 2011. Distribution and abundance of western gray whales off northeast Sakhalin Island, 2004-2010. International Whaling Commission Scientific Committee, Tromso, Norway.

Vladimirov, V. A., S. P. Starodymov, M. S. Kornienko, and J. E. Muir. 2010. Distribution and abundance of western gray whales in the waters off northeast Sakhalin Island, Russia, 2004-2009. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.

Wade, P. M., and coauthors. 2006. Acoustic detection and satellite tracking leads to discovery of rare concentration of endangered North Pacific right whales. Biology Letters 2:417-419.

Wade, P. R., A. M. Burdin, A. L. Bradford, R. L. Brownell, and D. W. Weller. 2003a. Abundance estimates of western gray whales (*Eschrichtius robustus*) off northeastern Sakhalin Island, Russia. International Whaling Commission Scientific Committee, Berlin.

Wade, P. R., J. W. Durban, J. M. Waite, A. N. Zerbini, and M. E. Dahlheim. 2003b. Surveying killer whale abundance and distribution in the Gulf of Alaska and Aleutian Islands. NAFSC Quarterly Report 2003(October-November):1-16.

Wade, P. R., and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Reports of the International Whaling Commission 43:477-493.

Wade, P. R., and coauthors. 2011. The world's smallest whale population? Biology Letters 7(1):83-85.

Waite, J. 2003. Cetacean Assessment And Ecology Program: Cetacean survey. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.

Waite, J. M., K. Wynne, and D. K. Mellinger. 2003. Documented sighting of a North Pacific right whale in the Gulf of Alaska and post-sighting acoustic monitoring. Northwestern Naturalist 84(1):38-43.

Walker, K. A., A. W. Trites, M. Haulena, and D. M. Weary. 2012. A review of the effects of different marking and tagging techniques on marine mammals. Wildlife Research 39(1):15-30.

Waring, G. T. 1993. Spatial patterns of six cetaceans along a linear habitat. Pages 2 *in* Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.

Waring, G. T., C. P. Fairfield, C. M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2(2):101-105.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2006. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2005. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, NOAA Technical Memorandum NMFS-NE-194, Woods Hole, Massachusetts.

Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2007. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2006. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, NOAA Technical Memorandum NMFS-NE-201, Woods Hole, Massachusetts.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2013. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2012. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Waring, G. T., R. M. Pace, J. M. Quintal, C. P. Fairfield, and K. Maze-Foley. 2004. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2003. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Watkins, W. A. 1977. Acoustic behavior of sperm whales. Oceanus 20:50-58.

Watkins, W. A. 1981a. Activities and underwater sounds of fin whales. Scientific Reports of the Whales Research Institute 33:83-117.

Watkins, W. A. 1981b. Reaction of three species of whales, *Balaenoptera physalus, Megaptera novaeangliae*, and *Balaenoptera edeni* to implanted radio tags. Deep Sea Research Part I: Oceanographic Research Papers 28(6):589-599.

Watkins, W. A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science 2(4):251-262.

Watkins, W. A., M. A. Daher, K. M. Fristrup, T. J. Howald, and G. N. Disciara. 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Marine Mammal Science 9(1):55-67.

Watkins, W. A., and C. A. Goebel. 1984. Sonar observations explain behaviors noted during boat maneuvers for radio tagging of humpback whales (*Megaptera novaeangliae*) in the Glacier Bay area [Alaska, USA]. Cetology 48:1-8.

Watkins, W. A., K. E. Moore, and P. L. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W. A., K. E. Moore, D. Wartzok, and J. H. Johnson. 1981. Radio tracking of finback (*Balaenoptera physalus*), and humpback (*Megaptera novaeangliae*) whales in Prince William Sound, Alaska, USA. Deep Sea Research Part I: Oceanographic Research Papers 28(6):577-588.

Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (*Physeter catodon*) react to pingers. Deep Sea Research and Oceanogaphic Abstracts 22(3):123-129 +1pl.

Watkins, W. A., and W. E. Schevill. 1977. Spatial distribution of *Physeter catodon* (sperm whales) underwater. Deep Sea Research 24(7):693-699.

Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987. The 20-Hz signals of finback whales (*Balaenoptera physalus*). Journal of the Acoustical Society of America 82(6):1901-1912.

Watters, D., M. Yoklavich, M. Love, and D. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60:131-138.

Watwood, S. L., P. J. O. Miller, M. Johnson, P. T. Madsen, and P. L. Tyack. 2006. Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*). Journal of Animal Ecology 75:814-825.

Webster, P. 2003. Will oil spell trouble for Western Pacific gray whales? Science 300(5624):1365.

Weilgart, L. S., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galapagos Islands. Canadian Journal of Zoology 71(4):744-752.

Weilgart, L. S., and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40(5):277-285.

Weinrich, M. T., J. Bove, and N. Miller. 1993. Return and survival of humpback whale (*Megaptera novaeangliae*) calves born to a single female in three consecutive years. Marine Mammal Science 9(3):325-328.

Weinrich, M. T., and A. E. Kuhlberg. 1991. Short-term association patterns of humpback whale (*Megaptera novaeangliae*) groups on their feeding grounds in the southern Gulf of Maine. Canadian Journal of Zoology 69(12):3005-3011.

Weinrich, M. T., R. H. Lambertsen, C. S. Baker, M. R. Schilling, and C. R. Belt. 1991. Behavioural responses of humpback whales (*Megaptera novaeangliae*) in the southern Gulf of Maine to biopsy sampling. Report of the International Whaling Commission Special Issue 13:91-97.

Weinrich, M. T., and coauthors. 1992. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. Fishery Bulletin 90(3):588-598.

Weir, C. R., A. Frantzis, P. Alexiadou, and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). Journal of the Marine Biological Association of the United Kingdom 87(1):39-46.

Weirathmueller, M. J., W. S. D. Wilcock, and D. C. Soule. 2013. Source levels of fin whale 20Hz pulses measured in the Northeast Pacific Ocean. Journal of the Acoustical Society of America 133(2):741-749.

Weller, D., and coauthors. 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. Marine Mammal Science 12(4):588-594.

Weller, D. W. 2005. Report of the large whale tagging workshop. Marine Mammal Commission.

Weller, D. W., A. L. Bradford, A. M. Burdin, and J. Robert L. Brownell. 2009a. The incidence of killer whale tooth rakes on western gray whales off Sakhalin Island, Russia. (Orcinus orca). Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Weller, D. W., and coauthors. 2008a. A photographic match of a western gray whale between Sakhalin Island, Russia, and Honshu, Japan: The first link between the feeding ground and a migratory corridor. Journal of Cetacean Research and Management 10(1):89-91.

Weller, D. W., A. L. Bradford, A. R. Lang, A. M. Burdin, and J. Robert L. Brownell. 2009b. Birth-intervals and sex composition of western gray whales summering off Sakhalin Island, Russia. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Weller, D. W., and coauthors. 2008b. Status of western gray whales off northeastern Sakhalin Island, Russia, in 2007. IWC Scientific Committee, Santiago, Chile.

Weller, D. W., and coauthors. 2007. Status of western gray whales off northeastern Sakhalin Island, Russia. Unpublished paper to the IWC Scientific Committee. 11 pp. Anchorage, AK, May (SC/59/BRG19).

Weller, D. W., and coauthors. 2005. Status of western gray whales off northeastern Sakhalin Island, Russia, in 2004. Unpublished paper to the IWC Scientific Committee. 10 pp. Ulsan, Korea, June (SC/57/BRG1).

Weller, D. W., and coauthors. 2004a. Western gray whales off Sakhalin Island, Russia: A joint Russia-U.S. scientific investigation July-September 2003.

Weller, D. W., and coauthors. 2004b. Status of western gray whales off northeastern Sakhalin Island, Russia, in 2003. IWC Scientific Committee, Sorrento, Italy.

Weller, D. W., and coauthors. 2006a. Status of western gray whales off northeastern Sakhalin Island, Russia, in 2005. Unpublished paper to the IWC Scientific Committee. 10 pp. St Kitts and Nevis, West Indies, June (SC/58/BRG3).

Weller, D. W., and coauthors. 2003. Summer sightings of western gray whales in the Okhotsk and western Bering Seas. International Whaling Commission Scientific Committee, Berlin.

Weller, D. W., A. M. Burdin, B. Würsig, B. L. Taylor, and R. L. Brownell. 2002a. The western North Pacific gray whale: a review of past exploitation, current status and potential threats. Journal of Cetacean Research and Management 4:7-12.

Weller, D. W., Y. V. Ivashchenko, G. A. Tsidulko, A. M. Burdin, and J. Robert L Brownell. 2002b. Influence of seismic surveys on western gray whales off Sakhalin Island, Russia in 2001. IWC Scientific Committee.

Weller, D. W., and coauthors. 2011. Movements of western gray whales from the Okhotsk Sea to the eastern North Pacific. International Whaling Commission-Scientific Committee, Tromso, Norway.

Weller, D. W., and coauthors. 2012. Movements of gray whales between the western and eastern North Pacific. Endangered Species Research 18(3):193-199.

Weller, D. W., S. H. Rickards, A. L. Bradford, A. M. Burdin, and J. R. L. Brownell. 2006b. The influence of 1997 seismic surveys on the behaviour of western gray whales off Sakhalin

Island, Russia. Unpublished paper to the IWC Scientific Committee. 12 pp. St Kitts and Nevis, West Indies, June (SC/58/E4).

Weller, D. W., G. A. Tsidulko, Y. V. Ivashchenko, A. M. Burdin, and J. R. L. Brownell. 2006c. A re-evaluation of the influence of 2001 seismic surveys on western gray whales off Sakhalin Island, Russia. Unpublished paper to the IWC Scientific Committee. 9 pp. St Kitts and Nevis, West Indies, June (SC/58/E5).

Weller, D. W., and coauthors. 1999. Gray whales (*Eschrichtius robustus*) off Sakhalin Island, Russia: Seasonal and annual patterns of occurrence. Marine Mammal Science 15(4):1208-1227.

Wells, J. V., and M. E. Richmond. 1995. Populations, metapopulations, and species populations: What are they and who should care? Wildlife Society Bulletin 23(3):458-462.

Whitehead, H. 1995. Status of Pacific sperm whale stocks before modern whaling. Report of the International Whaling Commission 45:407-412.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242:295-304.

Whitehead, H. 2003. Sperm Whales: Social Evolution in the Ocean. University of Chicago Press.

Whitehead, H. 2008. Social and cultural evolution in the ocean: Convergences and contrasts with terrestrial systems. Pages 143-160 *in* S. C. Morris, editor. The Deep Structure of Biology: Is Convergence Sufficiently Ubiquitous to Give a Directional Signal? Templeton Foundation Press, West Conshohocken, Pennsylvania.

Whitehead, H., and T. Arnbom. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. Canadian Journal of Zoology 65(4):913-919.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361:291-300.

Whitehead, H., J. Gordon, E. A. Mathews, and K. R. Richard. 1990. Obtaining skin samples from living sperm whales. Marine Mammal Science 6(4):316-326.

Wiggins, S. M., E. M. Oleson, M. A. McDonald, and J. A. Hildebrand. 2005. Blue whale (*Balaenoptera musculus*) diel call patterns offshore of southern California. Aquatic Mammals 31(2):161-168.

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(1):196-205.

Williams, R., A. W. Trites, and D. E. Bain. 2002. Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. Journal of Zoology 256(2):255-270.

Williams, R., and coauthors. 2013. Evidence for density-dependent changes in body condition and pregnancy rate of North Atlantic fin whales over four decades of varying environmental conditions. International Council For the Exploration of the Seas Journal of Marine Science 70(6):1273-1280.

Winn, H. E., W. L. Bischoff, and A. G. Taruski. 1973. Cytological sexing of Cetacea. Marine Biology 23(4):343-346.

Winn, H. E., P. J. Perkins, and T. C. Poulter. 1970a. Sounds of the humpback whale. Pages 39-52 *in* Seventh Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park, California.

Winn, H. E., P. J. Perkins, and L. Winn. 1970b. Sounds and behavior of the northern bottle-nosed whale. Pages 53-59 *in* Seventh Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park, California.

Winn, H. E., and N. E. Reichley. 1985. Humpback whale - *Megaptera novaeangliae*. Pages 241-274 *in* S. H. Ridgway, and S. R. Harrison, editors. Handbook of Marine Mammals, volume 3 The Sirenians and Baleen Whales. Academic Press, London.

Wisdom, S., A. Bowles, and J. Sumich. 1999. Development of sound production in gray whales, *Eschrichtius robustus*. Pages 203-204 *in* Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii.

Wisdom, S., A. E. Bowles, and K. E. Anderson. 2001. Development of behavior and sound repertoire of a rehabilitating gray whale calf. Aquatic Mammals 27(3):239-255.

Wise Sr., J. P., and coauthors. 2009. A global assessment of chromium pollution using sperm whales (*Physeter macrocephalus*) as an indicator species. Chemosphere 75(11):1461-1467.

Witteveen, B. H., R. J. Foy, K. M. Wynne, and Y. Tremblay. 2008. Investigation of foraging habits and prey selection by humpback whales (*Megaptera novaeangliae*) using acoustic tags and concurrent fish surveys. Marine Mammal Science 24(3):516-534.

Witteveen, B. H., and coauthors. 2011. Trophic levels of North Pacific humpback whales (*Megaptera novaeangliae*) through analysis of stable isotopes: Implications on prey and resource quality. Aquatic Mammals 37(2):101-110.

Wright, A. J. 2005. Lunar cycles and sperm whales (*Physeter macrocephalus*) strandings on the North Atlantic coastlines of the British Isles and Eastern Canada. Marine Mammal Science 21(1):145-149.

Wursig, B., T. A. Jefferson, and D. J. Schmidly. 2000. The Marine Mammals of the Gulf of Mexico. Texas A&M University Press.

Wursig, B., S. K. Lynn, T. A. Jefferson, and K. D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

Wynne, K., R. J. Foy, and L. Buck. 2005. Gulf apex predator-prey study. University of Alaska, Kodiak, Alaska.

Yablokov, A. V., and L. S. Bogoslovskaya. 1984. A review of Russian research on the biology and commercial whaling of the gray whale. Pages 465-486 *in* M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Yablokov, A. V., and V. A. Zemsky. 2000. Soviet whaling data (1949-1979). Center for Russian Environmental Policy, Moscow.

Yablokov, A. V., V. A. Zemsky, Y. A. Mikhalev, V. V. Tormosov, and A. A. Berzin. 1998. Data on Soviet whaling in the Antarctic in 1947-1972 (population aspects). Russian Journal of Ecology 29(1):38-42.

Yakovlev, Y. M., and O. Y. Tyurneva. 2004. Photo-identification of the western gray whale (*Eschrichtius robustus*) on the northeastern Sakhalin shelf, Russia, 2002-2003. International Whaling Commission Scientific Committee, Sorrento, Italy.

Yakovlev, Y. M., and O. Y. Tyurneva. 2005. A note on photo-identification of the western gray whale (*Eschrictius robustus*) on the northeastern Sakhalin shelf, Russia, 2002-2004. International Whaling Commission Scientific Committee, Ulsan, Korea.

Yakovlev, Y. M., O. Y. Tyurneva, and V. V. Vertyankin. 2011. Migration of western gray whales (*Escrichtius robustus*) between feeding areas off the northeastern coast of Sakhalin Island and southeast Kamchatka. The result of the study 2002-2010. 19th Biennial Confernce on the Biology of Marine Mammals, Tampa, Florida.

Yazvenko, S. B., and coauthors. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):45-73.

Yazvenko, S. B., and coauthors. 2007b. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):93-106.

Yochem, P. K., and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). Pages 193-240 *in* S. H. Ridgway, and R. Harrison, editors. Handbook of Marine Mammals, volume 3: The Sirenians and Baleen Whales. Academic Press, London.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. 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.

Zoidis, A. M., and coauthors. 2008. Vocalizations produced by humpback whale (*Megaptera novaeangliae*) calves recorded in Hawaii. Journal of the Acoustical Society of America 123(3):1737-1746.