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

Action Agencies: NOAA's National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division

Activity Considered: Issuance of permit amendments to Bruce Mate (Oregon State University) (Permit 14856-04) and Doug Nowacek (Duke University) (Permit 14809-02)

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

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ACRONYMS AND ABBREVIATIONS

CFR- Code of Federal Regulations

NOAA-National Oceanic and Atmospheric Administration

DPS-Distinct Population Segment

RPA-Reasonable and Prudent Alternative

ESA-Endangered Species Act

SE-Standard Error

LIMPET- Low Impact Minimally Percutaneous Electronic Transmitter

μPa-microPascal

MMPA-Marine Mammal Protection Act

US-United States

NAO-North Atlantic Oscillation

USFWS-United States Fish and Wildlife Service

NMFS-National Marine Fisheries Service

CI -Confidence interval

CV -Coefficient of variation

DNA- deoxyribonucleic acid

1 INTRODUCTION

Section 7 (a)(2) of the Endangered Species Act (ESA) requires Federal agencies to insure 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 United States Fish and Wildlife Service (USFWS), depending on the endangered species (50 Code of Federal Regulations [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)).

Section 7 (b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agencies' actions will affect ESA-listed species and their critical habitat under their jurisdictions. If an incidental take is expected, section 7 (b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to lessen such impacts.

For the actions described in this document, the action agency is the NMFS Office of Protected Resources, Permits and Conservation Division (Permits Division), which proposes to authorize permit amendment 14856-04 for close approach of humpback whales in the Atlantic, Pacific, and Southern Ocean basins as well as satellite tagging of humpback whales in the Atlantic and Southern Oceans under permit amendment 14809-02. The consulting agency for this proposal is the NMFS Office of Protected Resources, Endangered Species Act Interagency Cooperation Division.

This biological and conference opinion (opinion) and incidental take statement were prepared by 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 NMFS' opinion on the effects of these actions on proposed, endangered, and threatened species and critical habitat that has been designated for those species. A complete record of this consultation is on file at NMFS' Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

On December 18 2013, the Permits Division issued permit 14856 for close approach, biopsy, aerial survey, and tagging activities on blue, bowhead, fin, western North Pacific gray, humpback, sei, North Pacific and southern right, and sperm whales in the Atlantic, Arctic, Indian, Pacific, and Southern Ocean basins and Mediterranean Sea. Unintentional harassment of Hawaiian insular false killer and southern resident killer whales, Guadalupe fur, Hawaiian monk, bearded, and ringed seals as well as eastern and western Distinct Population Segments (DPSs) of Steller sea lions was also authorized from aerial and surface vessel approaches. On August 13 2014, the Permits Division issued an amendment to permit 14856 that removed reapproach restrictions for blue, bowhead, fin, western North Pacific gray, humpback, North Pacific right, sei, southern right, and sperm whales. On May 15 2015, the Permits Division issued an additional amendment to permit 14856 to allow retagging and additional biopsy of some whale species. On April 2 2015, the Permits Division contacted the ESA Interagency Cooperation Division to discuss whether consultation would be appropriate on another amendment related to how humpback whale takes had been accounted for. On May 8 2015, the ESA Interagency Cooperation Division responded, requesting more specific information to determine whether reinitiation would be appropriate. On July 8 2015, the Permits Division requested reinitiation of consultation on Permit 14856.

On March 24 2014, the Permits Division issued permit 14809 for approach, behavioral observation, biopsy, suction cup tagging, and acoustic playback of humpback and sperm whales in the North Atlantic Ocean, as well as humpback whales in the North Pacific Ocean, and humpback and southern right whales in the Southern Ocean. On December 4 2014, the Permits Division issued an amendment to permit 14809 that allowed for different tag designs to be deployed than those originally authorized. On July 8 2015, the Permits Division requested reinitiation of consultation on permit 14809 to allow for additional tagging of humpback whales in the Atlantic and Southern Oceans. On July 13 2015, the Permits Division submitted additional information to the ESA Interagency Cooperation Division on its own accord. Information was sufficient to initiate consultation on this date for both permit amendments. Because of the similarities in species and actions, the consultations were batched into a single opinion.

2 DESCRIPTION OF THE PROPOSED ACTION

In this opinion, we consider two separate actions being carried out by the Permits Division: issuance of amendments 14856-04 and 14809-02. “Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. These amendments will largely allow actions already considered through ESA consultation to continue, but call out specific modifications that can affect humpback whales: increase in allowed take in permit 14856-04 and the use of dart tags in permit 14809-02. We relied on information provided by the applicants in their applications as well as follow-up information provided by the Permits Division verbally and in email to understand the activities proposed.

2.1 Proposed activities

Permit 14856-04 will not allow any added effort or activities by the applicant. It will, however, allow additional take. When the applicant applied for, received, and signed permit 14856 and its later amendments, he understood take to occur as a response to activities undertaken, not as something to be counted simply by engaging in the activity close to protected species. So, for example, the applicant estimated and counted take based on behavioral responses observed from marine mammals, but did not count closely approaching individuals closer than the defined boundary under Marine Mammal Protection Act (MMPA) regulations as take. This difference became obvious after the permit was signed and, with this new understanding, the applicant believes that authorized take will not allow him to undertake the authorized activities to the extent he intends. Therefore, the applicant has applied for an increase in the number of takes authorized, but not for additional activities or with an expectation of increasing research effort. This increase is for humpback whales only (although potentially anywhere in the Atlantic, Pacific, Indian, or Southern oceans), from 1,000 annual takes via close approach to 2,000 . In addition, the applicant will be permitted to take an individual six times per day, an increase from the three per day allowance in the current permit. Future reporting will incorporate the applicant's revised understanding of take.

Permit 14809-02 will allow for the use of dart satellite tags on humpback whales in the Atlantic and Southern Oceans. The applicants state their research on behavioral ecology of and responses of cetaceans to disturbances requires good understanding of baseline behavior, ecology and movement patterns. Recent advances in the miniaturization of technology and a track record of reliability in gathering these types of data have compelled the applicant to request the addition of dart tags, and Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) tags in particular, to their research permit. No additional activities, such as close approach, will be undertaken.

Some of the LIMPET tags will contain an Argos satellite transmitter as well as a time-depth recorder, light level and temperature gauge. The dimensions of these tags are 58x47x25 millimeters, and they weigh 63 grams. Smaller, lighter LIMPET units that contain only Argos satellite transmitters will also be used. Once deployed via crossbow, tags attach to the animal via two titanium dart anchors that are configured with either three or six petals. The dimensions of these are 45x22 millimeters x 4 grams and 68x24 millimeters x 6 grams, respectively. These tags are deployed either with an air-gun or crossbow with a customized bolt and cradle to the side of the animal. These tags are designed to transmit for up to 80 days (those with multi-sensors) or 160 days (with Argos only). After this time, the darts are designed to migrate out of the animal leaving a small scar that heals over time (Andrews 2012). All tag posts are sterilized and kept this way until deployment.

In addition to the LIMPET tags, a larger platform tag has been developed specifically for mysticete whales to collect multi-sensor data over variable time frames. This dart-tag uses four dart anchors that are similar in size and shape to those in the LIMPET tag. The main difference in this tag design is the tag platform is recovered and data are archived for download. The platform of the tag is 20x12x3 centimeters and the attached sensors are the Wildlife Computers MK10/SPLASH time-depth recorder, a Very High Frequency transmitter, a Fast-loc Global Positioning System, and a Daily Diary multi-sensor recorder. The weight of this Dart-tag is about

400 grams and it is deployed using a carbon-fiber hand pole with a customized housing. The tags are attached to the whale in the area below the dorsal fin and the posts, similar to the LIMPET tag, migrate out of the animal after a period of time. The tag floats and is recovered for data offload and reuse. All tag posts are sterilized and kept this way until deployment.

The permit amendment will allow for up to 30 adult or juvenile humpback whales per year to be tagged with any of these devices in the Southern Ocean and up to 50 in the Atlantic Ocean. Individuals may not be tagged with multiple devices simultaneously (for example, suction tagging is not permitted with a dart tag on the same individual at the same time).

2.2 Action area

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 CFR 402.02).

The action area for permit 14856-04 will encompass all Unites States (US) Exclusive Economic Zone waters, as well as international waters worldwide. Although previous permits have been issued to the applicant with a similarly broad geographic scope, the applicant's activities have been limited to North Pacific, northwestern Atlantic, Mediterranean Sea, South African, and Gulf of Mexico waters. However, as humpback whales do not generally occur in the Gulf of Mexico, we do not expect the proposed action to occur here. We have not received information to indicate the applicant will engage in new activities or projects outside the scope of what he has previously conducted. Although we acknowledge that activities could occur in any of the locations broadly specified, we expect most if not all activities will occur in areas the applicant has operated in, based on more than a decade of past performance reporting data. The permit will allow for proposed activities to occur any time of year. Permit 14809-02 will authorize activities in the northwestern Atlantic Ocean from Canada to the Caribbean, American Samoa, and the Southern Ocean southward from 60° South.

2.3 Interrelated and interdependent actions

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent use, apart from the action under consideration. For permit amendments 14856-04 and 14809-02, we did not identify any interrelated or interdependent actions.

3 Overview of NMFS' Assessment Framework

Section 7 (a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure 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; and 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 does not rely on the regulatory definition of “destruction or adverse modification” of critical habitat at 50 C.F.R. 402.02. Instead, we have relied on the statutory provisions of the ESA to complete the following analysis about critical habitat.[1] 2
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.

[1] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the “Destruction or Adverse Modification” Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

9. We integrate and synthesize factors one through nine 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 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 conduct these analyses, we rely on all the best scientific and commercial evidence available to us. This evidence consists of:

- The environmental assessment submitted by the Permits Division
- Monitoring reports submitted in conjunction with past research
- Reports from NMFS Science Centers
- Reports prepared by natural resource agencies in states and other countries
- Reports from nongovernmental organizations involved in marine conservation issues
- The information provided by NMFS' Permits Division when it initiated formal consultation
- The general scientific literature
- Our expert opinion

During the consultation, we conducted electronic searches of the general scientific literature using search engines, including Agricola, Ingenta Connect, Aquatic Sciences and Fisheries Abstracts, JSTOR, Conference Papers Index, First Search (Article First, ECO, WorldCat), Web of Science, Oceanic Abstracts, Google Scholar, and Science Direct. We also referred to an internal electronic library that represents a major repository on the biology of ESA-listed species under the NMFS' jurisdiction.

We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests whales will exhibit a particular response to acoustic exposure or close vessel approach) as well as data that do not support that conclusion.

When data are equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action will not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

4 Status of ESA-Listed and Proposed Species

This section identifies the ESA-listed and proposed species that potentially occur within the action areas that may be affected by permit amendments 14856-04 and 14809-02 (Table 1). It then summarizes the biology and ecology of those species that is pertinent to this consultation and what is known about species' life histories in the action areas. The ESA-listed species potentially occurring within the action area are listed in Table 1, with their regulatory status. This does not include species that we do not expect will be affected by the action.

Table 1. Threatened, endangered, and proposed species that may be affected by the Permit Division's proposed permit amendments 14856-04 and 14809-02.

Species	ESA Status	Critical Habitat	Recovery Plan
Humpback whale (*Megaptera novaeangliae*)	E – 35 FR 18319	-- --	55 FR 29646
Humpback whale (*Megaptera novaeangliae*) - Central America Distinct population segment (DPS) (proposed threatened)	E – 80 FR 22304	-- --	55 FR 29646
Humpback whale (*Megaptera novaeangliae*) - Cape Verde Islands/Northwest Africa DPS (proposed endangered)	E – 80 FR 22304	-- --	55 FR 29646
Humpback whale (*Megaptera novaeangliae*) – Western North Pacific DPS (proposed endangered)	E – 80 FR 22304	-- --	55 FR 29646

4.1 ESA-listed and proposed species and critical habitat not likely to be adversely affected

NMFS uses two criteria to identify the ESA-listed or proposed species or critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed or proposed species or designated critical habitat. If we conclude that an ESA-listed or proposed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed or proposed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed or proposed species in Table 1 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial*, *insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed or proposed species or its specific habitat needs and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to constituting an adverse effect. That means the ESA-listed or proposed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species),but it is very unlikely to occur.

For permit amendments 14856-04 and 14508-02, no ESA-listed or proposed species or critical habitats may be affected but are unlikely to be adversely affected.

4.2 ESA-listed species and critical habitat likely to be adversely affected

This opinion examines the status of each ESA-listed or proposed species that will be affected by the proposed action. The status is determined by the level of risk the ESA-listed or proposed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The *Status of ESA-Listed or Proposed Species* section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02.

One factor affecting the range-wide status of humpback whales, and aquatic habitat at large, is climate change. Although the effects of climate change are ongoing, many of the expected effects are likely to occur years to centuries from now, well beyond when the proposed amendments would expire. We primarily discuss climate change as a threat common to all species addressed in this opinion, rather than in each of the species-specific narratives. As we better understand responses to climate change, we address these effects in relevant species-specific sections.

In general, based on forecasts made by the Intergovernmental Panel on Climate Change, climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the near future (IPCC 2002). From 1906 to 2006, global surface temperatures have risen 0.74º C and continue at an accelerating pace; 11 of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed and proposed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). North Atlantic and Pacific sea surface temperatures have shown trends in being unusually warm in recent years (Blunden and Arndt 2013). The ocean along the US eastern seaboard is also much saltier than historical averages (Blunden and Arndt 2013). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe as well as an increase in the mass of the Antarctic and Greenland ice sheets, although the magnitude of these changes remain unknown. Species that are shorter-lived, larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely on specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2008). As such, we expect the risk of extinction to ESA-listed or proposed species to rise with the degree of climate shift associated with global warming.

Indirect effects of climate change would result from changes in the distribution of temperatures suitable for whale calving and rearing, the distribution and abundance of prey, and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). With warming temperatures and decreasing sea ice, humpback and fin whales have been found in increasing numbers at the northern extreme of their Pacific range and are regularly found now in the southern Chukchi Sea (Clarke et al. 2013). We do not know if this is due to range expansion owing to species recovery, or due to altered habitat associated with climate change (Clarke et al. 2013). Climate change can influence reproductive success by altering prey availability, as evidenced by high success of northern elephant seals during El Niño periods, when cooler, more productive waters are associated with higher first year pup survival (McMahon and Burton. 2005). Reduced prey availability resulting from increased ocean temperatures has also been suggested to explain reductions in Antarctic fur seal pup and harbor porpoise survival (Forcada et al. 2005; Macleod et al. 2007). Polygamous marine mammal mating systems can also be perturbed by rainfall levels, with the most competitive grey seal males being more successful in wetter years than in drier ones (Twiss et al. 2007). Sperm whale females were observed to have lower rates of conception following unusually warm sea surface temperature periods (Whitehead 1997). Marine mammals with restricted distributions linked to water temperature may be exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based on expected shifts in water temperature, 88% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to nontropical waters and preferences for shelf habitats (Macleod 2009). Modeling of North Atlantic cetacean species found that three of four odontocete species would likely undergo range contraction while one would expand its range (Lambert et al. 2014). Kaschner et al. (2011) modeled marine mammal species richness, overlaid with projections of climate change and found that species in lower-latitude areas would likely be more affected than those in higher-latitude regions. Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice cover during winter months. Although the IPCC (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran et al. (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by 20% since the 1950s.

Roughly 50% of the Earth's marine mammal biomass occurs in the Southern Ocean, with all baleen whales feeding largely on a single krill species, *Euphausia superba*, here and feeding virtually nowhere else (Boyd 2002). Atkinson et al. (2004) found severe decreases in krill populations over the past several decades in some areas of the Antarctic, linked to sea ice loss. Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators (Antarctic fur seals, gentoo penguins, macaroni penguins, and black-browed albatrosses) that depend on krill for prey. They concluded these populations experienced increases in the 1980s, followed by significant declines in the 1990s associated with more years of reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50% in the 1990s, although incidental mortalities from longline fisheries probably contributed to the decline of the albatross. These declines resulted, at least in part, from changes in the structure of krill population (reduced recruitment into older krill age classes), which lowered the number of predator's krill could sustain. The authors concluded the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s. By 2055, severe reductions in fisheries catch (including krill) because of climate change have been predicted to occur in the Indo-Pacific, Red Sea, Mediterranean Sea, Antarctic, and tropical areas worldwide while increased catches are expected in the Arctic, North Pacific, North Atlantic, and northern portions of the Southern Ocean (Cheung et al. 2010).

Climate-mediated changes in the distribution and abundance of keystone prey species, such as krill, are likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. If sea ice extent decreases, then larval krill may not be able to survive without access to underice algae to feed on. This may be a cause of decreased krill abundance in the northwestern Antarctic Peninsula during the last decade (Fraser and Hofmann 2003). Meltwaters have also reduced surface water salinities, shifting primary production along the Antarctic Peninsula (Moline et al. 2004). 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. 1986; Payne et al. 1990). If they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations would likely experience declines similar to those observed in other krill predators, including dramatic declines in population size and increased year-to-year variation in population size and demographics. These outcomes would dramatically increase the extinction probability of baleen whales. Edwards et al. (2007) found a 70% decrease in one zooplankton species in the North Sea and an overall reduction in plankton biomass as warm-water species invade formerly cold-water areas. However, in other areas, productivity may increase, providing more resources for local species (Brown et al. 2009). This has been proposed to be the case in the eastern North Pacific, where a poleward shift in the North Pacific Current that would likely continue under global warming conditions would enhance nutrient and planktonic species availability, providing more prey for many higher trophic level species (Sydeman et al. 2011). Species such as gray whales may experience benefits from such a situation (Salvadeo et al. 2013). In addition, reductions in sea ice may alleviate “choke points” that allow some marine mammals to exploit additional habitats (Higdon and Ferguson 2009). Long-term shifts of sperm whale prey (squids) in the California Current have also been attributed to the re-distribution of squids’ prey resulting from climate-based shifts in oceanographic variables (Salvadeo et al. 2011). Similar changes have also been suggested for sardines and anchovy in the California Current (Salvadeo et al. 2011), which are important prey for humpback and fin whales, among others. Humpback whale foraging locations in the North Atlantic have shifted by significant distances over the past few decades, potentially because of global warming (Palsboll et al. 2013).

Foraging is not the only potential aspect of ESA-listed species biology that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Schumann et al. 2013; Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms (which humpback whales have died from) could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Climate change has been linked to changing ocean currents as well. Ocean temperatures around Iceland are linked with alterations in the continental shelf ecosystem there, including shifts in minke whale diet (Víkingsson et al. 2014); humpback whales may experience similar effects.

Climactic shifts also occur because of natural phenomena. In the North Atlantic, this primarily concerns fluctuations in the North Atlantic Oscillation (NAO), which results from changes in atmospheric pressure between a semi-permanent high pressure feature over the Azores and a subpolar low pressure area over Iceland (Curry and McCartney 2001; Hurrell 1995; Stenseth et al. 2002). This interaction affects sea surface temperatures, wind patterns, and oceanic circulation in the North Atlantic (Stenseth et al. 2002). The NAO shifts between positive and negative phases, with a positive phase having persisted since 1970 (Hurrell 1995). The NAO is significant for North Atlantic right whales and probably humpback whales because of its influence on the species' primary prey, zooplankton of the genus *Calanus*, which are more abundant in the Gulf of Maine during positive NAO years (Conversi et al. 2001; Greene and Pershing 2004; Greene et al. 2003). This subsequently impacts the nutritional state of at least North Atlantic right whales and the rate at which sexually mature females can produce calves (Greene et al. 2003).

4.2.1 Humpback whale

Population designations. Populations have been relatively well defined for humpback whales.

North Atlantic. Humpback whales range from the Mid-Atlantic Bight and the Gulf of Maine across the southern coast of Greenland and Iceland to Norway in the Barents Sea. Whales migrate to the western coast of Africa (Waerebeek et al. 2013), the Cape Verde Islands, and the Caribbean Sea during the winter. Humpback whales collect in four summer feeding areas: Gulf of Maine and eastern Canada, west Greenland, Iceland, and Norway (Boye et al. 2010; Katona and Beard 1990; Smith et al. 1999). Although historically absent from the North Sea and European waters, humpback whales have been occurring in Dutch, English, and Irish waters with increasing frequency since the turn of the century, potentially exploiting foraging opportunities in the region (Leopold et al. 2014).

The principal breeding range for Atlantic humpback whales lies from the Antilles and northern Venezuela to Cuba (Balcomb III and Nichols 1982; Whitehead and Moore 1982; Winn et al. 1975). The largest breeding aggregations occur off the Greater Antilles where humpback whales from all North Atlantic feeding areas have been photo-identified (Clapham et al. 1993; Katona and Beard 1990; Mattila et al. 1994; Palsbøll et al. 1997; Smith et al. 1999; Stevick et al. 2003b). However, the possibility of historic and present breeding further north remains enigmatic but plausible (Smith and G.Pike 2009). Winter aggregations also occur at the Cape Verde Islands in the eastern North Atlantic and along Angola and Suriname (De Boer and Willems 2015) (Cerchio et al. 2010; Reeves et al. 2002b; Reiner et al. 1996; Weir 2007). Accessory and historical aggregations also occur in the eastern Caribbean (Levenson and Leapley 1978; Mitchell and Reeves 1983; Reeves et al. 2001a; Reeves et al. 2001b; Schwartz 2003; Smith and Reeves 2003; Swartz et al. 2003; Winn et al. 1975). To further highlight the "open" structure of humpback whales, a humpback whale migrated from the Indian Ocean to the South Atlantic Ocean, demonstrating that interoceanic movements can occur (Pomilla and Rosenbaum 2005). Genetic exchange at low-latitude breeding groups between Northern and Southern Hemisphere individuals and wider-range movements by males has been suggested to explain observed global gene flow (Rizzo and Schulte 2009). However, there is little genetic support for wide-scale interchange of individuals between ocean basins or across the equator.

Increasing range and occurrence in the Mediterranean Sea coincides with population growth and may represent reclaimed habitat from pre-commercial whaling (Frantzis et al. 2004; Genov et al. 2009; Panigada et al. 2014).

In 2015, NMFS proposed to designate humpback whale DPSs separately, listing some of them as endangered, some as threatened, and not list others (NOAA 2015). Within the North Atlantic Ocean, two DPSs are proposed: the West Indies DPS (proposed as non-listed) and the Cape Verde Islands/Northwestern Africa DPS (proposed endangered). The Cape Verde Islands plus Northwest Africa DPS consists of the humpback whales whose breeding range includes waters surrounding the Cape Verde Islands, as well as an undetermined breeding area in the eastern tropical Atlantic which may be more geographically diffuse than the West Indies breeding ground. The population of whales breeding in the Cape Verde Islands plus this unknown area likely represents the remnants of a historically larger population breeding around Cape Verde Islands and northwestern Africa (Reeves et al. 2002a). There is no known overlap in breeding range with North Atlantic humpback whales that breed in the West Indies, although overlap occurs among feeding aggregations from different breeding populations.

North Pacific. Based on genetic and photo-identification studies, NMFS currently recognizes 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 (Hill and DeMaster 1998). Gene flow between them may exist. Humpback whales summer in 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 (Ashe et al. 2013; Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during winter. More northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in Hawaii waters while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico (Rasmussen et al. 2012). However, 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. Humpback whales were recently found to migrate to the northwestern Hawaiian Islands; this may represent an undescribed breeding group or expansion of breeding from the main Hawaiian Islands (Lammers et al. 2011). 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 (1985b) identified genetic exchange between the humpback whales that winter off Hawaii and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawaii may have emigrated from Mexican wintering areas. A “population” of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, Guam, Rota, and Saipan from January-March (Darling and Mori 1993; Eldredge 1991;

Eldredge 2003; Rice 1998; Silberg et al. 2013). 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 2007; Calambokidis 1997; Calambokidis et al. 2001).

NMFS is proposing five humpback whale DPSs in the North Pacific: Hawaii (proposed non-listed), Central America (proposed threatened), Mexico (proposed non-listed), and a western Pacific DPS (proposed threatened) (NOAA 2015). The Central American DPS is composed of whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua. Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington–southern British Columbia feeding grounds. This DPS was determined to be discrete based on resight data as well as findings of significant genetic differentiation between it and other populations in the North Pacific. The genetic composition of the DPS is also unique in that it shares mitochondrial DNA haplotypes with some Southern Hemisphere DPSs, suggesting it may serve as a conduit for gene flow between the North Pacific and Southern Hemisphere. The western Pacific DPS (constituted by an Okinawa/Philippines DPS and a second unknown western Pacific DPS) consists of the whales' breeding and wintering around Okinawa and the Philippines as well as unknown areas. Animals transiting the Ogasawara area are believed to be a mixture of whales from this DPS and the second western Pacific DPS. The Okinawa/ Philippines DPS migrates to feeding grounds in the northern Pacific, primarily off the Russian coast. The population was determined to be discrete based on both significant genetic differentiations from other North Pacific populations and apparently limited exchange with other breeding populations in the North Pacific.

Southern Hemisphere. Eight stocks, or populations, of humpback whales occur in waters off Antarctica (Figure 1). Individuals from these stocks winter and breed in separate areas and are known to return to the same areas. However, the degree (if any) of gene flow (i.e., adult individuals wintering in different breeding locations) is uncertain (Carvalho et al. 2011). Genetic relatedness is high between eastern and western Australian breeding populations, but significantly different (Schmitt et al. 2014). Individuals from here may migrate past New Zealand, although other stocks also migrate through the area (Franklin et al. 2014). Individuals from breeding grounds in Ecuador are somewhat heterogeneous from individuals in other breeding areas, but may maintain a genetic linkage (Felix et al. 2009). Based on recent satellite telemetry, a revision of stocks A and G may be warranted to reflect stock movements within and between feeding areas separated east of 50º W (Dalla Rosa et al. 2008). Individuals from breeding stock G along the Antarctic Peninsula forage off Columbia (Albertson et al. 2015). Besides being a breeding area, the west coast of South Africa and Namibia also appears to serve as a foraging ground because of upwelling of the Benguela Current (Barendse et al. 2010; Elwen et al. 2013). North of this, along Gabon, a separate breeding group also occurs (Elwen et al. 2013). Females appear in this area in large numbers well before their male counterparts, frequently with calves (Barendse et al. 2010). Low-level movement between breeding locations across years has been documented, bringing into question the genetic discreteness of at least Southern Hemisphere populations (particularly between Oceania groups and Australia)(Garrigue et al. 2011a; Garrigue et al. 2011b; Stevick et al. 2011). However, mixing between some populations has not been found (such as between B2 and C1 groups). Sao Tome appears to be primarily a resting, nursing, and calving area with very little breeding occurring (Carvalho et al. 2011). At least two stop-over sites exist along Madagascar for the C stock (Fossette et al. 2014). Another breeding area may exist along the Kenya and Somali coasts, with females moving more directly along migratory corridors while males potentially searching for and intercepting females along the way (Cerchio et al. 2013). Movement between several locations, either islands or bathymetric features, in the southwestern Indian Ocean appears to be frequent (Dulau et al. 2014).

NMFS is proposing to designate eight DPSs in the Southern Ocean, but all as non-listed (NOAA 2015).

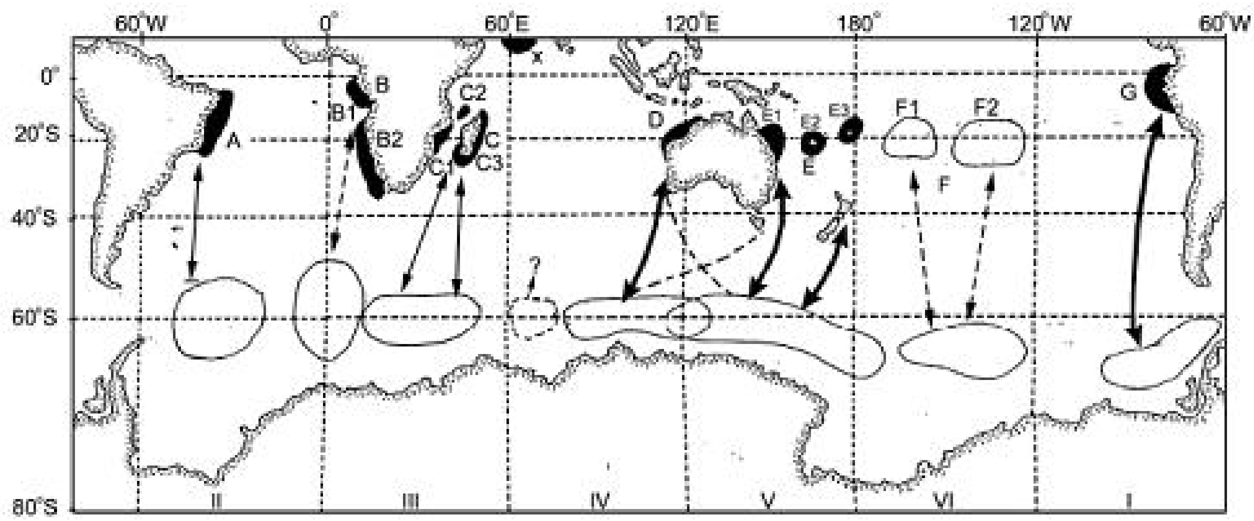

Figure 1. Southern Hemisphere humpback stocks (populations)(IWC 2005).

Distribution. Humpback whales are a cosmopolitan species that occur 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; (Gendron and Urban 1993)). In both regions, humpback whales occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985b). Humpback whales wintering in the West Indies migrate relatively directly to the Gulf of Maine and areas around Iceland and Norway (Kennedy et al. 2013). Some individuals may not migrate, or species occurrence in foraging areas may extend beyond summer and winter months (Murray et al. 2014; Van Opzeeland et al. 2013).

Reproduction and growth. Humpback whale calving and breeding occurs during winter at lower latitudes. 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 5-7 years old 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 Alaska, Gabriele et al. 2007). Females usually breed every 2-3 years, although consecutive calving is not unheard of (Clapham and Mayo 1987; 1990; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; Weinrich et al. 1993). Males return to breeding grounds more frequently than do females (Herman et al. 2011). Larger females produce larger calves that may have a greater chance of survival (Pack et al. 2009). Females preferentially select larger-sized males (Pack et al. 2012). In some Atlantic areas, females prefer shallow nearshore waters for calving and rearing, even when these areas are extensively trafficked by humans (Picanco et al. 2009). In Hawaii, humpback whales with calves prefer shallow waters, where they move more slowly than their postpartum counterparts in deeper waters (who are frequently accompanied by adult males) (Craig et al. 2014). Offspring return to the same breeding areas where they were born once they are independent (Baker et al. 2013).

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 or male dominance polygamy (Clapham 1996). Calving occurs in the shallow coastal waters of continental shelves and oceanic islands worldwide (Perry et al. 1999). Males “court” females in escort groups and compete for proximity and presumably access to reproduce females (particularly larger females)(Pack et al. 2009). Although long-term relationships do not 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 because of improved feeding cooperation (Ramp et al. 2010). Site fidelity off Brazilian breeding grounds was extremely low, both within and between years (Baracho-Neto et al. 2012).

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

Feeding. During the feeding season, humpback whales form small groups that occasionally aggregate on fairly constant concentrations of food. 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. 1992a; Witteveen et al. 2011). The principal fish prey in the western North Atlantic are sand lance, herring, and capelin (Kenney et al. 1985). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are 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). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best. 1995). Additional evidence, such as songs sung in northern latitudes during winter, provide additional support to plastic seasonal distribution (Smith and G.Pike 2009). Relatively high rates of resighting in foraging sites in suggest whales return to the same areas year after year (Ashe et al. 2013; Kragh 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). Prey distribution does not necessarily result in shifts in humpback whale distributions (Nottestad et al. 2014), which suggests humpbacks may not exhibit plastic behavior in all cases to respond to climate-related changes.

Status and trends. Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. Winn and Reichley (1985a) argued the global humpback whale population consisted of at least 150,000 whales in the early 1900s, mostly in the Southern Ocean. Consideration of the status of populations outside the action area is important under the present analysis to determine the risk to the affected population(s) bears on the status of the species as a whole. Table 2 provides estimates of historic and current abundance for ocean regions.

Table 2. Summary of past and present humpback whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% Confidence interval (CI)	Recent estimate	95% CI	Source
Global	~~	1,000,000	~~	~~	~~	(Roman and Palumbi 2003)
				10,000		(NMFS 1987)
North Atlantic	Basinwide	240,000	156,000-401,000*	11,570	10,005-13,135*	(Stevick et al. 2003a)
	~~	~~	~~	>5,500	~~	(Sigurjonsson 1995)
	Basinwide-females	~~	~~	2,804	1,776-4,463	(Palsbøll et al. 1997)
	Basinwide-males	~~	~~	4,894	3,374-7,123	(Palsbøll et al. 1997)
	Western North Atlantic from Davis Strait, Iceland, to the West Indies	>4,685*	~~	~~	~~	*circa 1865; (Mitchell and Reeves 1983)
	West Greenland	~~	~~	4,090	CV=0.50	(Heide-Jorgensen and Laidre 2013)
	Iceland	~~	~~	5,000	~~	(Pike et al. 2009)

Region	Population, stock, or study area	Pre-exploitation estimate	95% Confidence interval (CI)	Recent estimate	95% CI	Source
	NMFS-Gulf of Maine stock	~~	~~	845	CV=0.55	(NMFS 2008b)
	NMFS-Gulf of Maine stock including portions of the Scotian Shelf	~~	~~	902	177-1,627	(Clapham et al. 2003)
	Barents and Norwegian Seas	~~	~~	889	331-1,447*	(Øien 2001) in (Waring et al. 2004)
North Pacific	Basinwide	15,000	~~	6,000-8,000	~~	(Calambokidis et al. 1997)
	~~	~~	~~	18,300	~~	(Calambokidis et al. 2008a)
	~~	~~	~~	20,800	~~	(Barlow et al. 2009)
	NMFS-western North Pacific stock	~~	~~	394	329-459*	(Angliss and Allen 2007)
	NMFS-central North Pacific stock	~~	~~	4,005	3,259-4,751*	(Angliss and Allen 2007)
	NMFS-eastern North Pacific stock	~~	~~	1,391	1,331-1,451*	(Carretta et al. 2008)
	NMFS-CA/OR/WA stock	~~	~~	2,043	CV=0.10	(Carretta et al. 2013)
Southern Hemisphere	Basinwide	100,000	~~	19,851	~~	(Gambell 1976; IWC 1996)
	Gabon	~~	~~	>1,200	~~	(Strindberg et al. 2011)
	Oceania			2,300-3,500		(Constantine et al. 2010)
	~~	~~	~~	4,329	3,345-5,313	(Constantine et al. 2012) circa 2005

Region	Population, stock, or study area	Pre-exploitation estimate	95% Confidence interval (CI)	Recent estimate	95% CI	Source
	Western Australia	~~	~~	26,100[3]	20,152-33,272	(Kent et al. 2012)
	Mozambique	~~	~~	6,808	CV=0.14	(Findlay et al. 2011)
	American Samoa	~~	~~	150	~~	(Carretta et al. 2012)
	Brazil			6,404		(Andriolo et al. 2010)
	South of 60°S	~~	~~	42,000	34,000-52,000	(IWC 2007)

*Note: CIs not provided by the authors were calculated from Coefficients of Variation where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. Historical estimates have ranged from 40,000-250,000 (Smith and G.Pike 2009). Smith and Reeves (2010) estimated that roughly 31,000 individuals were removed from the North Atlantic because of whaling since the 1600s. Estimates of animals on Caribbean breeding grounds exceed 2,000 individuals (Balcomb III and Nichols 1982). Several researchers report an increasing trend in abundance for the North Atlantic population, based on increased sightings within the Gulf of Maine feeding aggregation (Barlow 1997; Katona and Beard 1990; Smith et al. 1999; Waring et al. 2001). The rate of increase varies from 3.2-9.4%, with rates of increase slowing over the past two decades (Barlow 1997; Katona and Beard 1990; Stevick et al. 2003a). If the North Atlantic population has grown according to the estimated instantaneous rate of increase (r = 0.0311), this would lead to an estimated 18,400 individual whales in 2008 (Stevick et al. 2003a). Punt (2010) estimated the rate of increase for humpback whales in the Gulf of Maine to be 6.3% annually (1.2 standard error [SE]). Pike et al. (2009) suggested the eastern and northeastern waters off Iceland are areas of significant humpback consumption, estimating nearly 5,000 whales in 2001 and proposing an annual growth rate of 12% for the area. The authors suggest that humpback whales in the area had probably recovered from whaling. Recent data suggest the upward growth may have slowed or ceased around Iceland according to analysis of survey data there (Pike et al. 2010). The Gulf of Maine stock is estimated to be increasing at a rate of 3.1% annually (Waring et al. 2013). Humpback whales summering off West Greenland are increasing at a rate of 9.4% annually (Heide-Jorgensen et al. 2012).

[3] Accounting for perception bias, 33,300 Kent, C. S., C. Jenner, M. Jenner, P. Bouchet, and E. Rexstad. 2012. Southern Hemisphere Breeding Stock D humpback whale population estimates from North West Cape, Western Australia. Journal of Cetacean Research and Management 12(1):29-38.

North Pacific. It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978). However, from 1905 to 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). This estimate does not account for under-reporting by Soviet whalers, who took approximately 2,700 more individuals than were reported (Ivashchenko et al. 2013). Estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Because estimates vary by methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,010 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific stock suggest an increase of 6-7% annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005). Barlow et al. (2009) estimated an annual growth rate of 4.9%. Punt (2010) estimated the rate of increase for humpback whales in the eastern North Pacific to be 6.4% annually (0.9 SE) between 1992 and 2003 and 10.0% for Hawaii (3.32 SE). Modeled abundance increase in southeastern Alaska was 5.1% annually from 1986 to 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% (Saracco et al. 2013). For Asia, an annual rate of growth of 6.7% has been estimated (Calambokidis et al. 2008b).

Southern Hemisphere. The International Whaling Commission compiled population data on humpback whales in the Southern Hemisphere. However, humpback whales in this region experienced severe whaling pressure. Based on whaling logs, particularly by Soviet vessels, at least 75,542 humpback whales were harvested from Antarctic waters from 1946 through 1973, largely from management areas IV, V, and VI (Clapham et al. 2009). One-third of these catches occurred from 1959-1961 in Area V. These numbers support Southern Hemisphere humpbacks being well below their carrying capacities (Clapham et al. 2009). A 2009 spike in calf mortality along western Australia brings into question whether carrying capacity has been reached by this population or other factors have increased mortality (Coughran and Gales 2010). Some vital rates of the humpback whale population summering off eastern Australia (E1) were recently estimated, including adult annual survival of 0.925 and subadult survival of 0.70 (Hoffman et al. 2010). Growth rates for certain age classes included 10.7% for adult females and 12.4% for juveniles (Hoffman et al. 2010). Punt (2010) estimated the rate of increase for humpback whales off eastern and western Australia to be 10.9% and 10.1% annually, respectively (0.23 and 4.69 SE, respectively). Kent et al. (2012) provided an even higher estimate of 13% from 2000-2008. Humpback whales off Mozambique are more numerous now than when surveyed in the 1990s (Findlay et al. 2011). Population growth along Brazil showed a growth rate of 7.4% annually between 1995-1998 (Ward et al. 2011).

Natural threats. Natural sources and rates of mortality of humpback whales are not well known. Based on 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). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks when attacked by killer whales, but engage in a flight response if predators are perceived, but not in the immediate vicinity (Cure et al. 2015). 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). The Canadian humpback whale stock has twice the scarring rate of other North Atlantic stocks, suggesting that this group may experience higher levels of predation than humpback whales elsewhere in the North Atlantic (McCordic et al. 2014).

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). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period. One-quarter of humpback whales of the Arabian Sea population show signs of tattoo skin disease, which may reduce the fitness of afflicted individuals (Baldwin et al. 2010).

Anthropogenic threats. Three human activities are known to threaten humpback whales: whaling, entanglement, and shipping. Historically, whaling represented the greatest threat to every population of whales, and was ultimately responsible for listing several species as endangered. Because of the large scale of the action areas, current threats are discussed more fully in the *Environmental Baseline*.

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 areas, the anticipated impacts of all proposed Federal projects in the action areas 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 Habitat degradation

Several factors may directly or indirectly affect listed species in the action areas by degrading habitat; perhaps most significant among them is anthropogenic noise in the ocean. Natural sources of ambient noise include wind, waves, surf noise, precipitation, thunder, and biological noise from marine mammals, fishes, and crustaceans. Anthropogenic sources of ambient noise include: transportation and shipping traffic, dredging, construction activities, geophysical surveys, and sonars. In general, it has been asserted that ocean background noise levels have doubled every decade for several decades in some areas, primarily because of shipping traffic

(IWC 2004). The acoustic noise that commercial traffic contributes to the marine environment is a concern for listed species because it may impair communication between individuals (Hatch et al. 2008; Naguib 2013; Papale et al. 2015).

Vessel noise could affect marine animals in the action area. Shipping and seismic noise dominates ambient noise at frequencies from 20 to 300 Hertz (Andrew et al. 2002; Hildebrand 2009; Richardson et al. 1995b). Background noise has increased significantly in the past 50 years because of increasing vessel traffic, and particularly shipping, with increases of as much as 12 dB in low frequency ranges and 20 dB versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995b). Over the past 50 years, the number of commercial vessels has tripled, carrying an estimated six times as much cargo (requiring larger, more powerful, and consequently louder vessels) (Hildebrand 2009). Seismic signals also contribute significantly to the low frequency ambient sound field (Hildebrand 2009). Baleen whales may be more sensitive to sound at those low frequencies than are toothed whales. Dunlop et al. (2010b) found that humpback whales shifted from using vocal communication (which carries relatively large amounts of information) to surface-active communication (splashes; carry relatively little information) when low-frequency background noise increased because of increased sea state. Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009). Cetaceans in the Mediterranean Sea are found in areas with lower vessel abundance, suggesting that vessel noise may influence habitat use (Campana et al. 2015).

The northeastern US hosts some of the busiest commercial shipping lanes in the world, including those leading into Boston, Providence, Newark, and New York (MARAD 2011). In addition to vessel traffic, marine construction activities occur in the Cape Cod area (liquefied natural gas terminal construction, pile driving, dredging, cable laying, drilling, and others) that contributes to local and regional background sound levels.

Commercial shipping in the Gulf of Alaska is dominated by cargo transports, container freight, crude oil tankers, and barges. Military vessels, ferries, and other commercial and recreational fishing vessels also converge in the Gulf of Alaska. Two primary shipping lanes radiate from the Gulf of Alaska to Honolulu and San Francisco. Important Alaskan ports include Kodiak, Alaska’s largest commercial fishing port, and Valdez, the southern terminus of the 1,300 km trans-Alaska pipeline.

Several major ports occur further south along the US west coast, including Portland, San Francisco, Los Angeles, Long Beach, and San Diego (DoT 2005). These ports service a wide variety of vessels, including cargo, tug and barges, small ships, liquid bulk, dry bulk, break bulk, intermodal (container, roll-on/roll-off, lighter aboard ship), ferry, tourist passenger vessels (sailboats, ferry, party-boat fishing, whale watching) and cruise ships. Long Beach is among the largest ports in the US, accounting for 6% of the total cargo entering the US, and increasing rapidly (growing 122% between 2003 and 2006) (DoT 2007a; DoT 2007b). Los Angeles is also the fifth-largest cruise ship terminal in the US. A shipping lane runs along the US west coast south to southern California and additional shipping lanes extend westward from San Francisco and near Santa Barbara Island.

In-water construction activities (e.g., pile driving associated with shoreline projects) in both inland and coastal waters in the action areas can produce sound levels sufficient to disturb ESA-listed and proposed species under some conditions. Pressure levels from 190-220 dB re 1 μPa were reported for piles of different sizes in a number of studies (NMFS 2006b). The majority of the sound energy associated with pile driving is in the low frequency range (<1,000 Hertz) (Illingworth and Rodkin Inc. 2001; Illingworth and Rodkin Inc. 2004; Reyff 2003). Dredging operations also have the potential to emit sounds at levels that could disturb individuals of many taxa. Depending on the type of dredge, peak sound pressure levels from 100 to 140 dB re 1 μPa were reported in one study (Clarke et al. 2003). As with pile driving, most of the sound energy associated with dredging is in the low-frequency range, below 1 kiloHertz (Clarke et al. 2003).

Several measures have been adopted to reduce the sound pressure levels associated with in-water construction activities or prevent exposure of marine mammals to sound. For example, a six-inch block of wood placed between the pile and the impact hammer used in combination with a bubble curtain can reduce sound pressure levels by about 20 dB (NMFS 2008d). Alternatively, pile driving with vibratory hammers produces peak pressures that are about 17 dB lower than those generated by impact hammers (Nedwell and Edwards 2002). Other measures used in the action area to reduce the risk of disturbance from these activities include avoidance of in-water construction activities during times of year when marine mammals may be present; monitoring for marine mammals during construction activities; and maintenance of a buffer zone around the project area, within which sound-producing activities would be halted when marine mammals enter the zone (NMFS 2008d).

The input of plastics into the marine environment also constitutes a significant degradation to the marine environment. In 2010, an estimated 4.8-12.7 million metric tons of plastic entered the ocean globally (Baulch and Simmonds 2015). South Korea alone is believed to loss roughly 38,5000 tons of gillnetting per year, which can lead to entanglements of marine mammals (Baulch and Simmonds 2015).

Microplastics were recently discovered in the gut contents of humpback whales; the impact of this and the chemicals these plastics contain is unknown (Besseling et al. 2015), but have the potential to impact the immune system and stress response. Pollutants

Organochlorines, including polychlorinated biphenyl and dichlorodiphenyltrichloroethane, have been identified from humpback whale blubber (Gauthier et al. 1997). Higher polychlorinated biphenyl levels have been observed in whales in western Atlantic waters versus Pacific waters along the US and levels 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 have the highest polychlorinated biphenyl concentrations, overall levels are on par with other baleen whales, which are lower than odontocete cetaceans (Elfes et al. 2010). 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). Huang et al. (2015) theorized that at intermediate levels of contaminants, this biomagnification could act to reduce the survival and/or reproduction of predators, which could increase the abundance of their prey.

5.2 Bycatch and entanglement

Humpback whales are also killed or injured during interactions with commercial fishing gear (Cole and Henry 2013). Humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 are known to have died (Lien 1994; Perkins and Beamish 1979). From 1979-2008, 1,209 whales were recorded entangled, 80% of which were humpback whales (Benjamins et al. 2012). Along the Atlantic coast of the US 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. 2007). Of these, 95 entangled humpback whales were confirmed, with 11 whales known to sustain injuries and at least nine dying of their wounds. The first estimate of population-level effects of entanglement were recently produced, with over 12% of the Gulf of Maine population of humpbacks acquiring new scars from entanglement interactions annually (Mattila and Rowles 2010).

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). Between 30 and 40% of humpback whales in the Arabian Sea show scarring from entanglements, with fishing effort on the rise (Baldwin et al. 2010). Alava et al. (2012) reported that 0.53% 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 US 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). Modeling suggests that 6-50 humpback whales were bycaught in the California drift gillnet fishery from 1990-2009, with up to 21 of these individuals dying (Martin et al. 2015). 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 Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale. In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. From 2001 through 2006, there were 23 reports of entangled humpback whales in Hawaiian waters; 16 of these reports were from 2005 and 2006. Ten humpback whales were found entangled in gill nets or long lines between 1995 and 2002 off Peru (Garcia-Godos et al. 2013).

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 US Navy rescued in 1996 had been entangled in gear that was traced to a recreational fisherman in southeast Alaska. Thus far, 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 2008c). In each instance, however, 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.

5.3 Ship strike

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). Of 123 humpback whales that stranded along the Atlantic coast of the US between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist et al. 2001). From 1975-2011, 68 collisions (not necessarily mortalities) were actually witnessed in the main Hawaiian Islands, 63% 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 and 2005, there were 18 reports of humpback whales being struck by vessels along the Atlantic coast of the US and the Maritime Provinces of Canada (Cole et al. 2005; Nelson et al. 2007). 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 2001-2008 (COSEWIC 2011; Ford et al. 2009). From 2006-2010, 10 instances of mortality stemming from vessel collision were documented (Waring et al. 2013). 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 through 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 has changed the probability of ship strike to large whales (particularly right whales), but data are still being gathered to evaluate the extent of this change to humpback whales (Silber and Bettridge 2012).

On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow et al. 1997). 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). Although data for actual strikes is lacking off Pacific Panama, study of shipping data and satellite tag data on humpback whales showed that 8 of 15 whales tagged came within 200 meters of 81 different ships on 98 occasions in a period of 11 days (Guzman et al. 2013).

5.4 Naval activities

Naval activity, notably sonar use during training exercises, has gained notoriety for its coincidence with marine mammal strandings. However, other activities (also during training exercises in designated naval operating areas and training ranges) also have the potential to harm humpback whales. The action areas overlap several naval training ranges or facilities listed below. Listed whales travel widely through ocean basins and could be exposed to naval activities in several ranges.

- The Southern California Range Complex, where numerous listed whales forage
- The Northwest Training Range Complex, where humpback whales forage
- The Gulf of Alaska Operating Area, where several listed whale species are known to forage
- The Hawaiian Islands Operating Area, where humpback whales regularly breed and give birth
- The Northeast Training Range Complex, where humpback whales forage
- The Virginia Capes, Cherry Point, and Jacksonville-Charleston Operating Areas and the Key West, Gulf of Mexico, Bermuda, and Puerto Rican Complexes have the potential to overlap the range of humpback whales, but presence within these areas is rare or undocumented.

Naval activities to which individuals could be exposed include, among others, vessel and aircraft transects, munition detonations, and sonar use. Responses by marine mammals could include no response, short-term and long-term behavioral responses and changes (altered vocal activity, changes in swimming speed and direction, respiration rates, dive times, and social interactions), temporary or permanent hearing loss, debris ingestion, ship-strike injury, and death.

Although naval vessels represent a small fraction of the total sound energy put into the ocean and are designed to operate quietly, these ships are large and equipped with high-output sonar equipment such as ANISQS-53C tactical sonar, which produces signals at source levels of 235 dB re 1 μPa_{rms} at 1 m. The signals emitted from these devices have the potential to affect humpback whales in the action areas; however, empirical data are limited. No stranding or mortality events have been documented in or around other operating areas or training ranges within the action areas that appear linked to naval sonar. However, an event that occurred in the Strait of Juan de Fuca and Haro Strait on May 5, 2003 demonstrates the potential for naval activities to impact whales that can also hear these frequencies. The US Navy guided missile destroyer *Shoup* passed through the strait operating its mid-frequency sonar during a training exercise. Members of J pod (a family group of southern resident killer whales) were in the strait at the same time and exhibited unusual behaviors coincident with exposure to the sonar, as reported by local researchers (Commander U.S. Pacific Fleet 2003; NMFS 2005; NMFS 2006b). Based on the duration of exposure, the received levels experienced by the whales, and information on sound levels known to cause behavioral reactions in other cetaceans, NMFS concluded J pod was exposed to levels likely to cause behavioral disturbance, but not temporary or permanent hearing loss (NMFS 2005; NMFS 2006b). Underwater detonations are sometimes performed at this site and there was an occasion when J pod was fewer than 1.5 km away when a blast occurred, which caused the whales to suddenly change their direction of travel (NMFS 2006b). In another incident, five beaked whales were discovered stranded or floating dead coincident in time with the Alaska Shield/Northern Edge 2004 exercise between June 17 and 19, 2004 in the Gulf of Alaska operating area. However, no mid-frequency sonar or explosives were used during this exercise and evidence linking the exercise to mortalities is circumstantial, at best.

5.5 Vessel approaches – commercial and private marine mammal watching

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 and strikes the whale. Another concern is that preferred habitats may be abandoned if disturbance levels are too high. In the Notice of Availability of Revised Whale Watch Guidelines for Vessel Operations in the Northeastern United States (64 FR 29270; June 1, 1999), NMFS noted that whale watch vessel operators seek out areas where whales concentrate, which has led to numbers of vessels congregating around groups of whales, increasing the potential for harassment, injury, or even the death of these animals. Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987). Humpback whales may respond in similar ways to the same stressors.

Several studies have specifically examined the effects of whale watching on marine mammals, and investigators have observed a variety of short-term responses from animals, ranging from no apparent response to changes in vocalizations, duration of time spent at the surface, swimming speed, swimming angle or direction, respiration rate, dive time, feeding behavior, and social behavior (NMFS 2006b). Responses appear to be dependent on factors such as vessel proximity, speed, and direction, as well as the number of vessels in the vicinity (Au and Green. 2000; Corkeron 1995; Erbe 2002; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Watkins 1986; Williams et al. 2002a; Williams et al. 2002b).

5.6 Seismic surveys and oil and gas development

Numerous surveys have been conducted in the northwest Atlantic using seismic airguns, and have the potential to affect ESA-listed or proposed species. As a general mitigation measure, airguns are shut down if marine mammals approach too closely, presumably avoiding the potential for temporary or permanent threshold shifts in their hearing. However, some species (such as bowhead whales) appear to be sensitive to seismic, vessel, and industrial sounds and may move rapidly up to several kilometers away from the sound source (Gallagher and Hall. 1993; George 2010; Greene 1982; Richardson et al. 1995a; Richardson et al. 1985a; Richardson et al. 1990; Richardson et al. 2004; Richardson and Williams 2003; Richardson and Williams 2004; Schick and Urban 2000; Streever et al. 2008; Wartzok et al. 1989). Other baleen whales frequently do the same (Malme et al. 1984a; Malme et al. 1985; McCauley et al. 2000; McCauley et al. 1998a; McCauley et al. 1998b; Miller et al. 1999; Stone and Tasker 2006). Noise pollution associated with seismic surveys and oil and gas activities along Brazil overlaps the same sound frequencies used by humpback whales here during their breeding and calving period, potentially interfering with the ability of individuals here to communicate or collect information about their environment (Rossi-Santos 2015).

From 1968-2003, approximately 212,967 line miles of seismic survey data acquisition were collected in the Atlantic region for commercial purposes (MMS 2005). In addition, several academic-based research seismic surveys have been undertaken in the region. During October and November 2003, the National Science Foundation undertook a seismic survey over the mid-Atlantic Ridge. No marine mammals or sea turtles were observed during the cruise, which had airgun operations for six days (Holst 2004). The airgun array discharge size was 8,760 in^3.

Another seismic survey was conducted along North Carolina during September and October 2014. This seismic survey used a 3,300 in^3, 20-airgun array. A monitoring report is not yet available for this cruise and we are unaware of what protected species, if any, were actually impacted by this project, and to what extent.

A seismic survey was undertaken during July and August of 2014 along New Jersey with a 40-airgun source array of 1,400 in^3. However, because of several issues, the cruise completed only a small amount of its effort. Airguns were operational at some level for a total of 61 hours (Ingram et al. 2014). A humpback whale was sighted while airguns were off. As the seismic survey could not be completed in 2014, it resumed June through August 2015, but with a reduced source array of 700 in^3. No information is available regarding the impacts of the 2015 seismic survey.

During August and September 2014, and again at the time of this writing, the US Geological Survey funded a seismic survey along the US eastern seaboard from roughly Massachusetts to South Carolina. The 6,600 in^3, 40-airgun array was operational for 357 hours in 2014. No information is available on the impacts from the 2015 component, but humpback whales were not seen in during the 2014 cruise.

On May 13, 2013, NMFS completed programmatic consultation on Bureau of Ocean Energy Management-authorized geological and geophysical activities in the Mid- and South Atlantic Planning Areas from 2013 to 2020 (NMFS 2013). The biological opinion estimated, using NMFS's 180 dB criterion for "level A harassment," 38 instances in which a humpback whale would be "taken" in the form of harassment by all active sound sources associated with the seismic and high resolution geophysical survey activities from 2013-2020. All of these takes were expected to stem from airgun activities. Under another set of criteria using information that better reflects current understanding of humpback whale hearing (Southall et al. 2007), 17 instances of humpback whale "takes" from airgun surveys were expected between 2013 and 2020. In addition, the biological opinion estimated that, using NMFS' 160 dB criterion for "level B harassment," 3,829 humpback whales (all but three from seismic airguns) would be "taken" by all active sound sources associated with the seismic and high resolution geophysical surveys from 2013-2020. Humpback whales would be exposed primarily during the winter months.

5.7 Invasive species

Invasive species have been referred to as one of the top four threats to the world's oceans, consistently ranked just behind habitat degradation and alteration (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). Invasive species, facilitated by human commerce, have the ability to directly alter ecosystems on which listed species rely.

Invasive species are a major threat to many ESA-listed species. For species listed by the USFWS, 26% were listed partially because of the impacts of invasive species, and 7% were listed because invasive species were the major cause of listing (Anttila et al. 1998). Pimentel et al. (2004) found that roughly 40% of ESA-listed species are at risk of becoming endangered or extinct completely, or in part, because of invasive species, while Wilcove et al. (1998) found this to be 49%, with 27% of invertebrates, 37% of reptiles, 53% of fishes, and 57% of plants imperiled partly or wholly because of non-native invasions. In some regions of the world, up to 80% of species facing extinction are threatened by invasive species (Pimentel et al. 2004; Yan et al. 2002). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the International Union for the Conservation of Nature database; invasive species were the only cited cause in 20% of those cases. Richter et al. (1997) identified invasive species as one of three top threats to threatened and endangered freshwater species in the US as a whole.

5.8 Scientific research and permits

Scientific research permits issued by the NMFS authorize studies of listed species in the Atlantic, Pacific, and Southern Oceans, all of which are a part of the action areas. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, breath sampling, tagging, ultrasound, and exposure to acoustic activities. Research activities involve non-lethal “takes” of these whales by harassment, with none authorized to result in mortality. Tables 3 through 5 show the number of takes authorized for humpback whales in the action area in scientific research permits.

Table 3. Humpback whale takes in the Southern Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Acoustic playback
2009	2,074	140	163	25	0
2010	1,979	150	173	15	0
2011	1,979	50	163	5	0
2012	869	50	163	5	0
2013	1,724	200	160	5	0
2014	2,150	450	160	5	50
2015	2,150	450	160	5	50
2016	1,000	300	10	5	50
Total	**13,925**	**1,790**	**1,152**	**70**	**150**

Permit numbers: *774-1714, 782-1719, 808-1735, 1058-1733, 14809, 14097, and 14856.*

Table 4. Humpback whale takes in the Pacific Ocean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Belt tagging	Acoustic playback	Exhalation sampling	Ultrasound
2009	44,399	4,640	357	67	0	280	10	5
2010	67,171	6,060	1,447	237	0	970	10	5
2011	84,191	6,700	6,755	1,590	0	690	1,070	5
2012	64,353	7,125	6,845	1,710	125	1,120	1,260	5
2013	59,483	7,375	7,210	1,735	125	1,820	1,250	0
2014	61,619	6,665	7,197	1,735	125	230	1,250	0
2015	60,809	7,365	7,197	1,735	125	180	1,250	0
2016	34,388	5,835	5,757	1,595	125	100	1,250	0
Total	**476,413**	**51,765**	**42,765**	**10,404**	**625**	**5,390**	**7,350**	**20**

Permit numbers: *393-1772, 473-1700, 532-1822, 540-1811, 545-1761, 587-1767, 0662-1661, 0642-1536, 716-1705, 727-1915, 731-1774, 774-1714, 781-1824, 782-1719, 945-1776, 965-1821, 1000-1617, 1120-1898, 1029-1675, 1049-1718, 1071-1770, 1120-1898, 1127-1921, 10018, 13846, 14097, 14118, 14122, 14245, 14296, 14353, 14451, 14534, 14585, 14599, 14682, 14610, 14809, 15240, 15271, 15330, 15569, 15750, 15844, 16111, 16160, 16163, 16239, 16388, 16479, 16919, 17312, and 17845.*

Table 5. Humpback whale takes in the North Atlantic Ocean and Mediterranean Sea.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Belt tag	Exhalation sampling	Acoustic playback
2009	5,260	415	173	45	0	0	624
2010	5,568	415	173	45	0	0	600
2011	8,653	1,040	723	95	0	0	600
2012	10,354	1,370	723	95	125	2,410	600
2013	17,555	1,980	1,465	395	125	2,410	600
2014	18,215	2,230	1,490	435	125	2,410	650
2015	17,570	2,230	1,490	435	125	2,410	50
2016	14,085	1,930	1,190	135	125	2,410	50
Total	**97,260**	**11,610**	**7,427**	**1,680**	**625**	**12,050**	**3,774**

Permit numbers: *605-1904, 633-1778, 775-1875, 948-1692, 981-1707, 1036-1744, 1058-1733, 1121-1900, 1128-1922, 10014, 13927, 14118, 14245, 14451, 14586, 14856, 15575, 15682, 16109, 16325, 16388, 16473, and 17355.*

5.9 The impact of the baseline on ESA-listed and proposed species

Listed resources are exposed to a wide variety of past and present state, Federal, or private actions and other human activities that have already occurred, and continue to occur, in the action areas. Federal projects in the action areas that have already undergone formal or early section 7 consultation, and state or private actions that are contemporaneous with this consultation also impact listed resources. However, the impact of those activities on the status, trend, or the demographic processes of proposed, threatened, and endangered species remains largely unknown. To the best of our ability, we summarize the effects we can determine based on the information available to us.

Acoustic effects from anthropogenic sources, whether they are vessel noise, seismic sound, military activities, oil and gas activities, or wind turbine construction and operation, could have biologically significant impacts to humpback whales in the action areas. These activities increase background noise levels in the marine environment, making communication more difficult over a variety of ranges. We expect that this increased collective noise also reduces the sensory information that individuals can gather from their environment; an important consideration for species that do so primarily through sound. At closer ranges to some anthropogenic sound sources, behavioral responses also occur, including deflecting off migratory paths and changing vocalization, diving, and swimming patterns. At even higher received sound levels, physiological changes are likely to occur, including temporary or permanent loss of hearing, and potential trauma of other tissues. Although this is a small fraction of the total exposure individuals receive, it is expected to occur in rare instances, such as when individuals are near detonations or very close to sonar sources.

Authorized research on ESA-listed whales can have significant consequences for these species, particularly when viewed in the collective body of work that has been authorized. Researchers have noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Responses were different depending on the age, life stage, social status of the whales being observed (i.e., males, cows with calves) and context (feeding, migrating, etc.). Beale and Monaghan (2004a) concluded the significance of disturbance was a function of the distance of humans to the animals, the number of humans making the close approach, and the frequency of the approaches. These results suggest the cumulative effects of the various human activities in the action areas would be greater than the effects of the individual activity. This is discussed more fully in the *Effects of the Action on ESA-Listed and Proposed Species and Critical Habitat* section.

6 Effects of the Action on ESA-Listed and Proposed 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 *Overview of NMFS' Assessment Framework*, this opinion includes both a jeopardy analysis and an adverse modification analysis.

The jeopardy analysis relies on 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.

6.1 Stressors associated with the proposed action

The assessment for this consultation identified several possible stressors associated with the proposed research activities, including;

- Close approach and pursuit via vessel
- Application of telemetry tags
- Continued attachment of tags

- Exposure to acoustic transmissions from tags and echosounders

Based on a review of available information, this opinion determined which of these possible stressors would be likely to occur, and which would be discountable or insignificant. We expect that all of these potential stressors could have meaningful biological effects on humpback whales. Accordingly, this consultation focused on all of these stressors.

6.2 Mitigation to minimize or avoid exposure

Under permit 14809-02, observers select an animal for tagging and monitor this animal before tag attachment to test for any effects of tagging. The research vessel approaches slowly, typically from behind, and to one side of the animal, and moves into a position to allow attachment of the tag. When close to marine mammals, vessel operators move slowly and deliberately, but do not physically contact the listed marine mammals. To prevent duplicative tagging, a dedicated photographer photographs all animals exposed to tagging attempts. Adult females with calves, or individuals believed to be less than one year old are not targeted for tagging. Vessels are 5-10 meters long with outboard motors using consistent speeds and avoidance of sudden changes in speed or direction unless where necessary. Tagging materials are also sterilized and/or disinfected before use. Approach vessels used under permit 14856-04 operate under the same conditions.

6.3 Exposure and response analysis

As discussed in the *Overview of NMFS' Assessment Framework* section, response analyses determine how listed or proposed resources are likely to respond after exposure to an action's effects on the environment or directly on species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (physiological), or behavioral responses that might result in reducing the fitness of listed or proposed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

There is mounting evidence that wild animals respond to human disturbance in the same way that they respond to predators (Beale and Monaghan 2004b; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Lima 1998; Romero 2004). These responses manifest themselves as stress responses (in which an animal perceives human activity as a potential threat and undergoes physiological changes to prepare for a flight or fight response), interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combinations of these responses (Frid and Dill 2002; Romero 2004; Sapolsky et al. 2000b; Walker et al. 2005). These responses have been associated with abandonment of sites (Sutherland and Crockford 1993), reduced reproductive success (Giese 1996; Mullner et al. 2004), and the death of individual animals (Bearzi 2000; Daan 1996; Feare 1976). Stress is an adaptive response and does not normally place an animal at risk. However, distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Atkinson et al. 2015; Busch and Hayward 2009). These hormones subsequently can cause short-term weight loss, the release of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, fatigue, cardiovascular damage, and alertness, and other responses (Aguilera and Rabadan-Diehl 2000; Busch and Hayward 2009; Dierauf and Gulland 2001; Guyton and Hall 2000; NMFS 2006a; Omsjoe et al. 2009a; Queisser and Schupp 2012; Romero 2004), particularly over long periods of continued stress (Desantis et al. 2013; Sapolsky et al. 2000a). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer 2008). In highly-stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan and Curry 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Mammalian stress levels can vary by age, sex, season, and health status (Cockrem 2013; Delehanty and Boonstra 2012; Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Place and Kenagy 2000; Romero et al. 2008; St. Aubin et al. 1996). Marine mammal hormones associated with stress responses, as well as other body systems, may become imbalanced because of exposure to chlorinated hydrocarbons (Brouwer et al. 1989; Jin et al. 2015). In general, stress response pathways appear to be very similar to those in better-studied terrestrial mammal systems, although important difference in the renin-angiotensin-aldosterone system and catecholamines exist likely stemming from fasting and diving life history traits in many marine mammals (Atkinson et al. 2015). Smaller mammals react more strongly to stress than larger mammals (Peters 1983); a trend reflected in data from Gauthier and Sears (1999) where smaller whale species reacted more frequently to biopsy than larger whales. Stress is lower in immature right whales than adults and mammals with poor diets or undergoing dietary change and have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Several studies have suggested that stress can adversely impact female reproduction through alterations in the estrus cycle (Herrenkohl and Politch 1979; Moberg 1991; Mourlon et al. 2011; Rivier 1991). This is likely due to changes in sex steroids and growth hormone levels associated with the stress response (Sapolsky et al. 2000a). Komesaroff et al. (1998) found that estrus may inhibit the stress response to some extent, although several studies suggest estrus and the follicular stage may be susceptible to stress-induced disruption (see River (1991) and Moberg (1991) for reviews). Most of these studies were conducted with single or multiple invasive methodologies or chronic stress; we do not expect stressors associated with the proposed research to be nearly as stressful. Under less invasive and acutely stressful methods (but more invasive than those proposed by the applicant), Omsjoe et al. (2009b) found no impacts to the percentage of individuals with offspring the year following chase, capture, and restraint of reindeer (ungulates in general are prone to strong, potentially lethal stress responses). Overall, we do not expect reproduction to be impaired, primarily because of the applicants will not be using methods remotely as impactful as those presented in studies here to induce adverse reproductive impacts.

6.3.1 Implantable tags

Although external transmitting devices have been used by many researchers, few studies have examined the possible effects of these devices (Culik et al. 1994; Hawkins 2004a; Murray and Fuller 2000; White and Garrot 1990; Wilson and McMahon 2006). Godfrey and Bryne (2003) found that only 4.5% of scientific papers reporting on radio tracking of mammals assessed the effects of tags on subjects, but 61% of the studies that did investigate impacts found substantial tagging effects. Murray and Fuller (2000) surveyed a sample of articles in which vertebrates had been marked, covering nine journals that publish studies on a broad range of taxonomic groups, and found that in most instances (90% of 238 articles surveyed), the articles did not address potential effects of marking, or at least did not report that such effects had been considered.

However, attaching a device has the potential to generate physiological and behavioral effects to the extent that (even in large mammals), pain, distress, and reduced survival and reproduction can occur, depending on factors such as device weight, shape, and attachment location (Hawkins 2004a; Walker et al. 2012; White and Garrot 1990). To date, reproductive or growth effects have not been found in marine mammals. Mortality has been found in a few cases (surgically-placed abdominal devices; not the tags or procedures proposed for use here), although fairly little effort has been devoted to studying these effects compared to the amount of effort to place tags on marine mammals (Walker et al. 2012). No studies to date have investigated reproductive or growth effects of internal tagging such as in the proposed action for permit 14809-02 (Walker et al. 2012). Effects of attached devices may range from subtle, short-term behavioral responses to long-term changes that affect survival and reproduction; attached devices may also cause effects not detectable in observed behaviors, such as increased energy expenditure by the tagged animal (White and Garrot 1990; Wilson and McMahon 2006). Walker and Boveng (1995) concluded the effects of devices on animal behavior are expected to be greatest when the device-to-body size ratio is large. Although the weight and size of the device may be of less concern for larger animals such as cetaceans, there is still the potential for significant effects; for example, behavioral effects that may cause reduced biological performance, during critical periods such as lactation (Walker and Boveng 1995; White and Garrot 1990).

Once target individuals are approached under permit 14809-02, researchers propose to place devices in some whales to track movements and dive data. Implantable tags can cause behavioral responses similar to close approach as well as wounds, bruising, swelling, and hydrodynamic drag. Humpback whales are one of the least apparently responsive baleen whales to tagging, with 37 of 122 humpback whales tagged exhibiting a response to tagging (Mate et al. 2007) . Available data regarding the effects of tagging is almost exclusively focused on short-term effects, as few studies have attempted to follow up on tagged individuals weeks, months, or years after tagging. However, some opportunistic resightings have been documented; results are presented when available.

Physiological risks to whales from tagging include swelling, inflammation, or infection of the tag site. Although concerns about the potential to strike an animal in sensitive areas, such as the eyes or blowhole, have been raised in previous studies (Whitehead et al. 1990), permit conditions here are designed to prevent such occurrences. To reduce localized infection risks, the parts of the tags that would be inserted into whales would be constructed of stainless steel, and thoroughly disinfected before attachment. Most infections in wildlife resulting from invasive tagging stem from the skin (Hawkins 2004b; Mate et al. 2007). Invasive components are designed to reduce the potential for skin intrusion into the wound at time of tagging (Mate et al. 2007). Although a wide variety of implantable tags have been used over the past several decades, review of available data support tags to produce a similar, small variety of wound patterns in North Atlantic right and humpback whales: white scar, white scar and divot, a divot and cyamids (whale lice), localized swelling, and regional swelling (up to 90 centimeters across and persisting for years), although roughly one in eight individuals showed no wound pattern (Kraus et al. 2000; Mate et al. 2007; Quinn et al. 2000; Weller 2008). Follow-up monitoring shows local and regional swelling frequently occurs around the tag site following implantation in humpback and North Atlantic right whales (Mate et al. 2007). Southern right whales appeared to lack swelling around implantable tags, but divots were frequently seen after tag rejection on individuals resighted more than one year post tagging (Best and Mate. 2007). Divots are theorized to result from fat cells being ruptured on tag entry (Mate et al. 2007). The physiological consequences of such responses remain unstudied, but a general response of glucocorticoid secretion and lymphocyte suppression is known to occur in whales entangled in fishing gear (Cole et al. 2006). Seaweed became entangled with a harbor porpoises' dorsal fin tag and had to be removed when an infection became apparent (Geertsen et al. 2004). Because of the streamlined design of the tags to be used, we do not expect tag entanglement to be an issue for humpback whales tagged under permit 14809-02.

Expert reviewers in a workshop summarized by Kraus et al. (2000) looked at and ultimately were not concerned by the consequences of divots, cyamids, or scars. However, workshop participants looked at swelling and determined it to be due either to hematoma, abscess, or an active inflammatory response to a foreign body or agent (such as bacteria), rupture through the subdermal sheath, foreign body granuloma, or benign tumor. Several reviewers had serious concerns for the potential of tags penetrating into the muscle layer, potentially introducing serious infections into muscle and expanding the infection because of shear forces at the muscle-blubber interface (Kraus et al. 2000; Quinn et al. 2000; Weller 2008). The extensive resighting history of North Atlantic right whales permits some analysis of tagging effects and, ultimately, survival rates of tagged versus untagged individuals is not discernibly different (Mate et al. 2007). Resightings from other species, although not as extensive, has also failed to support long-term effects at the individual level (Best and Mate. 2007; Mate et al. 2007). Only two studies of a wound after tagging exist. One was based on a gray whale that died after stranding dead 18 days post-tagging; although the animal was decomposed, investigators found no evidence of infection at the tag site or other findings that suggested the tag/tagging process resulted in the animal's death (Weller 2008). The other study was of a North Atlantic right whale that had a deep-penetrating sedation dart shot into it. Post mortem examination revealed extensive muscle tissue damage, likely because of the aforementioned shear forces between the blubber (which likely anchored the dart) and muscle (which, being less dense, was "shredded" by the dart tip) (McLellan 2011). Studies of odontocetes along Hawaii show that tag sites become inflamed within days of attachment, but do not appear to become infected (Hanson et al. 2009). Tissues appeared to break down around the attachment site as the tags migrated out of the body (Hanson et al. 2009). Once expelled, wound sites appeared to heal completely, with some individuals showing raised or depressed marks at the tagging location (Hanson et al. 2009). Sperm whales tagged and resighted in the Gulf of California did not show signs of emaciation, but did occasionally show inflammation or tissue extrusions when resighted with tags still present (Hayslip et al. 2009). After expulsion, tagging sites showed devoted, reconstituted tissue (Hayslip et al. 2009).

Keeping implanted tags stable promotes healing, as new epithelial cells and scar tissue form around the foreign body to wall it off (Mate et al. 2007). Researchers expect that the presence of recurved barbs on the cylinder housing should enable the tag to remain embedded for longer periods of time and be more stable in the body. However, over time, the tag would be rejected by the body and migrate out of the blubber because of possible infection, reaction to a foreign body, irritation from motion from body flexing, as well as mechanical stress from hydrodynamic drag on the external components of the tag (Watkins et al. 1981). Southern right whales tagged with implantable tags designed to be retained for long periods were found to retain tags for 27 months, but have been expelled by 36 months (Best et al. 2015). Implantation sites were found to have healed within two years (Best et al. 2015). No difference in pregnancy rates in tagged versus untagged females was found (Best et al. 2015). The tags to be used under permit 14809-02 are not designed to be retained for this long and we expect they will be expelled within a few months. Experimental evaluation of a short-term implantable tag anchor showed that the anchor left the body of humpback whales in the Gulf of Maine after a few days, which was followed shortly thereafter by complete healing (Baumgartner et al. 2015) (Figure 2). Only one of five tagging events produced a noticeable behavioral response (a tail flick).

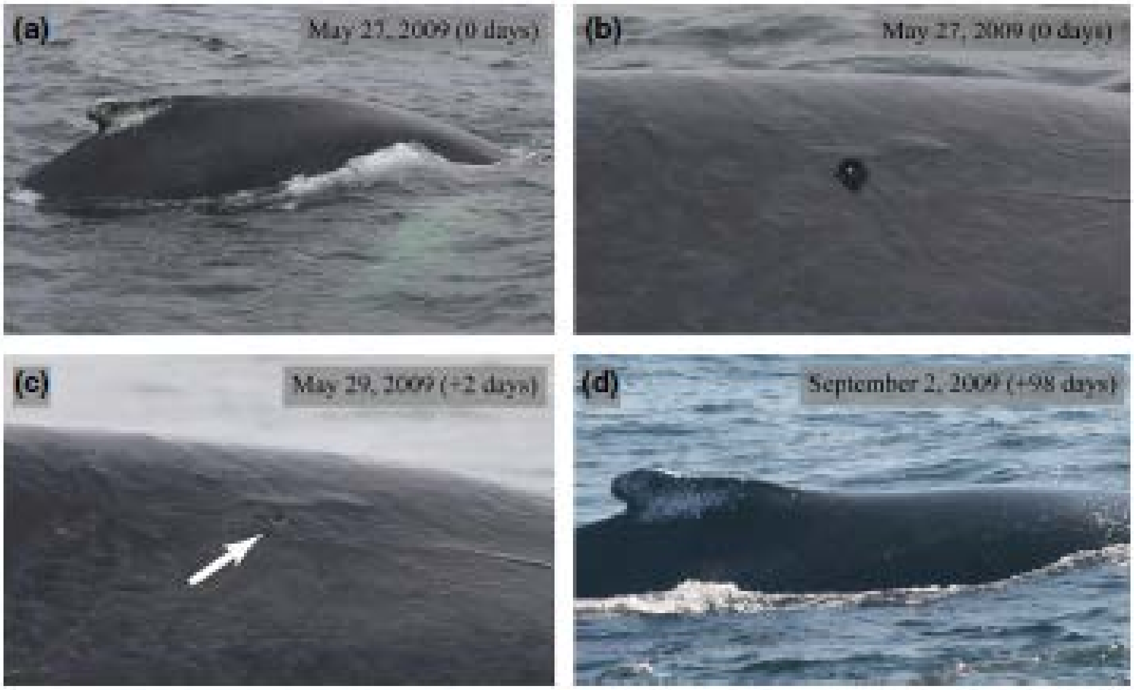

Figure 2. Dermal implantable tag migration out of a humpback whale and subsequent healing.

Apart from pathological effects, tagged marine mammals can also experience physiological effects, particularly from impaired hydrodynamics. Tags should be designed to reduce the drag experienced by the individual carrying the tag (Hawkins 2004b; Hooker et al. 2007). For example, Walker and Boveng (1995) found that average foraging-trip and nursing-visit durations were significantly greater for seals carrying time-depth recorders and radio transmitters than for seals carrying radio transmitters only. A spotted dolphin fitted with a bulky satellite transmitter was recaptured eight days after tagging in poor body condition, presumably because of the large drag effects the tag created (Scott et al. 1990). A harbor porpoise consistently lost weight after having an implantable tag attached for several weeks (although the authors attributed this to a normal, seasonal blubber change) (Geertsen et al. 2004). Harbor porpoises carrying two tags, versus those carrying one, were found to dive to deeper depths on average (i.e., larger tag packages with potentially more drag), but did not differ in other behavioral factors studied (Berga et al. 2015). Bottlenose dolphins did not exhibit metabolic costs when wearing a tag, versus without, but did swim 11% slower when wearing the tags (Van Der Hoop et al. 2014). However, the tag designs under the proposed action minimize drag so as to increase attachment duration. Drag would be considered minute when compared to that inherent to most target species, even as calves, because of the large drag individuals experience as a consequence of their large body size. The additional energy expenditure, even when considered over the course of a year, would be small in comparison to the drag created by such large animals in a viscous medium. This is supported by data from Best and Mate (2007), who found that six out of seven female southern right whales birthed in their routine intervals (similar to the rate of detection of untagged individuals; (Best et al. 2005)). In addition, dorsal fin tag models tested under various configurations and angles were found to have a less than 4% drag coefficient, meaning the amount of energy needed to be expended with a dorsal fin tag (larger compared to body size versus those on large whales and, hence, greater impact) was not much more than without the tag (Pavlov and Rashad 2012). Biofouling coatings may be necessary to prevent long-term tags from becoming coated in growth and increasing drag (Wells et al. 2013) (Figure 3). Additional concerns exist on the ability of tissue surrounding implantable barbs to continue to be effectively perfused with blood, potentially leading to compromised thermoregulation or tissue degeneration. However, thermal imaging has not found this to be the case (Andrews et al. 2014).

Figure 3. Implantable satellite tags with biofouling preventive coating (right) and no coating (left) (Wells 2013).

Use of behavior as an indicator of a whale's response to tagging may or may not accurately reflect the whale's experience, and we cannot definitively know whether such behavioral responses have long-term consequences. Responses to human disturbances, such as tagging, may manifest as stress responses, interruptions of essential behavioral or physiological events, alteration of an animal's time budget, or some combination of these responses. Weinrich et al. (1992) associated "moderate" responses with alarm reactions and "strong" behavioral reactions with stress responses. Wild harbor porpoises restrained and tagged did not show consistent elevations in cortisol nor did heart rate change in ways consistent with a stress reaction (Eskesen et al. 2009); these actions were much more invasive that those proposed. Moderate responses might also be associated with a stress response, given that certain behavioral responses may have metabolic consequences. As a result, we assume the proposed tagging could be stressful for a significant portion of the whales; however, the significance of this stress response and its consequences, if any, on the fitness of individual whales are not definitively known. However, the limited information available from Erickson (1978) indicates that for a more invasive radio package attachment on the dorsal fin, the blood parameters of killer whales showed no significant change. Recognizing the evidence indicating that behavioral responses would be short-lived, we provisionally assume the tagging activities produce short-lived stress responses in some individuals.

Short-term, behavioral effects are also documented for humpback whales. General whale responses include no response at all, skin twitching, startle reactions or flinching, altered swimming speed and orientation, diving, rolling, head lifts, high back arching, fluking, and tail swishing (Goodyear 1981; Goodyear 1993b; Hooker et al. 2001; Mate et al. 1997; Watkins 1981b; Watkins et al. 1984). Mate et al. (1998) found humpback whales to not respond to satellite tagging at all. Humpback whales responded to shallow implantable tags by turning away from the tagging vessel and undertaking short dives, and increasing their swimming speed (Goodyear 1993b). Watkins (1981a) found humpback whales in the North Atlantic to respond to tagging with startle reactions, increased swimming speed, or with no reaction at all; all responding individuals returned to baseline behavior within 15 minutes. A humpback whale was found to resume singing within 13 minutes of tagging in another case (Mate et al. 2007). “Strong” reactions were found in only 3.3-5.6% of humpbacks tagged (Weinrich et al. 1991; Weinrich et al. 1992b). Alves et al. (2005) found increased respiration rate, longer dives, and tail splashes (80% of trials) in response to implantable tagging. Humpback reactions can also occur to misses, possibly because of splashes in the water (Brown et al. 1994; Watkins 1981b). Baseline behavior appears to resume within minutes. Responses to tagging may be difficult to discern from responses to close approaches. In two studies of humpback whales off Hawaii and Alaska, no additional responses were found to approach and tagging versus approach alone (Mate et al. 1991; Watkins 1981b). Ultimately, humpback whale survival does not appear altered by invasive tagging; seven individuals tagged in Alaska 20-30 years ago have been reidentified in recent years also in Alaska (Mizroch et al. 2008). Humpback calves responded to tagging in various behavioral ways, including delayed surfacing, fast dive, small tail flick, or slow evasive swimming, but returned to baseline behavior with a few minutes (Stimpert et al. 2013).

Permit amendment 14809-02 will allow for up to 30 adult or juvenile humpback whales to be tagged with these devices per year in the Southern Ocean and up to 50 in the Atlantic Ocean. Based on the tagging response rate in **.** of 30.3%, we expect roughly 9 Southern Ocean and 15 North Atlantic humpback whales will respond to tagging attempts under permit amendment 14809-02 annually, or 36 and 60 over the remaining four-year life of the permit. If the proposed DPS listing structure proposed by NMFS comes into effect, this would mean that only the ESA-listed DPS that could be affected by the action would be the Azores DPS. To date, the applicant has not conducted research in this area, although the permit would allow work in this area. As such, we do not expect takes would occur to any proposed ESA-listed DPS, but up to 60 in the Azores DPS could reasonably be expected to .

Responses would include low to moderate responses such as skin twitching, startle reactions or flinching, altered swimming speed and orientation, diving, rolling, head lifts, high back arching, fluking, and tail swishing. A short-term (days to weeks), temporary localized swelling and an immune response are also expected.

6.3.2 Close approaches-surface vessel

Vessel approaches to be authorized under permit 14856-04 have the potential to induce behavioral and physiological changes in targeted individuals. The degree to which individuals are disturbed is variable. Whales may respond differently depending on what behavior the individual or pod is engaged in before the vessel approaches (Hooker et al. 2001; Wursig et al. 1998), the degree to which they have become accustomed to vessel traffic (Richter et al. 2006), and between species or individuals (Gauthier and Sears 1999). Overall, reactions include little to no observable change in behavior to momentary changes in swimming speed, pattern, orientation, diving and time spent submerged, foraging, respiratory patterns, and may include aerial displays like breaching and lob tailing (Baker and Herman. 1989; Best et al. 2005; Brown et al. 1991; Clapham and Mattila 1993; Jahoda et al. 2003). 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, in spite of the fact that Gauthier and Sears (1999) found fin whales to be less responsive than humpbacks.

Humpback whales have been the best-studied whale species in regards to responses to close approaches by vessels. Numerous studies have documented varied responses of humpback whales to vessel approaches, ranging from no response to evasion (Goodyear 1993a; Salden 1993). 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).In response to vessel approach, Felix et al. (2001) found that 27 of 86 individuals approached engaged in behavior that 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. 1983c; Baker et al. 1982; Dunlop et al. 2009; Holt et al. 2009). Goodyear (1993a) did not observe changes in behavior because of vessel approaches in most cases, although an increase in speed did occur on one occasion when a whale was approached to within 10 meters. Cantor et al. (2010) found resting or socializing whales to switch to traveling on 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, and moving away from the vessel with strong fluke motions. Baker and Herman (1989), Baker et al. (1983a; 1983c; 1982), Bauer (1986b), Bauer and Herman (1986b), and Green and Green (1990) found that humpbacks spent less time at the surface and altered their direction of travel in response to approaching vessels. 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, possibly because of physical ocean features in the area that likely altered sound properties such that vessel noise was difficult to detect except at close range, resulting in whales suddenly becoming aware of boats nearby and reacting strongly as a result. Norris (1994) documented changes in humpback song structure in response to passing vessels, with unit and phrase durations reduced versus control periods.

Bauer and Herman (1986a) studied the potential consequences of vessel disturbance on humpback whales wintering off Hawaii. They as well as Scheidat et al. (2004) and Hemphill et al. (2006) noted changes in respiration, diving, swimming speed (50-300%) and direction, social exchanges, and other behavioral changes correlated with the number, speed, direction, and proximity of vessels. Agonistic behavior has also been noted (Bauer and Herman 1986a). Results of vessel approach were different depending on individual sex and age class (smaller groups and groups with calves appeared more responsive), but humpback whales tried to avoid vessels beginning at 500 to 1,000 meters away. Similar results were found in Alaskan waters, with increased dive durations and orientation away from the path of moving boats, often at ranges up to 3-4 kilometers (Baker et al. 1983b; Baker and Herman. 1989). 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 distance.

Responses can also change over long timeframes; Watkins (1986) looked at whale responses off Cape Cod over a several decade period and found that humpbacks shifted their response from being evasive to a tendency to approach vessels. Mizroch et al. (2010) followed-up on several humpback whales that were approached and radio tagged over the course of several decades. They found no basis for substantiating a long-term reaction to approach, including gross measures of growth and reproduction.

Information on contextual responses is also relatively abundant for humpback whales. Responses by humpback whales likely depend on 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 from vessel maneuvering (Watkins 1981a). 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). Weinrich et al. (1991) and (1992b), Cantor et al. (2010), as well as Krieger and Wing (1984) found feeding animals to be least responsive, although data from these studies was contradictory when evaluating responses while resting or on breeding grounds. The Weinrich studies also found that respiratory parameters are not good indicators of responsiveness due to the large natural variance associated with them. However, numerous studies have identified significant changes in respiration and diving in association with vessel traffic (see Bauer and Herman (1986a) for a summary). 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 1986a). Würsig et al. (1998) found milling or resting cetaceans to be more sensitive.

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 on re-exposure. However, 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 to 1978, whereas humpback whales in other nearby areas with less traffic did not undergo such changes (Bauer and Herman 1986a). It should be noted that potentially reduced prey resources may also have been important in this redistribution (Bauer and Herman 1986a). Matkin and Matkin (1981) did not find a correlation between humpback whale behavior and recreational vessels.

The close approach of vessels also presents the possibility that valuable acoustic information could be missed by the target individual(s) due to masking by the vessel's engines. The acoustic properties of vessels likely to be used by the applicant are similar to the frequency range used by target marine mammals during vocalization such that communication could be impaired (Clark et al. 2009; Dunlop et al. 2010a). Parks et al. (2010) and Anonymous (2010) found that North Atlantic right whales temporarily modify the amplitude of their calls, making them louder with increased background noise (including noise from vessel traffic), as well as shifting call frequency over longer time frames. Killer whales in high traffic areas have been found to increase call duration or call amplitude in response to increased anthropogenic noise in the marine environment (Erbe 2002; Foote et al. 2004; Holt et al. 2011; Holt et al. 2009). As a broader issue, increased anthropogenic noise in the marine environment has the potential to reduce the range over which individuals communicate, conceivably increasing calf mortality, altering ideal group or individual spacing, and making identification and selection of mates more difficult or impossible (Croll et al. 2001). The applicants use one vessel per survey, and we do not anticipate masking will occur for several reasons:

- Operations will be conducted at low speed with a minimum of throttling and directional changes.
- Low vessel speed means that less cavitation will occur, which is the primary source of sound energy emitted by motorized vessels (Mazzuca et al. 2001; Ross 1976).
- Lower speed and fewer directional changes will also result in fewer changes in sound characteristics, which are believed to add to the significance of vessel noise and its impact to cetaceans.
- Most interactions with target individuals should be brief before the vessel breaks contact following photoidentification, acoustic recording, tagging, exhalation sampling, and/or behavioral documentation.

Permit amendment 14856-04 will not authorize any additional effort or activities on the part of the applicant. It will, however, authorize additional take via close approach not previously documented by the applicant. Although the practical effect of the action on ESA-listed species will not change, NMFS' accounting for this effect at the level of "take" will. Also, the applicant will be permitted to take an individual six times a day, an increase from the three a day allowance in the current permit.

We expect most humpback 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. Available evidence, including approaches of individuals of other species in a variety of locations, leads us to conclude there should be few strong behavioral responses to close approaches. Based on the available literature and anticipated levels of future exposure, one to a few dozen humpback whales annually may also respond with low-to moderate-level behavioral responses described above. It is also possible a subset of individuals exposed will undergo a stress response (particularly those that show moderate to strong behavioral responses, but also some which show little or no behavioral response).

6.4 Risk analysis

The *Response analysis* found that responses by whales to these activities are such that a majority of targeted individuals are not expected to show an overt response. We do expect all individuals to at least be aware of approach and tagging attempts and undergo a low-level stress reaction because of these activities. Some individuals are expected to respond behaviorally. Information available to us does not support behavioral responses by an individual being more severe (as opposed to more frequent) when additional activities (such as biopsy already authorized under permit 14856-03) are added to approach or tagging, although we do expect more frequent responses to the combined activities versus approach or tagging alone.

6.4.1 Implantable tags

Implantable tags have the potential to introduce pathogenic agents into the blubber and muscle of targeted individuals. This concern has been addressed to some extent by several reviews presented in Section 6.3.1, but conclusive evidence for or against the potential for infection is lacking (Best and Mate. 2007; Kraus et al. 2000; Mate et al. 2007; Weller 2008). At present, available evidence from a single animal of advanced decomposition, a single observation of a deceased North Atlantic right whale and numerous observations of live whales does not suggest regular occurrence of debilitating infection or muscle damage caused by implantable tags (McLellan 2011; Weller 2008). This is further supported by the fact that tags proposed for use do not cross the muscle-blubber interface and not result in more severe effects thought to potentially result from such a tag that crosses the blubber-muscle interface. Methods adopted by the applicant under permit amendment 14809-02, including use of disinfectants on tagging materials penetrating target individuals, should lessen the risk of infection (Mate et al. 2007; Weller 2008). We do expect that tagged individuals will exhibit similar inflammatory responses, development of divots, and scar tissue from implantable tags as has been seen in whale species who have been tagged in the past (Best and Mate. 2007; Kraus et al. 2000; Mate et al. 2007; Quinn et al. 2000; Weller 2008). We also expect implantably-tagged individuals to experience increased drag during the days to months that tags will be protruding from the blubber as they migrate out of the body (Best and Mate. 2007). However, we expect the amount of drag to not be significant to target whales, as the tags are small compared to the size of target whales. More severe effects have been found in some odontocete species, such as reduced swimming speed in bottlenose dolphins, and weight loss in harbor porpoises. Considering the relatively much smaller tag size relative to body size in the proposed tagging activities on humpback whales and lack of similar findings in large whales, we do not expect these effects to occur under the proposed actions. As evidenced from the apparent ability of whales to survive and reproduce successfully given potential infection and additional drag (Baumgartner and Hammar 2010; Best and Mate. 2007; Mate et al. 2007), we do not expect these physiological responses to be significant to any individuals' overall metabolic balance or health state given available evidence.

6.4.2 Close approach

Vessel approaches frequently result in behavioral changes in ESA-listed whales, with most approaches resulting in no response or apparently "minor" to "moderate" responses (increasing swim speed and direction, startle reaction, movement away, changes in respiration and diving, agonistic behavior, evasion (Baker et al. 1983b; Baker and Herman. 1989; Bauer and Herman 1986a; Bauer 1986; Clapham and Mattila 1993; Hall 1982; Hemphill et al. 2006; Koski and Johnson 1987; Malme et al. 1983; Malme et al. 1984b; Richardson et al. 1985b; Scheidat et al. 2004)). Strong responses are rarely observed. Cumulative vessel approaches (Bauer and Herman 1986a; Herman 1979) or additive effects of vessel approach and other anthropogenic stressors (Fraker et al. 1982) can have more significant effects, including the displacement of humpback whales from Alaskan foraging areas and displacement of gray whales from habitat (Reeves

1977). The presence of additional anthropogenic stressors, such as commercial vessel traffic, are likely to induce additional disturbance on potential target individuals (Fraker et al. 1982; NMFS 2008a). For humpback whales, the number and severity of responses to research vessel approaches that individuals will experience is negligible, given the incremental increase in stressors individuals, populations, and listed entities as a whole must cope with and does not reduce growth, survival, or reproduction. . Although it is possible that individuals are being displaced from more preferable habitat, we have no evidence to suggest this. On the contrary, Weinrich (2010) found that individuals exposed to extensive whale watching retained high calving rates and positive population trajectories. Coupled with trends suggesting recovery for most target species, the continuation of close approach activities under proposed permit amendment 14809-02 are not expected to measurably hamper survival or recovery of listed species.

6.5 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 areas of the Federal actions 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.

Government and private actions may include changes in land and water use patterns, including ownership and intensity, any of which could affect ESA-listed or proposed species. It is difficult, and perhaps speculative, to analyze the effects of such actions, considering the broad geographic landscape covered by this opinion, the geographic and political variation in the action areas, extensive private land holdings, the uncertainties associated with State and local government and private actions, and ongoing changes in the region's economy. However, State and local governments have regulations in place to reduce these effects to ESA-listed species, including regulations regarding construction best management practices, storm water control, and treatment of wastewater.

6.6 Integration and synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the proposed action. In this section, we add the *Effects of the Action on ESA-Listed Species and Critical Habitat* (Section 6) to the *Environmental Baseline* (Section 5) and the *Cumulative Effects* (Section 6.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: "reduce appreciably the likelihood of both the survival and recovery of a ESA-listed and proposed species in the wild by reducing its numbers, reproduction, or distribution." This assessment is made in full consideration of the *Status of ESA-listed and Proposed Species* (Section 4).

As explained in the *Overview of NMFS' Assessment Framework* 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 ESA-listed or proposed 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 ESA-listed or proposed animals are not likely to experience reductions in their fitness, we conclude our assessment. If possible reductions in individuals' fitness are likely to occur, the assessment considers the risk posed to population(s) to which those individuals belong, and then to the species those population(s) represent.

The following discussions separately summarize the probable risks the proposed actions pose 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.

Overall, we expect all targeted whales to experience some degree of stress response to approach, tagging, and tagging attempts. We also expect a fraction of these individuals to undergo short-term behavioral responses to these activities, varying from twitches to evasion. We do not expect more than temporary displacement of some individuals from small areas because of the proposed actions. Individuals responding in such ways may temporarily cease feeding, breeding, resting, or otherwise disrupt vital activities. However, we do not expect that these disruptions will cause a measureable impact to any individual's growth or reproduction. We expect all implantably-tagged individuals to experience additional physiological reactions associated with foreign body penetration into the blubber and possibly muscle, including inflammation, scar tissue development, and a small amount of drag associated with the applied tags. We do not expect any single individual to experience a fitness consequence because of the proposed actions and, by extension, do not expect population-level effects.

7 CONCLUSION

After reviewing the *Status of ESA-listed and Proposed Species*, the *Environmental Baseline* within the action areas, the *Effects of the Action on ESA-Listed Species and Critical Habitat*, any effects of interrelated and interdependent actions, and Cumulative Effects, it is NMFS' opinion these proposed actions are not likely to jeopardize the continued existence of humpback whales as currently listed or in any proposed threatened or endangered DPS. No critical habitat has been designated or proposed for this species; therefore, none will be affected.

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.

We do not expect incidental take of threatened or endangered species as a result of the proposed actions because all actions that may affect ESA-listed species would be undertaken in a directed manner.

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, to help implement recovery plans or develop information (50 CFR 402.02).

- The Endangered Species Act Interagency Cooperation Division recommends that annual reports submitted to the Permits Division require detail on the response of listed individuals to permitted activities. A minimum of general comments on response can be informative regarding methodological, population, researcher-based responses in future consultations. The number and types of responses observed should be summarized and include responses of both target and non-target individuals. This will greatly aid in analyses of likely impacts of future activities.

In order for the 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 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 for the Permit’s Division proposed issuance of permit amendments 14856-04 and 14809-02. 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

Acevedo-Whitehouse, K., and A. L. J. Duffus. 2009. Effects of environmental change on wildlife health. Philosophical Transactions of the Royal Society of London B Biological Sciences 364(1534):3429-3438.

Aguilera, G., and C. Rabadan-Diehl. 2000. Vasopressinergic regulation of the hypothalamic-pituitary-adrenal axis: Implications for stress adaptation. Regulatory Peptides 2296(1-2):23–29.

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.

Albertson, G. R., and coauthors. 2015. Genetic identification, temporal and mixed-stock analyses of humpback whales (*Megaptera novaeangliae*) in the nearshore waters of western Antarctic Peninsula from 2014. International Whaling Commission, San Diego, California.

Alves, L. C. P. S., and coauthors. 2005. Preliminary results of behavioral responses of humpback whale (*Megaptera novaeangliae*) to satellite tag deployment. Pages 13 *in* Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.

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

Andrew, R. K., B. M. Howe, and J. A. Mercer. 2002. Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. Journal of the Acoustical Society of America 3:65-70.

Andrews, R., and coauthors. 2014. Improving attachments of remotely-deployed dorsal fin-mounted tags: Tissue structure, hydrodynamics, in situ performance, and tagged-animal follow-up. Pages 53 *in* Fifth International Biologging Science Symposium, Strasbourg, France.

Andrews, R. D. 2012. Development of a cetacean tagging best practices guidelines document. Office of Naval Research.

Andriolo, A., P. G. Kinas, M. H. Engel, C. C. Albuquerque Martins, and A. M. Rufino. 2010. Humpback whales within the Brazilian breeding ground: distribution and population size estimate. Endangered Species Research 11(3):233-243.

Angliss, R. P., and A. L. Allen. 2007. Draft Alaska marine mammal stock assessments 2008. National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, Washington.

Angliss, R. P., and K. L. Lodge. 2004. Alaska marine mammal stock assessments, 2003. NOAA Technical Memorandum NMFS-AFSC-144. 230pp.

Angliss, R. P., and R. B. Outlaw. 2005. Alaska marine mammal stock assessments, 2005. U.S. Department of Commerce, NOAA Technical Memorandum NMFSAFSC-161, 250 p.

Angliss, R. P., and R. B. Outlaw. 2007. Alaska Marine Mammal Stock Assessments, 2006. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-168, 244 p.

Anonymous. 2010. Lone whales shout to overcome noise. Marine Pollution Bulletin 60(9):1387.

Anttila, C. K., C. C. Daehler, N. E. Rank, and D. R. Strong. 1998. Greater male fitness of a rare invader (Spartina alterniflora, Poaceae) threatens a common native (Spartina foliosa) with hybridization. American Journal of Botany 85:1597-1601.

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.

Atkinson, A., V. Siegel, E. Pakhomov, and P. Rothery. 2004. Long-term decline in krill stock and increase in salps within the Southern Ocean. Nature 432:100-103.

Atkinson, S., D. Crocker, D. Houser, and K. Mashburn. 2015. Stress physiology in marine mammals: How well do they fit the terrestrial model? Journal of Comparative Physiology B Biochemical, Systemic and Environmental Physiology 185(5):463-486.

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

Baker, C. S. 1985. The behavioral ecology and populations structure of the humpback whale (*Megaptera novaeangliae*) in the central and eastern Pacific. University of Hawaii at Manoa.

Baker, C. S., and L. M. Herman. 1987. Alternative population estimates of humpback whales in Hawaiian waters. Canadian Journal of Zoology 65(11):2818-2821.

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 Marine Mammal Laboratory, Seattle, Washington.

Baker, C. S., L. M. Herman, B. G. Bays, and G. Bauer. 1983b. Impact of vessel traffic on the behavior of humpback whales in Southeast Alaska, 1982. Report for National Marine Fisheries Service, Seattle, WA. 30pgs.

Baker, C. S., L. M. Herman, B. G. Bays, and G. B. Bauer. 1983c. The impact of vessel traffic on the behavior of humpback whales. Fifth Biennial Conference on the Biology of Marine Mammals, 27 November-1 December New England Aquarium Boston MA. p.5.

Baker, C. S., L. M. Herman, B. G. Bays, and W. F. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in Southeast Alaska. (Megaptera novaeangliae). Natl. Mar. Fish. Ser. Contract No. 81-ABC-00114. University of Hawaii, Kewalo Basin Marine Mammal Laboratory, Honolulu, 39 p.

Baker, C. S., and L. M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: Experimental and opportunistic observations. (Megaptera novaeangliae). Tech. Rep. No. NPS-NR-TRS-89-01. 50 pgs. Final report to the National Park Service, Alaska Regional Office, Anchorage, Alaska [Available from the U.S. Dept. Interior, NPS, Alaska Reg. Off., Room 107, 2525 Gambell St., Anchorage, AK 99503.

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.

Balcomb III, K. C., and G. Nichols, Jr. 1982. Humpback whale censuses in the West Indies. Report of the International Whaling Commission 32:401-406.

Baldwin, R., and coauthors. 2010. Arabian Sea humpback whales: Canaries for the northern Indian Ocean? International Whaling Commission Scientific Committee, Agadir, Morocco.

Baracho-Neto, C. G., and coauthors. 2012. Site fidelity and residence times of humpback whales (*Megaptera novaeangliae*) on the Brazilian coast. Journal of the Marine Biological Association of the United Kingdom 92(8):1783-1791.

Baraff, L., and M. T. Weinrich. 1993. Separation of humpback whale mothers and calves on a feeding 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.

Barendse, J., and coauthors. 2010. Migration redefined? Seasonality, movements and group composition of humpback whales *Megaptera novaeangliae* off the west coast of South Africa. African Journal of Marine Science 32(1):1-22.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon, and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, California.

Barlow, J., and coauthors. 2009. Humpback whale abundance in the North Pacific estimated by phographic capture-recapture with bias correction from simulation studies. Pages 25 *in* 18th Biennial Conference on the Biology of Marine Mammals.

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

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

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. 1986b. Effects of vessel traffic on the behavior of humpback whales in Hawaii. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Honolulu, Hawaii.

Baulch, S., and M. P. Simmonds. 2015. An update on research into marine debris and cetaceans. IWC Scientific Committee, San Diego, California.

Baumgartner, M. F., T. Hammar, and J. Robbins. 2015. Development and assessment of a new dermal attachment for short-term tagging studies of baleen whales. Methods in Ecology and Evolution 6(3):289-297.

Baumgartner, M. F., and T. R. Hammar. 2010. Using a new short-term dermal attachment tag to study bowhead whale foraging ecology in the western Beaufort Sea. Pages 114 *in* Alaska Marine Science Symposium, Anchorage, Alaska.

Beale, C. M., and P. Monaghan. 2004a. Behavioural responses to human disturbance: A matter of choice? Animal Behaviour 68(5):1065-1069.

Beale, C. M., and P. Monaghan. 2004b. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

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.

Berga, A. S., A. J. Wright, A. Galatius, S. Sveegaard, and J. Teilmann. 2015. Do larger tag packages alter diving behavior in harbor porpoises? Marine Mammal Science 31(2):756-763.

Besseling, E., and coauthors. 2015. Microplastic in a macro filter feeder: Humpback whale *Megaptera novaeangliae*. Marine Pollution Bulletin 95(1):248-252.

Best, P. B., B. Mate, and B. Lagerquist. 2015. Tag retention, wound healing, and subsequent reproductive history of southern right whales following satellite-tagging. Marine Mammal Science 31(2):520-539.

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):111-114.

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

Blunden, J., and D. S. Arndt. 2013. State of climate in 2013. Bulletin of the American Meteorological Society 95(7):S1-S257.

Boyd, I. L. 2002. Antarctic marine mammals. Pages 30-36 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, California.

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.

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

Brashares, J. S. 2003. Ecological, behavioral, and life-history correlates of mammal extinctions in West Africa. Conservation Biology 17:733-743.

Brouwer, A., P. J. H. Reijnders, and J. H. Koeman. 1989. Polychlorinated biphenyl (PCB)-contaminated fish induces vitamin A and thyroid hormone deficiency in the common seal (*Phoca vitulina*). Aquatic Toxicology 15(1):99-106.

Brown, C. J., and coauthors. 2009. Effects of climate-driven primary production change on marine food webs: implications for fisheries and conservation. Global Change Biology 16(4):1194-1212.

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.-Genetic Ecology of Whales and Dolphins).

Busch, D. S., and L. S. Hayward. 2009. Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. Biological Conservation 142:2844-2853.

Calambokidis, J. 1997. Humpback whales and the California - Costa Rica connection. Whales. Journal of the Oceanic Society Fall 1997:4-10.

Calambokidis, J., and coauthors. 2008a. SPLASH: Structure of populations, levels of abundance, and status of humpback whales in the North Pacific. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington.

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

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. Final Report under contract No. 5ABNF500113. NMFS Southwest Fisheries Science Center; La Jolla, California.

Campana, I., and coauthors. 2015. Cetacean response to summer maritime traffic in the western Mediterranean Sea. Marine Environmental Research 109:1-8.

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.

Cardillo, M. 2003. Biological determinants of extinction risk: Why are smaller species less vulnerable? Animal Conservation 6:63-69.

Cardillo, M., G. M. Mace, K. E. Jones, and J. Bielby. 2005. Multiple causes of high extinction risk in large mammal species. Science 309:1239-1241.

Carretta, J. V., and coauthors. 2008. Draft U.S. Pacific marine mammal stock assessments: 2008. Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-XXX.

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

Carretta, J. V., and coauthors. 2013. U.S. Pacific marine mammal stock assessments: 2012. NMFS, Southwest Fisheries Science Center.

Carvalho, I., C. Brito, M. E. D. Santos, and H. C. Rosenbaum. 2011. The waters of Sao Tome: A calving ground for West African humpback whales? African Journal of Marine Science 33(1):91-97.

Cerchio, S., T. Collins, S. Strindberg, C. Bennett, and H. Rosenbaum. 2010. Humpback whale singing activity off northern Angola: An indication of the migratory cycle, breeding habitat and impact of seismic surveys on singer number in Breeding Stock B1. International Whaling Commission Scientific Committee, Agadir, Morocco.

Cerchio, S., and coauthors. 2013. Satellite tagging of humpback whales off Madagascar reveals long range movements of individuals in the Southwest Indian Ocean during the breeding season. IWC Scientific Committee, Jeju, Korea.

Cheung, W. W. L., and coauthors. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. Global Change Biology 16:24-35.

Clapham, P., and coauthors. 2009. Catches of humpback whales, Megaptera novaeangliae, by the Soviet Union and other nations in the Southern Ocean, 1947–1973. Marine Fisheries Review 71(1):39-43.

Clapham, P. J. 1994. Maturational changes in patterns of association among male and female humpback whales. Journal of Zoology 71:440-443.

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

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 71:440-443.

Clapham, P. J., and coauthors. 2003. Abundance and demographic parameters of humpback whales in the Gulf of Maine, and stock definition relative to the Scotian shelf. Journal of Cetacean Research and Management 5(1):13-22.

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 65:2853-2863.

Clapham, P. J., and C. A. Mayo. 1990. Reproduction of humpback whales (*Megaptera novaeangliae*) observed in the Gulf of Maine. Report of the International Whaling Commission Special Issue 12:171-175.

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. W., and coauthors. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clarke, D., C. Dickerson, and K. Reine. 2003. Characterization of underwater sounds produced by dredges. Third Specialty Conference on Dredging and Dredged Material Disposal, Orlando, Florida.

Clarke, J., and coauthors. 2013. Subarctic cetaceans in the southern Chukchi Sea: Evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149.

Clavero, M., and E. Garcıa-Berthou. 2005. Invasive species are a leading cause of animal extinctions. Trends in Ecology and Evolution 20(3):110.

Cockrem, J. F. 2013. Individual variation in glucocorticoid responses in animals. General and Comparative Endocrinology 181:45–58.

Cole, T., D. Hartley, and M. Garron. 2006. Mortality and serious injury determinations for baleen whale stocks along the eastern seaboard of the United States, 2000-2004. Northeast Fisheries Science Center Reference Document 06-04. 18p.

Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005. Mortality and seriously injury determinations for North Atlantic Ocean large whale stocks 1999-2003. Northeast Fisheries Science Center Reference Document 05-08:U.S. Department of Commerce, NOAA, National Marine Fisheries Service Northeast Fisheries Science Center. Woods Hole, MA. 18p.

Cole, T. V. N., and A. G. Henry. 2013. Serious injury determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2007-2011. NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center.

Commander U.S. Pacific Fleet. 2003. Report on the results of the inquiry into allegations of marine mammal impacts surroundiilg the use of active sonar by USS Shoup (DDG 86) in the Haro Strait on or about 5 May 2003. U.S. Navy.

Constantine, R., and coauthors. 2010. Abundance of humpback whales in Oceania based on fluke photo-identification and DNA profiling. IWC Scientific Committee, Agadir, Morocco.

Constantine, R., and coauthors. 2012. Abundance of humpback whales in Oceania using photo-identification and microsatellite genotyping. Marine Ecology Progress Series 453:249-261.

Conversi, A., S. Piontkovski, and S. Hameed. 2001. Seasonal and interannual dynamics of Calanus finmarchicus in the Gulf of Maine (Northeastern US shelf) with reference to the North Atlantic Oscillation. Deep Sea Research Part Ii: Topical studies in Oceanography 48(1-3)519-530.

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. 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.

Coughran, D., and N. Gales. 2010. An unusual peak in recorded mortalities of humpback whales in Western Australia: Normal stochastic variability or a regional indication of carrying capacity? International Whaling Commission Scientific Committee, Agadir, Morocco.

Cowan, D. E., and B. E. Curry. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical pacific ocean: Research planning. National Marine Fisheries Service, Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-254.

Cowan, D. E., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.

Cowan, D. E., and B. E. Curry. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology 139(1):24-33.

Craig, A. S., L. M. Herman, A. A. Pack, and J. O. Waterman. 2014. Habitat segregation by female humpback whales in Hawaiian waters: Avoidance of males? Behaviour 151(5):613-631.

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

Culik, B. M., R. Bannasch, and R. P. Wilson. 1994. External devices on penguins: how important is shape? Marine Biology 118:353-357.

Cure, C., and coauthors. 2015. Predator sound playbacks reveal strong avoidance responses in a fight strategist baleen whale. Marine Ecology Progress Series 526:267-282.

Curran, M. A. J., T. D. V. Ommen, V. I. Morgan, K. L. Phillips, and A. S. Palmer. 2003. Ice core evidence for Antarctic sea ice decline since the 1950s. Science 302(5648):1203-1206.

Curry, R. G., and M. S. McCartney. 2001. Ocean gyre circulation changes associated with the North Atlantic Oscillation. Journal of Physical Oceanography 31:3374-3400.

Daan, N. 1996. Multispecies assessment issues for the North Sea. Pages 126-133 *in* E.K.Pikitch, D.D.Huppert, and M.P.Sissenwine, editors. American Fisheries Society Symposium 20, Seattle, Washington.

Dalla Rosa, L., E. R. Secchi, Y. G. Maia, A. N. Zerbini, and M. P. Heide-Jørgensen. 2008. Movements of satellite-monitored humpback whales on their feeding ground along the Antarctic Peninsula. Polar Biology 31(7):771-781.

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. Jmba2 - Biodiversity Records-Published Online 3Pgs.

Darling, J. D., and K. Mori. 1993. Recent observations of humpback whales (Megaptera novaeangliae) in Japanese waters, Ogasawara, and Okinawa. Canadian Journal of Zoology 71:325-333.

Darling, J. D., and H. Morowitz. 1986. Census of Hawaiian humpback whales (*Megaptera novaeangliae*) by individual identification. Canadian Journal of Zoology 64(1):105-111.

De Boer, M. N., and T. Willems. 2015. Observation of a humpback whale *Megaptera novaeangliae* with calf in the shallow coastal waters of Suriname. Academic Journal of Suriname 6:492-497.

Delehanty, B., and R. Boonstra. 2012. The benefits of baseline glucocorticoid measurements: Maximal cortisol production under baseline conditions revealed in male Richardson's ground squirrels (*Urocitellus richardsonii*). General and Comparative Endocrinology 178:470–476.

Desantis, L. M., B. Delehanty, J. T. Weir, and R. Boonstra. 2013. Mediating free glucocorticoid levels in the blood of vertebrates: Are corticosteroid-binding proteins always necessary? Functional Ecology 27:107-119.

Dierauf, L., and F. Gulland. 2001. CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton, Florida.

DoT. 2005. Report to congress on the performance of ports and the intermodal system. Department of Transportation Maritime Administration, Washington, D. C.

DoT. 2007a. U.S. public port development expenditure report (FYs 2005 & 2006-2010). Department of Transportation, Maritime Administration, Washington, D. C.

DoT. 2007b. U.S. water transportation statistical snapshot. Department of Transportation, Maritime Administration, Washington, D. C.

Dulau, V., and coauthors. 2014. Satellite tagging in reunion: New insight on the migratory movement of humpback whale within the western Indian Ocean. Pages 140 *in* Twenty Eighth Annual Conference of the European Cetacean Society, Liege, Belgium.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2010a. Your attention please: increasing ambient noise levels elicits a change in communication behaviour in humpback whales (Megaptera novaeangliae). Proceedings of the Royal Society B: Biological Sciences Published online at http://rspb.royalsocietypublishing.org on April 14, 2010.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2010b. Your attention please: increasing ambient noise levels elicits a change in communication behaviour in humpback whales (Megaptera novaeangliae). Proceedings of the Royal Society of London Series B: Biological Sciences in press(in press):in press.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2009. Your attention please: Increasing ambient noise levels elicits a change in communication behaviour in humpback whales (Megaptera novaeangliae). Proceedings of the Royal Society of London Series B Biological Sciences 277(1693):2521-2529.

Edds, P. L., and J. A. F. Macfarlane. 1987. Occurrence and general behavior of balaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. Canadian Journal of Zoology 65(6):1363-1376.

Edwards, M., D. G. Johns, P. Licandro, A. W. G. John, and D. P. Stevens. 2007. Ecological Status Report: results from the CPR survey 2005/2006, Plymouth, UK.

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

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.

Elwen, S. H., and coauthors. 2013. Humpback whales in Namibia 2005-2012: Occurrence, seasonality and a regional comparison of photographic catalogues and scarring rates with Gabon and West South Africa. IWC Scientific Committee, Jeju, Korea.

Erbe, C. 2002. 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.

Erickson, A. W. 1978. Population studies of killer whales (*Orcinus orca*) in the Pacific Northwest: a radio-marking and tracking study of killer whales. Final Report to the U.S. Marine Mammal Commission, Washington, D.C. Contract No. MM5AC012. 34p.

Eskesen, G., and coauthors. 2009. Stress level in wild harbour porpoises (*Phocoena phocoena*) during satellite tagging measured by respiration, heart rate and cortisol. Journal of the Marine Biological Association of the United Kingdom 89(5):885-892.

Feare, C. J. 1976. Desertion and abnormal development in a colony of Sooty Terns infested by virus-infected ticks. Ibis 118:112-115.

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.

Felix, F., S. Caballero, and C. Olavarria. 2009. Genetic diversity and population structure of humpback whales (Megaptera novaeangliae) from Ecuador based on mitochondrial DNA analyses. Update of SC/59/SH11. IWC Scientific Committee.

Findlay, K., and coauthors. 2011. Distribution and abundance of humpback whales, *Megaptera novaeangliae*, off the coast of Mozambique, 2003. Journal of Cetacean Research and Management Special Issue 3:163-174.

Findlay, K. P., and P. B. Best. 1995. Summer incidence of humpback whales on the west coast of South Africa. (Megaptera novaeangliae). South African Journal of Marine Science 15:279-282.

Foote, A. D., R. W. Osborne, and A. R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428(6986):910.

Forcada, J., P. N. Trathan, K. Reid, and E. J. Murphy. 2005. The effects of global climate variability in pup production of Antarctic fur seals. (Arctocephalus gazella). Ecology 86(9):2408-2417.

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

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

Fossette, S., and coauthors. 2014. Humpback whale (*Megaptera novaeangliae*) post breeding dispersal and southward migration in the western Indian Ocean. Journal of Experimental Marine Biology and Ecology 450:6-14.

Fraker, M. A., W. J. Richardson, and B. Wursig. 1982. Disturbance responses of bowheads. Behavior, Disturbance Responses and Feeding of Bowhead Whales Balaena mysticetus in the Beaufort Sea, 1980-81. W. John Richardson (ed.). p.145-248. Unpublished report to BLM, U.S. Dept. Interior, Washington, DC 20240.

Franklin, W., and coauthors. 2014. Photo-identification confirms that humpback whales (*Megaptera novaeangliae*) from eastern Australia migrate past New Zealand but indicates low levels of interchange with breeding grounds of Oceania. Journal of Cetacean Research and Management 14(1):133-140.

Frantzis, A., O. Nikolaou, J. M. Bompar, and A. Cammedda. 2004. Humpback whale (*Megaptera novaeangliae*) occurrence in the Mediterranean Sea. Journal of Cetacean Research and Management 6(1):25-28.

Fraser, W. R., and E. E. Hofmann. 2003. A predator's perspective on causal links between climate change, physical forcing and ecosystem response. Marine Ecology Progress Series 265:1-15.

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110(3):387-399.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1).

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.

Gabriele, C. M., J. M. Straley, and J. L. Neilson. 2007. Age at first calving of female humpback whales in southeastern Alaska. Marine Mammal Science 23(1):226-239.

Gallagher, M. L., and J. D. Hall. 1993. A comparison of the robustness of the Kolmogorov-Smirnov goodness of fit test and the nearest-neighbor analysis to determine changes in patterns of distribution of migrating bowhead (Balaena mysticetus) whales in the presence of industrial activity in Cam. Tenth Biennial Conference on the Biology of Marine Mammals, 11-15 November Galveston TX. p.50.

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

Garcia-Godos, I., K. V. Waerebeek, J. Alfaro-Shigueto, and J. C. Mangel. 2013. Entanglements of large cetaceans in Peru: Few records but high risk. Pacific Science 67(4):523-532.

Gardiner, K. J., and A. J. Hall. 1997. Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). Canadian Journal of Zoology 75(11):1773-1780.

Garrigue, C., and coauthors. 2011a. Movement of individual humpback whales between wintering grounds of Oceania (South Pacific), 1999 to 2004. Journal of Cetacean Research and Management Special Issue 3:275-281.

Garrigue, C., and coauthors. 2011b. First assessment of interchange of humpback whales between Oceania and the east coast of Australia. Journal of Cetacean Research and Management Special Issue 3:269-274.

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 from Northwestern Atlantic Balaenopterid whales summering in the Gulf of St Lawrence. Marine Environmental Research 44(2):201-223.

Geertsen, B. M., J. Teilmann, R. A. Kastelein, H. N. J. Vlemmix, and L. A. Miller. 2004. Behaviour and physiological effects of transmitter attachments on a captive harbour porpoise (*Phocoena phocoena*). Journal of Cetacean Research and Management 6(2):139-146.

Gendron, D., and J. Urban. 1993. Evidence of feeding by humpback whales (Megaptera novaeangliae) in the Baja California breeding ground, Mexico. Marine Mammal Science 9:76-81.

Genov, T., P. Kotnjek, and L. Lipej. 2009. New rescord of the humpback whale (*Megaptera novaengliae*) in the Adriatic Sea. Annales 19(1):25-30.

George, J. C. 2010. Some recent biological findings on bowhead whales: Implications to management and offshore industrial act. Pages 109 *in* Alaska Marine Science Symposium, Anchorage, Alaska.

Giese, M. 1996. Effects of human activity on Adelie penguin (Pygoscelis adeliae) breeding success. Biological Conservation 75:157-164.

Gill, J. A., K. Norris, and W. J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, Megaptera novaeangliae, in Hawaii. U.S. Marine Mammal Commission, Washington, D.C.; National Technical Information Service, Springfield, Virginia: 36p.

Godfrey, J. D., and D. M. Bryant. 2003. Effects of radio transmitters: Review of recent radio-tracking studies. Pages 83-95 *in* M. Williams, editor. Conservation Applications of Measuring Energy Expenditure of New Zealand Birds: Assessing Habitat Quality and Costs of Carrying Radio Transmitters.

Goodyear, J. 1981. ""Remora"" tag effects the first radio tracking of an Atlantic humpback. Fourth Biennial Conference on the Biology of Marine Mammals, 14-18 December Jack Tar Hotel San Francisco CA. p.46.

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

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

Gotelli, N. J., and A. M. Ellison. 2004. A Primer of Ecological Statistics.Sinauer Associates, Inc. Sunderland, Massachusetts. 510p.

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, June 1990. Ocean Mammal Institute, SUNY, Buffalo, NY.

Greene, C., and A. J. Pershing. 2004. Climate and the conservation biology of North Atlantic right whales: the right whale at the wrong time? . Front Ecol Environ 2(1):29-34.

Greene, C., A. J. Pershing, R. D. Kenney, and J. W. Jossi. 2003. Impact of climate variability on the recovery of endangered North Atlantic right whales. Oceanography 16(4):98-103.

Greene, C. R. 1982. Characteristics of waterborne industrial noise. Pages 249-346 *in* W. J. Richardson, editor. Behavior, Disturbance Responses and Feeding of Bowhead Whales *Balaena mysticetus* in the Beaufort Sea, 1980-81. LGL Ecological Research Associates, Inc., Bryan, Texas and Reston, Virginia.

Greer, A. W. 2008. Trade-offs and benefits: Implications of promoting a strong immunity to gastrointestinal parasites in sheep. Parasite Immunology 30(2):123–132.

Guyton, A. C., and J. E. Hall. 2000. Textbook of Medical Physiology, 10th edition. W. B. Saunders Company, Philadelphia.

Guzman, H. M., C. G. Gomez, C. A. Guevara, and L. Kleivane. 2013. Potential vessel collisions with Southern Hemisphere humpback whales wintering off Pacific Panama. Marine Mammal Science 29(4):629–642.

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.

Hall, J. D. 1982. Humpback whale population and vessel traffic study. National Marine Fisheries Service.

Hanson, M. B., and coauthors. 2009. Tissue response to remotely-deployed dorsal fin-mounted telemetry tags: An assessment from re-sightings of tagged Hawaiian odontocetes. Pages 105 *in* Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.

Harrington, F. H., and A. M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter overflights. Arctic 45(3):213-218.

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

Hatch, L., and coauthors. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management 42:735-752.

Hawkins, P. 2004a. Bio-logging and animal welfare: Practical refinements. Memoirs of the National Institute for Polar Research Special Issue 58:58-68.

Hawkins, P. 2004b. Bio-logging and animal welfare: practical refinements. Memoirs of the National Institute of Polar Research 58:58-68.

Hayslip, C. E., B. A. Lagerquist, and B. R. Mate. 2009. Follow-up observations of satellite-tagged sperm whales in the Gulf of California for evaluation of potential tag effects. Pages 109 *in* Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada.

Heide-Jorgensen, M. P., and K. L. Laidre. 2013. Surfacing time, availability bias, and abundance of humpback whales in West Greenland. IWC Scientific Committee, Jeju, Korea.

Heide-Jorgensen, M. P., and coauthors. 2012. Rate of increase and current abundance of humpback whales in West Greenland. Journal of Cetacean Research and Management 12(1):1-14.

Hemphill, L., S. King, E. Partee, and C. McCann. 2006. Short term impact of vessel traffic on the Hawaiian humpback whale (Megaptera novaeangliae). The Ocean Mammal Institute.

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.

Herman, L. M. 1979. Humpback whales in Hawaiian waters: A study in historical ecology. Pacific Science 33:1-15.

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.

Herraez, P., and coauthors. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. Journal of Wildlife Diseases 43(4):770-774.

Herrenkohl, L. R., and J. A. Politch. 1979. Effects of prenatal stress on the estrous cycle of female offspring as adults. 34(9):1240-1241.

Higdon, J. W., and S. H. Ferguson. 2009. Loss of Arctic sea ice causing punctuated change in sightings of killer whales (Orcinus orca) over the past century. Ecological Applications 19(5):1365-1375.

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

Hill, P. S., and D. P. DeMaster. 1998. Alaska marine mammal stock assessments, 1998.

Hill, P. S., D. P. Demaster, and R. J. Small. 1997. Alaska marine mammal stock assessments, 1996. National Marine Fisheries Service.

Hoffman, W. S., G. D. Kaufman, and K. Jule. 2010. Estimation of survival, recruitment and realized growth rates of the East Australia humpback population (BS-1) using temporal symmetry models. IWC Scientific Committee, Agadir, Morocco.

Holst, M. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's TAG seismic study in the Mid-Atlantic Ocean, October–November 2003. LGL Ltd., King City, Ontario, Canada.

Holt, M. M., D. P. Noren, and C. K. Emmons. 2011. Effects of noise levels and call types on the source levels of killer whale calls. The Journal of the Acoustical Society of America 130(5):3100.

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. A. 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.

Hooker, S. K., M. Biuw, B. J. McConnell, P. J. O. Miller, and C. E. Sparling. 2007. Bio-logging science: Logging and relaying physical and biological data using animal-attached tags. Deep-Sea Research II 54(3-4):177-182.

Huang, Q., H. Wang, and M. A. Lewis. 2015. The impact of environmental toxins on predator-prey dynamics. Journal of Theoretical Biology 378:12-30.

Hunt, K. E., R. M. Rolland, S. D. Kraus, and S. K. Wasser. 2006. Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and Comparative Endocrinology 148(2):260-272.

Hurrell, J. W. 1995. Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. Science 269:676-679.

Illingworth and Rodkin Inc. 2001. Noise and vibration measurements associated with the pile installation demonstration project for the San Francisco-Oakland Bay Bridge east span, final data report.

Illingworth and Rodkin Inc. 2004. Conoco/Phillips 24-inch steel pile installation – Results of underwater sound measurements. Letter to Ray Neal, Conoco/Phillips Company.

Ingram, H., L. Marcella, L. Curran, C. Frey, and L. Dugan. 2014. Draft protected species mitigation and monitoring report 3-d seismic survey in the Northwest Atlantic Ocean off New Jersey. RPS, Houston, Texas.

IPCC, editor. 2001. Climate change 2001: The scientific basis, contribution of working group I to the third assessment report of the intergovernmental panel of climate change. Cambridge University Press, Cambridge, England.

IPCC. 2002. Climate Change and Biodiversity, volume Technical Paper V. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Isaac, J. L. 2008. Effects of climate change on life history: Implications for extinction risk in mammals. Endangered Species Research.

Issac, J. L. 2009. Effects of climate change on life history: Implications for extinction risk in mammals. Endangered Species Research 7(2):115-123.

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.

IWC. 1996. Report of the sub-committee on Southern Hemisphere baleen whales, Annex E Report of the International Whaling Commission 46:117-131.

IWC. 2004. Scientific committee - Annex K: Report of the standing working group on environmental concerns. Sorrento, Italy.

IWC. 2005. Chair's Report of the 57th Annual Meeting. International Whaling Commission. Available online at: http://www.iwcoffice.org/_documents/meetings/ulsan/CRREP57.pdf Accessed 7/26/2006.

IWC. 2007. Whale Population Estimates. International Whaling Commission. Accessed 02/07/2007 online at: http://www.iwcoffice.org/conservation/estimate.htm.

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.

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.

Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25.

Jin, L., C. Gaus, and B. I. Escher. 2015. Adaptive stress response pathways induced by environmental mixtures of bioaccumulative chemicals in dugongs. Environmental Science and Technology 49(11):6963-6973.

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

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

Kaschner, K., D. P. Tittensor, J. Ready, T. Gerrodette, and B. Worm. 2011. Current and future patterns of global marine mammal biodiversity. PLoS ONE 6(5):e19653.

Katona, S. K., and J. A. Beard. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Report of the International Whaling Commission (Special Issue 12):295-306.

Keay, J. M., J. Singh, M. C. Gaunt, and T. Kaur. 2006. Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. Journal of Zoo and Wildlife Medicine 37(3):234-244.

Kennedy, A. S., and coauthors. 2013. Local and migratory movements of humpback whales (*Megaptera novaeangliae*) satellite-tracked in the North Atlantic Ocean. Canadian Journal of Zoology:8-17.

Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States Outer Continental Shelf. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/NEC-41.

Kent, C. S., C. Jenner, M. Jenner, P. Bouchet, and E. Rexstad. 2012. Southern Hemisphere Breeding Stock D humpback whale population estimates from North West Cape, Western Australia. Journal of Cetacean Research and Management 12(1):29-38.

Komesaroff, P. A., M. Esler, I. J. Clarke, M. J. Fullerton, and J. W. Funder. 1998. Effects of estrogen and estrous cycle on glucocorticoid and catecholamine responses to stress in sheep. American Journal of Physiology, Endocrinology, and Metabolism (275):E671–E678.

Koski, W. R., and S. R. Johnson. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. LGL Ltd, King City, Ontario.

Kragh Boye, T., 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 90(8):1529-1538.

Kraus, S., C. A. Quinn, and C. K. Slay. 2000. A workshop on the effects of tagging on North Atlantic right whales. New England Aquarium, Boston, Massachussetts.

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. U.S. Department of Commerce, NMFS/NWC-66.

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., and coauthors. 2014. Cetacean range and climate in the eastern North Atlantic: Future predictions and implications for conservation. Global Change Biology 20(6):1782-1793.

Lambertsen, R. H. 1992. Crassicaudosis: a parasitic disease threatening the health and population recovery of large baleen whales. Rev. Sci. Technol., Off. Int. Epizoot. 11(4):1131-1141.

Lammers, M. O., and coauthors. 2011. Humpback whale Megaptera novaeangliae song reveals wintering activity in the northwestern Hawaiian Islands. Marine Ecology Progress Series 423:261-268.

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.

Learmonth, J. A., and coauthors. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: an Annual Review 44:431-464.

Leopold, M., and coauthors. 2014. The recent occurrence of humpback whales in the southern North Sea: A range expansion. Pages 44 *in* Twenty Eighth Annual Conference of the European Cetacean Society, Liege, Belgium.

Levenson, C., and W. T. Leapley. 1978. Distribution of humpback whales (*Megaptera novaeangliae*) in the Caribbean determined by a rapid acoustic method. Journal of the Fisheries Research Board of Canada 35:1150-1152.

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

Lima, S. L. 1998. Stress and decision making under the risk of predation. Advances in the Study of Behavior 27:215-290.

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, C. D., M. B. Santos, R. J. Reid, B. E. Scott, and G. J. Pierce. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: Could climate change mean more starving porpoises? Biology Letters 3(2):185-188.

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., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984a. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior: Phase II: January 1984 migration. U.S. Department of Interior, Minerals Management Service, Alaska OCS Office, 5586.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Final report for the period of 7 June 1982 - 31 July 1983. Report No. 5366. For U.S. Department of the Interior, Minerals Management Service, Alaska OCS Office, Anchorage, AK 99510. 64pp.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984b. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior: phase II: January 1984 migration. Report No. 5366. For U.S. Department of the Interior, Minerals Management Service, Alaska OCS Office, Anchorage, AK 99510. 64pp.

Malme, C. I., P. R. Miles, P. Tyack, C. W. Clark, and J. E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. Report No. 5851, prepared for Minerals Management Service, Alaska OCS Offfice, 949 East 36th Avenue, Anchorage, AK 99508. MMS 85-0019. 205pp.

MARAD. 2011. Data and statistics. Maritime Administration Department of Transportation.

Martin, S. L., S. M. Stohs, and J. E. Moore. 2015. Bayesian inference and assessment for rare-event bycatch in marine fisheries: A drift gillnet fishery case study. Ecological Applications 25(2):416-429.

Mate, B., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76:6.

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. Proceedings of the International Symposium on Bio-

Logging Science, Second International Conference on Bio-Logging Science, st Andrews, Uk, 13-16 June.

Mate, B. R., S. L. Nieukirk, S. D. Kraus, R. S. Mesecar, and T. J. Martin. 1991. Satellite-monitored movements and dive patterns of radio-tagged North Atlantic right whales, Eubalaena glacialis. Ninth Biennial Conference on the Biology of Marine Mammals, 5-9 December Chicago IL. p.45.

Mate, B. R., S. L. Nieukirk, and S. D. Kraus. 1997. Satellite-monitored movements of the northern right whale. (Eubalaena glacialis). 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.

Mattila, D., P. J. Clapham, O. Vásquez, and R. S. Bowman. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. Canadian Journal of Zoology 72:1898-1907.

Mattila, D. K., and T. Rowles. 2010. A review of large whale entanglement. IWC Scientific Committee, Agadir, Morocco.

Mazzuca, L. L., S. E. Moore, and D. DeMaster. 2001. Potential effects of low frequency sonnd (LFS) from commercial vessels on large whales. Pages 139 *in* Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

McCauley, R. D., and coauthors. 2000. Marine seismic surveys - a study of environmental implications. Australian Petroleum Production & Exploration Association Journal 40:692-708.

McCauley, R. D., M.-N. Jenner, C. Jenner, and D. H. Cato. 1998a. Observations of the movements of humpback whales about an operating seismic survey vessel near Exmouth, Western Australia. Journal of the Acoustical Society of America 103(5):2909.

McCauley, R. D., M.-N. Jenner, C. Jenner, K. A. McCabe, and J. Murdoch. 1998b. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. Appea Journal 38:692-707.

McCordic, J. A., S. K. Todd, and P. T. Stevick. 2014. Differential rates of killer whale attacks on humpback whales in the North Atlantic as determined by scarification. Journal of the Marine Biological Association of the United Kingdom 94(6):1311-1315.

McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006. Biogeographic characterization of blue whale song worldwide: using song to identify populations. Journal of Cetacean Research and Management 8(1):55-65.

McLellan, W. A. 2011. Necropsy report-EgNEFL1103. University of North Carolina Wilmington, Wilmington, North Carolina.

McMahon, C. R., and H. R. Burton. 2005. Climate change and seal survival: Evidence for environmentally mediated changes in elephant seal, Mirounga leonina, pup survival. Proceedings of the Royal Society of London Series B Biological Sciences 272(1566):923-928.

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.

Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Ltd.

Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fitness. Philosophy of Science 46:263-286.

Mitchell, E., and R. R. Reeves. 1983. Catch history, abundance and present status of northwest Atlantic humpback whales. Report of the International Whaling Commission (Special Issue 5):153-212.

Mizroch, S. A., and coauthors. 2010. Long-term survival of humpback whales radio-tagged in Alaska from 1976 through 1978. Marine Mammal Science 9999(9999).

Mizroch, S. A., and coauthors. 2008. Long-term survival of humpback whales radio-tagged in Alaska from 1976 through 1978. Unpublished paper to the IWC Scientific Committee. 10 pp. Santiago, Chile, June (SC/60/O14).

MMS. 2005. Geological & geophysical data acquisition: Outer Continental Shelf through 2003. Minerals Management Service.

Moberg, G. P. 1991. How behavioral stress disrupts the endocrine control of reproduction in domestic animals. Journal of Dairy Science 74(304-311).

Moline, M. A., H. Claustre, T. K. Frazer, O. Schofields, and M. Vernet. 2004. Alterations of the food web along the Antarctic Peninsula in response to a regional warming trend. Global Change Biology 10:1973-1980.

Mourlon, V., L. Naudon, B. Giros, M. Crumeyrolle-Arias, and V. Daugé. 2011. Early stress leads to effects on estrous cycle and differential responses to stress. Physiology & Behavior 102:304-310.

Mullner, A., K. E. Linsenmair, and W. Wikelski. 2004. Exposure to ecotourism reduces survival and affects stress response in hoatzin chicks (Opisthocomus hoazin). Biological Conservation 118:549-558.

Murray, A., A. N. Rice, and C. W. Clark. 2014. Extended seasonal occurrence of humpback whales in Massachusetts Bay. Journal of the Marine Biological Association of the United Kingdom 94(6):1117-1125.

Murray, D. L., and M. R. Fuller. 2000. A critical review of the effects of marking on the biology of vertebrates. Chapter 2 In: Boitiani, L. and T.K. Fuller (Eds), Research Techniques in Animal Ecology: Controversies and Consequences. Columbia University Press, New York.

Naguib, M. 2013. Living in a noisy world: Indirect effects of noise on animal communication. Behaviour 150(9-10):1069-1084.

Nedwell, J., and B. Edwards. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Subacoustech, Ltd.

Nelson, W. G., R. Brock, H. Lee II, J. O. Lamberson, and F. Cole. 2007. Condition of bays and estuaries of Hawaii for 2002: A statistical summary. Environmental Protection Agency, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Washington, D. C. .

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. . Scientific Reports of the Whales Research Institute, Tokyo 12:33-89.

NMFS. 1987. Marine Mammal Protection Act of 1972. National Marine Fisheries Service.

NMFS. 2005. Assessment of acoustic exposures on marine mammals in conjunction with USS Shoup active sonar transmissions in the Eastern Strait of Juan de Fuca and Haro Strait,

Washington 5 May 2003. National Marine Fisheries Service, Office of Protected Resources.
NMFS. 2006a. Biological Opinion on the 2006 Rim-of-the-Pacific Joint Training Exercises (RIMPAC). National Marine Fisheries Service, Silver Spring, Maryland. 123p.
NMFS. 2006b. Biological opinion on the issuance of section lO(a)(l)(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. 2008a. Biological opinion on oil and gas leasing and exploration activities in the U.S. Beafort and Chukchi Seas, Alaska; and authorization of small takes under the Marine Mammal Protection Act. National Marine Fisheries Service.
NMFS. 2008b. Draft U.S. Atlantic marine mammal stock assessments 2008.
NMFS. 2008c. Final programmatic biological opinion on U.S. Navy activities in the Hawaii Range Complex 2008-2013.
NMFS. 2008d. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.
NMFS. 2013. Programmatic geological and geophysical activities in the Mid and South Atlantic planning areas from 2013 to 2020. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.
NOAA. 2015. Endangered and threatened species; identification of 14 distinct population segments of the humpback whale (*Megaptera novaeangliae*). Federal Register 80:22303-22356.
Norris, T. F. 1994. Effects of boat noise on the acoustic behavior of humpback whales. The Journal of the Acoustical Society of America 95(5 Pt. 2):3251.
Nottestad, L., and coauthors. 2014. Ecological aspects of fin whale and humpback whale distribution during summer in the Norwegian Sea. Marine Ecology 35(2):221-232.
NRC. 1994. Low-frequency sound and marine mammals, current knowledge and research needs. (National Research Council). National Academy Press, Washington, D.C.
NRC. 2003. Ocean Noise and Marine Mammals.National Research Council: Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals.
NRC. 2005. Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. (National Research Council). National Academies Press, Washington, D.C.
Øien, N. 2001. Humpback whales in the Barents and Norwegian Seas.Paper SC/53/NAH21 presented to the International Whaling Commission Scientific Committee. Available from IWC, 135 Station Road, Impington, Cambridge, UK.
Omsjoe, E. H., and coauthors. 2009a. Evaluating capture stress and its effects on reproductive success in Svalbard reindeer. Canadian Journal of Zoology-Revue Canadienne De Zoologie 87(1):73-85.
Omsjoe, E. H., and coauthors. 2009b. Evaluating capture stress and its effects on reproductive success in Svalbard reindeer. Canadian Journal of Zoology 87:73-85.
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.

Palsbøll, P. J., and coauthors. 1997. Genetic tagging of humpback whales. Nature 388:767-769.

Palsboll, P. J., and coauthors. 2013. Genetic analysis suggests an ocean-wide, ~1000 kilometer northbound shift in summer feeding area by some humpback whales. Pages 166 *in* Twentieth Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand.

Panigada, S., S. Frey, N. Pierantonio, P. Garziglia, and F. Giardina. 2014. Are humpback whales electing the Mediterranean Sea as new residence? Pages 203 *in* Twenty Eighth Annual Conference of the European Cetacean Society, Liege, Belgium.

Papale, E., M. Gamba, M. Perez-Gil, V. M. Martin, and C. Giacoma. 2015. Dolphins adjust species-specific frequency parameters to compensate for increasing background noise. PLoS ONE 10(4):e0121711.

Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2010. Individual right whales call louder in increased environmental noise. Biology Letters.

Pastene, L. A., and N. Kanda. 2010. Initial comments on paper by Baker et al. 'Stock structure of western North Pacific minke whales based on mtDNA haplogroups from bycatch and scientific whaling' (SC/62/NPM20). IWC Scientific Committee, Agadir, Morocco.

Pavlov, V. V., and A. M. Rashad. 2012. A non-invasive dolphin telemetry tag: Computer design and numerical flow simulation. Marine Mammal Science 28(1):E16-E27.

Payne, P., J. Nicholas, L. O'Brien, and K. Powers. 1986. The distribution of the humpback whale, Megaptera novaeangliae, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, Ammodytes americanus. Fisheries Bulletin 84:271-277.

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 selected prey. Fishery Bulletin 88:687-696.

Perkins, J., and D. 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.

Peters, R. H. 1983. The Implications of Body Size. Cambridge University Press.

Picanco, C., I. Carvalho, and C. Brito. 2009. Occurrence and distribution of cetaceans in Sao Tome and Príncipe tropical archipelago and their relation to environmental variables. Journal of the Marine Biological Association of the United Kingdom 89(5):1071-1076.

Pike, D. G., T. Gunnlaugsson, G. A. Vikingsson, G. Desportes, and B. Mikkelsen. 2010. Estimates of the abundance of humpback whales (Megaptera novaengliae) from the T-NASS Icelandic and Faroese ship surveys conducted in 2007. IWC Scientific Committee, Agadir, Morocco.

Pike, D. G., C. G. M. Paxton, T. Gunnlaugsson, and G. A. Víkingsson. 2009. Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001. NAMMCO Scientific Publications 7:117-142.

Pimentel, D., R. Zuniga, and D. Morrison. 2004. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics.

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.

Place, N. J., and G. J. Kenagy. 2000. Seasonal changes in plasma testosterone and glucocorticosteroids in free-living male yellow-pine chipmunks and the response to capture and handling. Journal of Comparative Physiology B 170:245±251.

Poloczanska, E. S., C. J. Limpus, and G. C. Hays. 2009. Vulnerability of marine turtles in climate change. Pages 151-211 *in* Advances in Marine Biology, volume 56. Academic Press, New York.

Pomilla, C., and H. C. Rosenbaum. 2005. Against the current: an inter-oceanic whale migration event. Biology Letters 1(4):476-479.

Pughiuc, D. 2010. Invasive species: Ballast water battles. Seaways.

Punt, A. E. 2010. Further analyses related to the estimation of the rate of increase for an unknown stock using a Bayesian meta-analysis. IWC Scientific Committee, Agadir, Morocco.

Purvis, A., J. L. Gittleman, G. Cowlishaw, and G. M. Mace. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society B-Biological Sciences 267:1947-1952.

Queisser, N., and N. Schupp. 2012. Aldosterone, oxidative stress, and NF-κB activation in hypertension-related cardiovascular and renal diseases. Free Radical Biology and Medicine 53:314–327.

Quinn, C. A., P. K. Hamilton, S. D. Kraus, and C. K. Slay. 2000. An assessment of wounds caused by the attachment of remote sensing tags to North Atlantic right whales (Eubalaena glacialis):1988-1997. New England Aquarium, Boston, Massachussetts.

Raaymakers, S. 2003. The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. Proceedings of the Institute of Marine Engineering, Science and Technology Part B: Journal of Design and Operations (B4):2-10.

Raaymakers, S., and R. Hilliard. 2002. Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment, 1726-5886, Istanbul, Turkey.

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.

Rasmussen, K., J. Calambokidis, and G. H. Steiger. 2012. Distribution and migratory destinations of humpback whales off the Pacific coast of Central America during the boreal winters of 1996-2003. Marine Mammal Science 28(3):E267-E279.

Reeves, R. R. 1977. The problem of gray whale (Eschrichtius robustus) harassment: At the breeding lagoon and during migration. U.S. Marine Mammal Commission Report MMC-76/06. NTIS PB-272 506, 60pgs. (PDF only up to page 52).

Reeves, R. R., P. J. Clapham, and S. E. Wetmore. 2002a. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. Journal of Cetacean Research and Management 4(3):235-253.

Reeves, R. R., P. J. Clapham, and S. E. Wetmore. 2002b. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. Journal of Cetacean Research and Management 4(3):235-253.

Reeves, R. R., J. A. Khan, R. R. Olsen, S. L. Swartz, and T. D. Smith. 2001a. History of whaling in Trinidad and Tobago. Journal of Cetacean Research and Management 3(1):45-54.

Reeves, R. R., S. L. Swartz, S. E. Wetmore, and P. J. Clapham. 2001b. Historical occurrence and distribution of humpback whales in the eastern and southern Caribbean Sea, based on data from American whaling logbooks. Journal of Cetacean Research and Management 3(2):117-129.

Reid, K., and J. Croxall. 2001. Environmental response of upper trophic-level predators reveals a system change in an Antarctic marine ecosystem. Proceedings of the Royal Society London Series B 268:377–384.

Reiner, F., M. E. Dos Santos, and F. W. Wenzel. 1996. Cetaceans of the Cape Verde archipelago. Marine Mammal Science 12(3):434-443.

Reyff, J. A. 2003. Underwater sound levels associated with constnlction of the Benicia-Martinez Bridge. lllingworth & Rodkin, Inc.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation, and numbers. In K. S. Norris and R. R. Reeves (Editors), Report on a Workshop on Problems Related to Humpback Whales (*Megaptera novaeangliae*) in Hawaii. Contr. Rep. to U.S. Mar. Mammal Comm., NTIS PB-280-794.pp. 29–44.

Rice, D. W. 1998. Marine Mammals of the World. Systematics and Distribution.Special Publication Number 4. The Society for Marine Mammalogy, Lawrence, Kansas.

Richardson, W. J., K. J. Finley, G. W. Miller, R. A. Davis, and W. R. Koski. 1995a. Feeding, Social and Migration Behavior of Bowhead Whales, Balaena-Mysticetus, in Baffin-Bay Vs the Beaufort Sea - Regions with Different Amounts of Human Activity. Marine Mammal Science 11(1):1-45.

Richardson, W. J., M. A. Fraker, B. Wursig, and R. S. Wells. 1985a. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: Reactions to industrial activities. Biological Conservation 32(3):195-230.

Richardson, W. J., M. A. Fraker, B. Wursig, and R. S. Wells. 1985b. Behavior of bowhead whales Balaena mysticetus summering in the Beaufort Sea: Reactions to industrial activities. Biological Conservation 32(3):195-230.

Richardson, W. J., and coauthors. 1990. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska -- 1989 phase: Sound propagation and whale responses to playbacks of continuous drilling noise from an ice platform, as studied in pack ice conditions. Alaska Outer Continental Shelf Region of the Minerals Management Service, MMS 90-0017, Anchorage, AK.

Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995b. Marine mammals and noise. Academic Press; San Diego, California.

Richardson, W. J., T. L. McDonald, C. R. Greene, and S. B. Blackwell. 2004. Acoustic localization of bowhead whales near Northstar, 2001-2003: Evidence of deflection at high-noise times? W. J. Richardson, and M. T. Williams, editors. Monitoring of Industrial Sounds, Seals, and Bowhead Whales Near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2003. LGL Ltd, Greenridge Science Inc., and WEST Inc., Anchorage, Alaska.

Richardson, W. J., and M. T. Williams. 2003. Monitoring of industrial sounds, seals, and bowhead whales near BP's northstar oil development, Alaskan Beaufort Sea, 1999–2002 LGL Ltd. and Greeneridge Sciences Inc., King City, Ontario and Santa Barbara, California.

Richardson, W. J., and M. T. Williams. 2004. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea, 1999-2003. Annual and comprehensive report, Dec 2004. Pages 297 *in* LGL Report TA 4001. BP Exploration (Alaska) Inc., Anchorage, Alaska.

Richter, B. D., D. P. Braun, M. A. Mendelson, and L. L. Master. 1997. Threats to imperiled freshwater fauna. Conservation Biology 11:1081-1093.

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. Department of Conservation, Wellington, New Zealand. Science For Conservation 219. 78p.

Rivier, C. a. R., S. 1991. Effect of stress on the activity of the hypothalamicepituitaryegonadal axis: peripheral and central mechanisms. Biology of Reproduction 45:523-532.

Rizzo, L. Y., and D. Schulte. 2009. A review of humpback whales' migration patterns worldwide and their consequences to gene flow. Journal of the Marine Biological Association of the United Kingdom 89(5):995-1002.

Roman, J., and S. R. Palumbi. 2003. Whales before whaling in the North Atlantic. Science 301:508-510.

Romero, L. M. 2004. Physiological stress in ecology: lessons from biomedical research. Trends in Ecology and Evolution 19(5):249-255.

Romero, L. M., C. J. Meister, N. E. Cyr, G. J. Kenagy, and J. C. Wingfield. 2008. Seasonal glucocorticoid responses to capture in wild free-living mammals. American Journal of Physiology-Regulatory Integrative and Comparative Physiology 294(2):R614-R622.

Ross, D. 1976. Mechanics of Unterwater Noise. Pergamon Press, New York.

Rossi-Santos, M. R. 2015. Oil industry and noise pollution in the humpback whale (*Megaptera novaeangliae*) soundscape ecology of the southwestern Atlantic breeding ground. Journal of Coastal Research 31(1):184-195.

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. Tenth Biennial Conference on the Biology of Marine Mammals, 11-15 November Galveston TX. p.94.

Salvadeo, C., D. Lluch-Belda, S. Lluch-Cota, and M. Mercuri. 2011. Review of long term macro-fauna movement by multi-decadal warming trends in the northeastern Pacific. Pages 217-230 *in* J. Blanco, and H. Kheradmand, editors. Climate Change - Geophysical Foundations and Ecological Effects. Tech Publications.

Salvadeo, C. J., and coauthors. 2013. Impact of climate change on sustainable management of gray whale (*Eschrichtius robustus*) populations: Whale-watching and conservation. Archives of Biological Sciences 65(3):997-1005.

Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000a. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrine Reviews 21(1):55-89.

Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000b. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrine Reviews 21(1):55-89.

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.

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.

Schick, R. S., and D. L. Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetus*) distribution in the Alaskan Beaufort Sea. Canadian Journal of Fisheries and Aquatic Sciences 57:2193-2200.

Schmitt, N. T., and coauthors. 2014. Low levels of genetic differentiation characterize Australian humpback whale (*Megaptera novaeangliae*) populations. Marine Mammal Science 30(1):221-241.

Schumann, N., N. J. Gales, R. G. Harcourt, and J. P. Y. Arnould. 2013. Impacts of climate change on Australian marine mammals. Australian Journal of Zoology 61(2):146-159.

Schwartz, F. J. 2003. Bilateral asymmetry in the rostrum of the smalltooth sawfish, *Pristis pectinata* (Pristiformes: Family Pristidae). Journal of the North Carolina Academy of Science 119(2):41-47.

Scott, M. D., R. S. Wells, A. B. Irvine, and B. R. Mate. 1990. Tagging and marking studies on small cetaceans. Pages 489-514 *in* S. Leatherwood, and R. R. Reeves, editors. The Bottlenose Dolphin. Academic Press, San Diego.

Sigurjonsson, J. 1995. On the life history and autecology of North Atlantic rorquals. Pages 425-441 *in* A. S. Blix, L. Wallae, and O. Ulltang, editors. Whales, Seals, Fish and Man. Elsevier Science, Amsterdam.

Silber, G., and S. Bettridge. 2012. An assessment of the final rule to implement vessel speed restrictions to reduce the threat of vessel collisions with North Atlantic Right Whales. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silve Spring, Maryland.

Silberg, J. N., and coauthors. 2013. New insight into migration patterns of western North Pacific humpback whales between the Babuyan Islands, Philippines and the Commander Islands, Russia. Journal of Cetacean Research and Management 13(1):53-57.

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.

Smith, T. D., and coauthors. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Smith, T. D., and D. G.Pike. 2009. The enigmatic whale: the North Atlantic humpback. Nammco Scientific Publications 7:161-178.

Smith, T. D., and R. R. Reeves. 2003. Estimating American 19th century catches of humpback whales in the West Indies and Cape Verde Islands. Caribbean Journal of Science 39(3):286-297.

Smith, T. D., and R. R. Reeves. 2010. Historical catches of humpback whales, Megaptera novaeangliae, in the North Atlantic Ocean: Estimates of landings and removals. Marine Fisheries Review 72(3):1-43.

Southall, B. L., and coauthors. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-521.

St. Aubin, D. J., S. H. Ridgway, R. S. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncatus*, and influence of sex, age, and season. Marine Mammal Science 12(1):1-13.

Stearns, S. C. 1992. The evolution of life histories.Oxford University Press, 249p.

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 4:247-256.

Stenseth, N. C., and coauthors. 2002. Ecological effects of climate fluctuations. Science 297(5585):1292-1296.

Stevick, P., and coauthors. 2003a. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Marine Ecology Progress Series 258:263-273.

Stevick, P. T., and coauthors. 2003b. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology 259:231-237.

Stevick, P. T., and coauthors. 2011. A quarter of a world away: Female humpback whale moves 10,000 km between breeding areas. Biology Letters 7(2):299-302.

Stimpert, A., D. Mattila, E.-M. Nosal, and W. W. L. Au. 2013. Tagging young humpback whale calves: Methodology and diving behavior. Endangered Species Research 19(1):11-17.

Stone, C. J., and M. L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management 8(3):255-263.

Streever, B., and coauthors. 2008. Progress through collaboration: A case study examining effects of industrial sounds on bowhead whales. Bioacoustics 17(1-3):345-347.

Strindberg, S., P. J. Ersts, T. Collins, G.-P. Sounguet, and H. C. Rosenbaum. 2011. Line transect estimates of humpback whale abundance and distribution on their wintering grounds in the coastal waters of Gabon. Journal of Cetacean Research and Management Special Issue 3:153-160.

Sutherland, W. J., and N. J. Crockford. 1993. Factors affecting the feeding distribution of red breasted geese, Branta ruficollis, wintering in Romania. Biological Conservation 63:61-65.

Swartz, S. L., and coauthors. 2003. Acoustic and visual survey of humpback whales (*Megaptera novaeangliae*) distribution in the Eastern and Southeastern Caribbean Sea. Caribbean Journal of Science 39(2):195-208.

Sydeman, W. J., and coauthors. 2011. Does positioning of the North Pacific Current affect downstream ecosystem productivity? Geophysical Research Letters 38(12).

Terdalkar, S., A. S. Kulkarni, S. N. Kumbhar, and J. Matheickal. 2005. Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. Nature, Environment and Pollution Technology 4(1):43-47.

Tomilin, A. G. 1967. Mammals of the USSR, and adjacent countries. Volume 9, Cetacea. Israel Program Sci. Transl. No. 124, National Technical Information Service TT 65-50086. Springfield, Virginia (Translation of Russian text published in 1957).

Twiss, S. D., C. Thomas, V. Poland, J. A. Graves, and P. Pomeroy. 2007. The impact of climatic variation on the opportunity for sexual selection. Biology Letters 3(1):12-15.

Tyack, P. L. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology 8:105-116.

Van Der Hoop, J. M., and coauthors. 2014. Bottlenose dolphins modify behavior to reduce metabolic effect of tag attachment. Journal of Experimental Biology 217(23):4229-4236.

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., 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):283-297.

Víkingsson, G. A., and coauthors. 2014. Recent changes in the diet composition of common minke whales (*Balaenoptera acutorostrata*) in Icelandic waters. A consequence of climate change? Marine Biology Research 10(2):138-152.

Waerebeek, K. V., and coauthors. 2013. New evidence for a South Atlantic stock of humpback whales wintering on the northwest African continental shelf. African Zoology 48(1):177-186.

Walker, B. G., and P. L. Boveng. 1995. Effects of time-depth recorders on maternal foraging and attendance behavior of Antarctic fur seals. Canadian Journal of Zoology 73:1538-1544.

Walker, B. G., and P. L. Boveng. 1995. Effects of time-depth recorders on maternal foraging and attendance behavior of Antarctic fur seals (Arctocephalus gazella). Canadian Journal of Zoology 73(8):1538-1544.

Walker, B. G., P. Dee Boersma, and J. C. Wingfield. 2005. Physiological and behavioral differences in magellanic Penguin chicks in undisturbed and tourist-visited locations of a colony. Conservation Biology 19(5):1571-1577.

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.

Wambiji, N., P. Gwada, E. Fondo, S. Mwangi, and M. K. Osore. 2007. Preliminary results from a baseline survey of the port of Mombasa: with focus on molluscs. 5th Western Indian Ocean Marine Science Association Scientific Symposium; Science, Policy and Management pressures and responses in the Western Indian Ocean region, Durban, South Africa.

Ward, E., A. N. Zerbini, P. G. Kinas, M. H. Engel, and A. Andriolo. 2011. Estimates of population growth rates of humpback whales (*Megaptera novaeangliae*) in the wintering grounds off the coast of Brazil (Breeding Stock A). Journal of Cetacean Research and Management Special Issue 3:145-149.

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. NOAA Technical Memorandum NMFS-NE-182:Woods Hole, Massachusetts, 300p.

Waring, G. T., and coauthors. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2001. NOAA Technical Memorandum NMFS-NE-168:Woods Hole, Massachusetts. 318p.

Wartzok, D., W. A. Watkins, B. Wursig, and C. I. Malme. 1989. Movements and behaviors of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. (Balaena mysticetus). Whale Research Report, AMOCO Production Co., Anchorage, AK. 228p.

Watkins, W. A. 1981a. Reaction of three species of whales *Balaenoptera physalus*, *Megaptera novaeangliae*, and *Balaenoptera edeni* to implanted radio tags. Deep-Sea Research 28A(6):589-599.

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 A. 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., and C. A. Goebel. 1984. Sonar observations explain behaviors noted during boat manuevers for radio tagging of humpback whales (Megaptera novaeangliae) in the Glacirer Bay area. Cetology 48:1-8.

Watkins, W. A., K. E. Moore, J. Sigurjonsson, D. Wartzok, and G. N. D. Sciara. 1984. Fin whale (Balaenoptera physalus) tracked by radio in the Irminger Sea. Rit Fiskideildar 8(1):1-14.

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 A. Oceanographic Research Papers 28(6):577-588.

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., 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. 1992a. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. Fishery Bulletin 90:588-598.

Weinrich, M. T., and coauthors. 1992b. Behavioral reactions of humpback whales, Megaptera novaeangliae, to biopsy procedures. Fishery Bulletin 90(3):588-598.

Weir, C. R. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. Marine Turtle Newsletter 116:17-20.

Weller, D. 2008. Report of the large whale tagging workshop. U.S. Marine Mammal Commission and U.S. National Marine Fisheries Service, San Diego, California.

Wells, R., and coauthors. 2013. Experimental tests of small electronic tags for dolphins. Pages 222 *in* Twentieth Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand.

Wells, R. S. 2013. Evaluation of tag attachments on small cetaceans. Office of Naval Research.

White, G. C., and R. A. Garrot. 1990. Effects of Tagging on the Animal. Chapter 3 In: Analysis of Wildlife Radio-Tracking Data. Academic Press, San Diego, CA. 383p.

Whitehead, H. 1997. Sea surface temperature and the abundance of sperm whale calves off the Galapagos Islands: Implications for the effects of global warming. Report of the International Whaling Commission 47:941-944.-Sc/48/O30).

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.

Whitehead, H., and M. J. Moore. 1982. Distribution, and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48(8):607-615.

Williams, R., D. E. Bain, J. K. B. Ford, and A. W. Trites. 2002a. Behavioural responses of male killer whales to a "leapfrogging" vessel. (Orcinus orca). Journal of Cetacean Research and Management 4(3):305-310.

Williams, R., r. W. Trites, and D. E. Bain. 2002b. Behavioural responses of killer whales (Orcinus orca) to whale-watching boats: Opportunistic observations and experimental approaches. Journal of Zoology 256(2):255-270.

Wilson, R. P., and C. R. McMahon. 2006. Measuring devices on wild animals: what constitutes acceptable practice? Frontiers in Ecology and the Environment 4(3):147-154.

Winn, H. E., R. K. Edel, and A. G. Taruski. 1975. Population estimate of the humpback whale in the West Indies by visual and acoustic techniques. Journal of the Fisheries Research Board of Canada 32:499–506.

Winn, H. E., and N. E. Reichley. 1985a. 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.

Winn, H. E., and N. E. Reichley. 1985b. Humpback whale - *Megaptera novaeangliae*. Handbook of Marine Mammals: Vol. 3 The Sirenians and Baleen Whales:241-274.

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.

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.

Yan, N. D., R. Girard, and S. Boudreau. 2002. An introduced predator (Bythotrephes) reduces zooplankton species richness. Ecological Letters 5:481-485.