


**NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION**

Action Agencies: National Science Foundation-Division of Ocean Sciences and NOAA's National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

Activity Considered: *1) Seismic survey by the Lamont-Doherty Earth Observatory along New Jersey, and
2) Issuance of an Incidental Harassment Authorization pursuant to section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)*

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

Approved:

for


Donna S. Wieting
Director, Office of Protected Resources
MAY - 7 2015

Date: _____

Public Consultation Tracking System (PCTS) number: *FPR-2015-9109*

TABLE OF CONTENTS

	Page
1 INTRODUCTION.....	1
1.1 CONSULTATION HISTORY.....	1
2 DESCRIPTION OF THE PROPOSED ACTIONS	3
2.1 NATIONAL SCIENCE FOUNDATION PROPOSED ACTION	3
2.1.1 <i>Schedule</i>	3
2.1.2 <i>Source Vessel Specifications</i>	4
2.1.3 <i>Airgun Description</i>	5
2.1.4 <i>Multibeam Echosounder and Sub-bottom Profiler</i>	5
2.1.5 <i>Proposed Exclusion Zones</i>	6
2.2 NMFS PERMITS AND CONSERVATION DIVISION’S INCIDENTAL HARASSMENT AUTHORIZATION	11
3 APPROACH TO THE ASSESSMENT.....	15
3.1 ASSESSMENT APPROACH APPLIED TO THIS CONSULTATION	17
4 ACTION AREA	19
5 STATUS OF LISTED RESOURCES.....	20
5.1 SPECIES AND CRITICAL HABITAT NOT CONSIDERED FURTHER.....	20
5.2 SPECIES CONSIDERED FURTHER IN THIS OPINION	20
5.2.1 <i>Blue whale</i>	21
5.3 FIN WHALE.....	25
5.4 HUMPBACK WHALE.....	29
5.5 NORTH ATLANTIC RIGHT WHALE	33
5.6 SEI WHALE	38
5.7 SPERM WHALE.....	40
5.8 GREEN SEA TURTLE.....	46
5.9 KEMP’S RIDLEY SEA TURTLE.....	52
5.10 LEATHERBACK SEA TURTLE	57
5.11 LOGGERHEAD SEA TURTLE- NORTHWEST ATLANTIC DPS	62
ENVIRONMENTAL BASELINE.....	70
5.12 CLIMATE CHANGE	70

5.13	HABITAT DEGRADATION.....	74
5.14	DREDGING.....	75
5.15	SEISMIC SURVEYS.....	75
5.16	VESSEL TRAFFIC.....	76
5.17	U.S. NAVY TRAINING AND TESTING ACTIVITIES	76
5.18	U.S. MARINE CORPS TRAINING IN THE CHERRY POINT RANGE COMPLEX.....	78
5.19	ENTRAPMENT AND ENTANGLEMENT IN FISHING GEAR.....	78
5.20	INVASIVE SPECIES	82
5.21	DISEASES.....	83
5.22	WIND ENERGY	83
5.23	ENTRAINMENT IN POWER PLANTS.....	83
5.24	SHIP-STRIKES	84
5.25	COMMERCIAL WHALING.....	86
5.26	SCIENTIFIC AND RESEARCH ACTIVITIES	86
5.27	PHYSICAL AND OCEANOGRAPHIC FEATURES	97
5.28	IMPACTS OF THE ENVIRONMENTAL BASELINE ON LISTED SPECIES	99
6	EFFECTS OF THE PROPOSED ACTIONS	103
6.1	POTENTIAL STRESSORS	104
6.1.1	<i>Pollution by Oil or Fuel Leakage</i>	<i>104</i>
6.1.2	<i>Disturbance from Engine Noise.....</i>	<i>104</i>
6.1.3	<i>Ship Strike.....</i>	<i>104</i>
6.1.4	<i>Entanglement</i>	<i>105</i>
6.2	EXPOSURE ANALYSIS.....	105
6.2.1	<i>NSF Exposure Estimates.....</i>	<i>106</i>
6.2.2	<i>NMFS Exposure Calculations.....</i>	<i>107</i>
6.3	RESPONSE ANALYSIS	118
6.3.1	<i>Potential Response of Marine Mammals to Acoustic Sources.....</i>	<i>118</i>
6.3.2	<i>Potential Responses of Sea Turtles to Acoustic Sources.....</i>	<i>130</i>

7	CUMULATIVE EFFECTS	131
8	INTEGRATION AND SYNTHESIS OF EFFECTS	131
9	CONCLUSION	133
10	INCIDENTAL TAKE STATEMENT	134
10.1	AMOUNT OR EXTENT OF TAKE	134
10.2	EFFECT OF THE TAKE	135
10.3	REASONABLE AND PRUDENT MEASURES	136
10.4	TERMS AND CONDITIONS	136
11	CONSERVATION RECOMMENDATIONS	140
12	REINITIATION NOTICE	140
13	LITERATURE CITED	141

LIST OF FIGURES

	Page
Figure 1. Proposed area for the marine seismic survey off New Jersey.	4
Figure 2. Modelled distances for the four-airgun array at 4.5 meter tow depth in deep water.	7
Figure 3. Modelled distances for the four-airgun array at six meter tow depth in deep water.	8
Figure 4. Modelled distances for the 40 in ³ mitigation gun at six meter tow depth in deep water. 9	
Figure 5. Conceptual framework of how anthropogenic noise impacts individuals and how those impacts may lead to fitness consequences.	17
Figure 6. Proposed area for the marine seismic survey off New Jersey.	19
Figure 7. A North Atlantic right whale entangled in fisheries gear off Florida, with Georgia Department of Natural Resources and Coastwise Consulting staff attempting to cut rope off (Credit: EcoHealth Alliance and Georgia Department of Natural Resources, ESA permit number 932-1905).	80

LIST OF TABLES

	Page
Table 1 Specifications of the four-airgun array to be used by the R/V <i>Langseth</i> during the proposed seismic activities.	5
Table 2 Sub-bottom profiler specifications of the R/V <i>Langseth</i>	6
Table 3. Predicted distances to which sound levels of 180, 166, and 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ could be received from the four-airgun arrays as well as the 40 in ³ airgun in water depths under 100 m.. 10	
Table 4. Species listed under the Endangered Species Act (ESA) in the action area that may experience adverse effects as a result of the proposed actions.	20
Table 5. Summary of past and present blue whale abundance.	24
Table 6. Summary of past and present fin whale abundance.....	28
Table 7. Summary of past and present humpback whale abundance.	32
Table 8. Summary of past and present sei whale abundance.....	40
Table 9. Summary of past and present sperm whale abundance.	44
Table 10. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF).	46
Table 11. Leatherback nesting population site location information where multiple-year surveys were conducted or trends are known (data type, years surveyed, annual number (nests, females, trend). Nesting population trend symbols: ▲ = increasing; ▼ = decreasing.....	60
Table 12. Anticipated incidental take of ESA species within U.S. Navy East Coast Training Range Complexes.	77
Table 13. Incidental take associated with U.S. Marine Corps training in the Cherry Point Range Complex that is currently authorized.	78
Table 14. Estimated annual interactions between sea turtles and shrimp trawls in the Gulf of Mexico shrimp fisheries associated estimated mortalities based on 2007 Gulf effort data taken from Nance et al. (2008).	81
Table 15. Blue whale takes in the North Atlantic.....	87
Table 16. Fin whale takes in the North Atlantic.	88
Table 17. Humpback whale takes in the North Atlantic and Mediterranean.....	89
Table 18. North Atlantic right whale takes.....	90
Table 19. Sei whale takes in the North Atlantic.	91
Table 20. Sperm whale takes in the North Atlantic.	92
Table 21. Green sea turtle takes in the Atlantic Ocean.....	93
Table 22. Kemp’s ridley sea turtle takes in the Atlantic Ocean.....	94
Table 23. Leatherback sea turtle takes in the North Atlantic Ocean.	95

Table 24. Loggerhead sea turtle takes in the North Atlantic Ocean.	96
Table 25. Predicted distances for received sound levels. Distances are for water depths <100m. Adapted from NSF Environmental Assessment 2014.	106
Table 26. Comparisons of the proposed take estimates calculated by the NMFS Permits and Conservation Division, and the NMFS Interagency Cooperation Division for ESA-listed whales.	110
Table 27. Estimated exposure of ESA-listed whales to sound levels >160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ during the proposed seismic activities, based on a daily ensounded area of 1, 904 km^2	112
Table 28. Number of sea turtles sighted during summer AMAPPS aerial and vessel surveys (2010-2013) and CETAP (1978-1982) surveys.....	114
Table 29: Observer data for sea turtles in statistical areas 612, 614, and 615 (2000-2014).	115
Table 30. Estimated exposure of ESA-listed sea turtles to sound levels >166 dB re 1 $\mu\text{Pa}_{\text{rms}}$ during the proposed seismic activities.	117
Table 31. Number of individual ESA-listed whales and sea turtles authorized for incidental take.	135

LIST OF ACRONYMS

AMAPPS-Atlantic Marine Assessment Program for Protected Species	IWC-International Whaling Commission
BOEM-Bureau of Ocean Energy Management	kHz-kilohertz
CETAP-Cetacean and Turtle Assessment Program	kg-kilogram
CFR-Code of Federal Regulations	L-DEO-Lamont Doherty Earth Observatory
CI-Confidence interval	MMPA-Marine Mammal Protection Act
CV-Coefficient of variation	ms-millisecond
dB-decibel	NAO-North Atlantic oscillation
DDE-Dichlorodiphenyldichloroethylene	NMFS-National Marine Fisheries Service
DDT-Dichlorodiphenyltrichloroethane	NOAA-National Oceanic and Atmospheric Administration
DPS-Distinct population segment	NSF-National Science Foundation
EEZ-Exclusive economic zone	PAM-Passive acoustic monitoring
ESA-Endangered Species Act	PCB-Polychlorinated biphenyl
EZ-Exclusion zone	PFOA-Perfluorooctanoic acid
HCB-Hexachlorobenzene	PFOS-Perfluorooctanesulfonic acid
HMS FMP-Highly migratory species fisheries management plan	PSVO-Protected species visual observer
Hz-Hertz	PTS-Permanent threshold shift
IHA-Incidental harassment authorization	RMS-Root mean squared
IPCC-Intergovernmental Panel on Climate Change	SEL-Sound exposure level

SERDP SDSS- Strategic Environmental Research
and Development Program Spatial Decision Support
System

TEWG-Turtle Expert Working Group

TTS-Temporary threshold shift

U.S.-United States

U.S.C.-United States Code

USFWS-United States Fish and Wildlife Service

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 et seq.) requires that each federal agency insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency “may affect” a listed species or critical habitat designated for it, that agency is required to consult with NOAA’s National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the activities described in this document, the Federal action agencies are the National Science Foundation (NSF) and NMFS’ Permits and Conservation Division.

Two federal actions are considered in this biological opinion (Opinion). The first is the NSF’s proposal to allow the use of its research vessel, *Marcus G. Langseth (Langseth)*, which is operated by the Lamont-Doherty Earth Observatory (L-DEO), to conduct a seismic survey off the coast of New Jersey from June to August of 2015, in support of an NSF-funded collaborative research project led by Rutgers University. The second is the NMFS’ Permits and Conservation Division proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal “takes” by Level B harassment (as defined by the Marine Mammal Protection Act (MMPA)) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D). The consulting agency is the NMFS’ Office of Protected Resources, ESA Interagency Cooperation Division.

This document represents NMFS’s ESA Interagency Cooperation Division’s Opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA. This Opinion is based on information provided in the:

- MMPA IHA application
- draft public notice of proposed IHA
- a draft environmental assessment prepared pursuant to the National Environmental Policy Act
- monitoring reports from similar activities
- published and unpublished scientific information on endangered and threatened species and their surrogates
- scientific and commercial information such as reports from government agencies and the peer-reviewed literature
- biological opinions on similar activities, and
- other sources of information.

1.1 Consultation History

On December 19, 2014, the NMFS’ ESA Interagency Cooperation Division received a request for formal consultation pursuant to section 7 of the ESA from the NSF to incidentally harass marine mammal and sea turtle species during the seismic survey; information was sufficient to initiate consultation with the NSF on this date. On the same date, the NMFS’ Permits and Conservation Division received an application from the L-DEO to incidentally harass marine mammal species pursuant to the MMPA during the proposed seismic survey.

On March 17, 2015, the NMFS' Permits and Conservation Division sent the application for the proposed seismic survey out to reviewers and published a notice in the *Federal Register* soliciting public comment on their intent to issue an IHA.

On April 7, 2015, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation under section 7 of the ESA from the NMFS' Permits and Conservation Division.

On April 10, 2015, the NMFS' ESA Interagency Cooperation Division met with the Permits and Conservation Division to discuss the take estimation methods used by the Permits and Conservation Division in its initiation request. The Permits and Conservation Division agreed to modify its take estimate approach based upon discussion in that meeting.

On April 17, 2015 the NMFS' ESA Interagency Cooperation Division again met with the Permits and Conservation Division to discuss the modified take estimation methods used by the Permits and Conservation Division in their incidental harassment authorization. The ESA Interagency Cooperation Division requested documentation of this approach.

On April 20, 2015, the Permits and Conservation Division provided additional support documentation for the modified analytical approach and take authorization in the Permits and Conservation Division's MMPA incidental harassment authorization. Information was sufficient to initiate consultation with the Permits and Conservation Division on this date.

On May 1, 2015, the NMFS' ESA Interagency Cooperation Division again met with the Permits and Conservation Division to discuss analytical approaches to assessing the action. It was determined that both analyses produced no jeopardy outcomes and that the take estimates of the Permits and Conservation Division are more appropriate to include in the ITS.

2 DESCRIPTION OF THE PROPOSED ACTIONS

Two federal actions were evaluated in this Opinion. The first is the NSF's proposal to allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*), operated by the L-DEO, to conduct a seismic survey off the coast of New Jersey from June to August of 2015, in support of an NSF-funded collaborative research project led by Rutgers University. The second is the NMFS' Permits and Conservation Division proposal to issue an IHA authorizing non-lethal "takes" by Level B harassment pursuant to section 101 (a)(5)(D) of the MMPA.

2.1 National Science Foundation Proposed Action

The NSF proposes to allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*) to conduct a seismic survey off the coast of New Jersey during an approximate 30 day period from June to August, 2015. An array of four airguns will be deployed as an energy source. In addition, a multibeam echosounder and a sub-bottom profiler will continuously operate from the *Langseth*, except during transit to the survey site. A system of three kilometer-long hydrophone streamers (up to four streamers in total) will also be deployed.

The purpose of the proposed activities is to collect data across existing Integrated Ocean Drilling Program (IODP) Expedition 313 drill sites on the inner-middle shelf of the New Jersey continental margin to reveal the arrangement of sediments deposited during times of changing global sea level from roughly 60 million years ago to present. Features such as river valleys cut into coastal plain sediments, now buried under younger sediment and flooded by today's ocean, cannot be identified and traced with existing 2-D seismic data, despite their existence being clearly indicated in sediment cores recovered during IODP Expedition 313. These and other erosional and depositional features will be imaged using 3-D seismic data and will enable follow-on studies to identify the magnitude, time, and impact of major changes in sea level. The proposed seismic survey will collect data in support of a research proposal that was reviewed under the NSF merit review process and identified as an NSF program priority to meet NSF's critical need to foster a better understanding of Earth processes.

2.1.1 Schedule

The NSF proposes to allow the use of the *Langseth* by L-DEO roughly 30 days of seismic operations and an additional five days of non-airgun operations. Some minor deviation from the proposed dates is possible, depending on logistics, weather conditions, and the need to repeat some survey lines if data quality is substandard. During an approximate 30-day period in June to August 2015, corresponding to an effective IHA, the *Langseth* would survey the action area (**Figure 1**). The *Langseth* would depart from and return to New York, New York. NMFS' Permits and Conservation Division proposes to issue an authorization that is effective from June 1, 2015 to August 31, 2015.

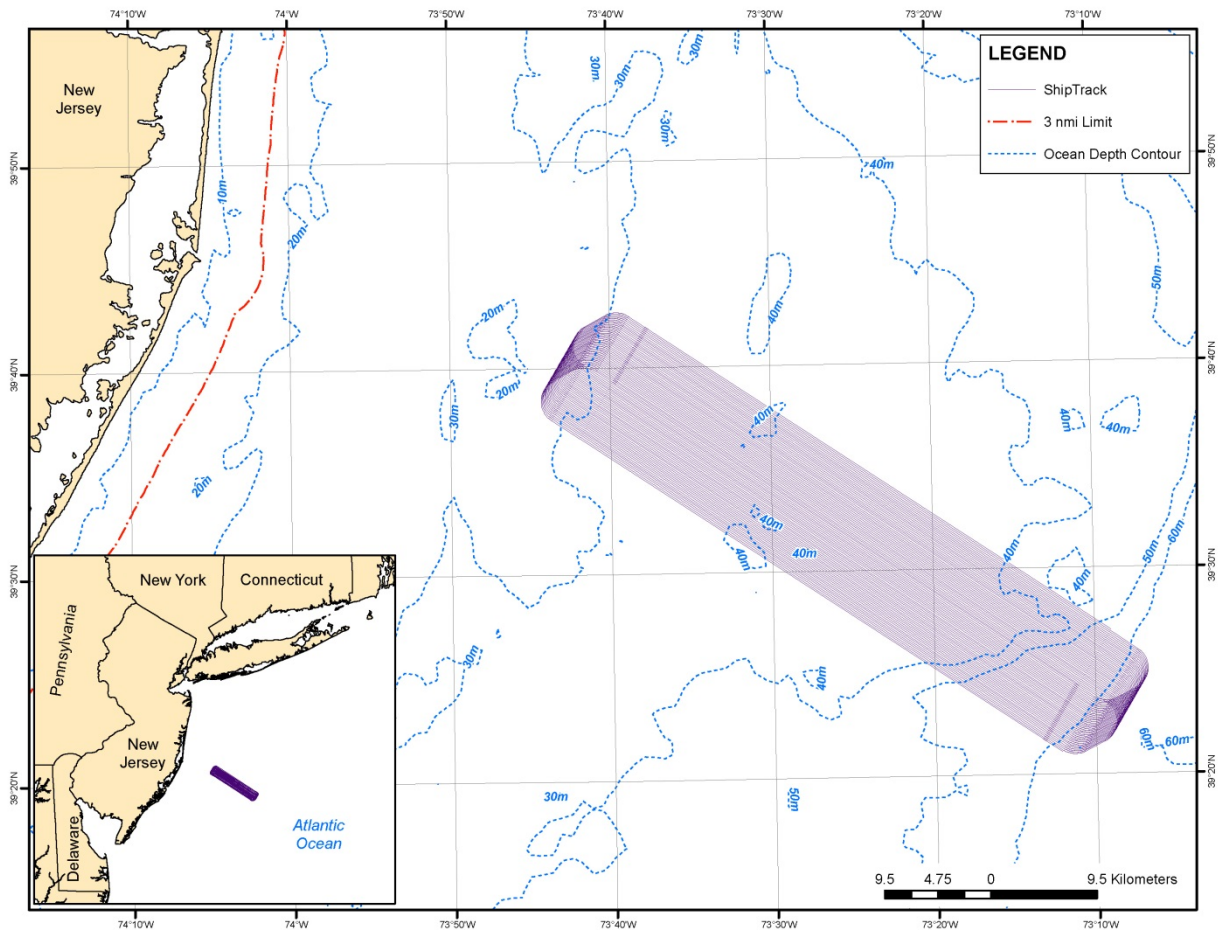


Figure 1. Proposed area for the marine seismic survey off New Jersey.

2.1.2 Source Vessel Specifications

The *Langseth* will tow a four-airgun array along predetermined lines (see Figure 1). The *Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic acquisition is typically 8.3 km/h (4.4 knots). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km/h (10 knots).

The *Langseth* will also serve as the platform from which protected species visual observers (PSVOs) would watch for animals. Although the airgun array will operate during straight-line and early turn portions of the transects, only a mitigation gun will operate during most of the turns and entries into straight-line transects.

A chase vessel will also be used in logistical support of the project. Although the exact vessel is uncertain, it is described in the NSF's Environmental Assessment prepared under the National Environmental Policy Act, as resembling an offshore utility vessel of roughly 28 m in length, 2.6 m in draft, and twin screws of 450 horsepower each. The chase vessel will operate at roughly the same speed as the *Langseth*.

2.1.3 Airgun Description

The airgun array will consist of two pairs of four airgun arrays (**Table 1**). However, only four of these airguns will be active at any given time (i.e., one pair at a time) and total discharge volume will be limited to 700 in³. The airgun configuration includes a pair of linear arrays or “strings”. Each string will have four airguns. Up to four airguns in one string would fire at any one time. The four-airgun strings will be towed approximately 150 m behind the vessel. The tow depth of the array will be 4.5 or 6 m. The airgun array will fire roughly every five to six seconds. During firing, a brief (approximately 0.1 s) pulse of sound will be emitted, but be silent during the intervening periods. This signal attenuates as it moves away from the source, decreasing in amplitude, but also increasing in signal duration. Airguns will operate continually during the survey period except for unscheduled shutdowns.

Table 1 Specifications of the four-airgun array to be used by the R/V *Langseth* during the proposed seismic activities.

Four-airgun array specifications	
Energy source	4-1,950 psi bolt airguns of 120-220 in ³ each, in four strings of nine operating airguns per string
Source our tput (downward)-4 airgun array	0-pk is 240.4 dB re 1 μ Pa·m; pk-pk is 246.3-246.7 dB re 1 μ Pa·m
Air discharge volume	~ 700 in ³
Dominant frequency components	0-188 Hz

Because the actual source originates from four airguns rather than a single point source, the highest sound levels measurable at any location in the water is less than the nominal source level. In addition, the effective source level for sound propagating in near-horizontal directions will be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array.

2.1.4 Multibeam Echosounder and Sub-bottom Profiler

Along with airgun operations, three additional acoustical data acquisition systems will operate during the survey from the *Langseth*. The multibeam echosounder and sub-bottom profiler systems will map the ocean floor during the survey. These sound sources will operate from the *Langseth* simultaneously with the airgun array.

The multibeam echosounder is a hull-mounted system operating at 10.5-13 kHz. The beamwidth is 1 or 2° fore-aft and 150° perpendicular to the ship’s line of travel. The maximum source level is 242 dB re 1 μ Pa·m_{rms}. For deepwater operation, each “ping” consists of eight successive fan-shaped transmissions, each 2 to 15 ms in duration and each ensonifying a sector that extends 1° fore-aft. The eight successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between the pulses for successive sectors (Maritime 2005).

The sub-bottom profiler provides information about the sedimentary features and the bottom

topography that is being mapped simultaneously by the multibeam echosounder (**Table 2**). The output varies with water depth from 50 watts in shallow water to 1,000 (204 dB) watts in deep water. The pulse interval is 1 s, but a common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

Table 2 Sub-bottom profiler specifications of the R/V *Langseth*.

<u>Langseth sub-bottom profiler specifications</u>	
Maximum/normal source output (downward)	204 dB re 1 μ Pa·m; 800 watts
Dominant frequency component	3.5 kHz
Bandwidth	1.0 kHz with pulse duration 4 ms
	0.5 kHz with pulse duration 2 ms
	0.25 kHz with pulse duration 1 ms
Nominal beam width	30°
Pulse duration	1, 2, or 4 ms

2.1.5 Proposed Exclusion Zones

The NSF identifies in its EA that the L-DEO will implement exclusion zones (EZs) around the *Langseth* to minimize any potential adverse effects of airgun sound on MMPA and ESA-listed species. These zones are areas where seismic airguns would be powered down or shut down to reduce exposure of marine mammals and sea turtles to sound levels expected to produce potential fitness consequences. These EZs are based upon modeled sound levels at various distances from the *Langseth*, described below.

Predicted Sound Levels vs. Distance and Depth. The L-DEO has predicted received sound levels in deep water (free-field model), in relation to distance and direction from a four-airgun array (Figure 2 and Figure 3) as well as a 40 in³ single 1900LLX airgun used during power-downs (Figure 4). In shallow water, empirical data concerning 180 and 160 dB re 1 μ Pa_{rms} distances were acquired during the acoustic calibration study of the *Langseth*'s 18-airgun 3,300 in³ array in the Gulf of Mexico (Diebold et al. 2010). However, the array configuration and tow depth were different in the Gulf of Mexico calibration study (3,300 in³, 6 m tow depth) than in the proposed survey (700 in³, 4.5 or 6 m tow depth). To adapt the shallow-water measurements obtained during the calibration survey to the proposed array configuration(s) and tow depth(s), scaling factors have been applied to the distances reported by Diebold et al. (2009) for shallow waters, and this scaling is done according to the sound exposure level (SEL) contours obtained from the free-field modeling. Figures 3-5 show predicted distances of the various configurations of the airguns.

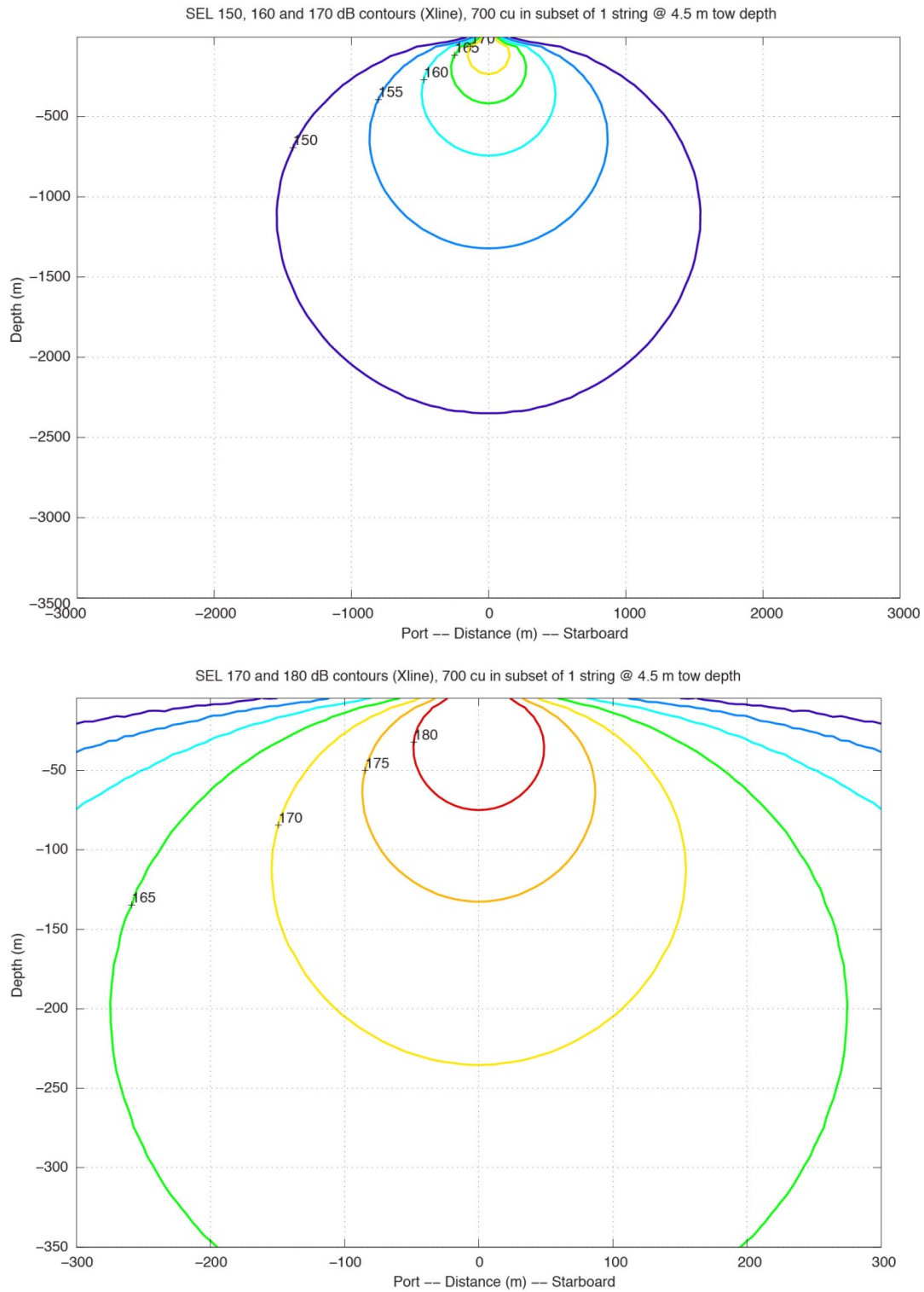


Figure 2. Modelled distances for the four-airgun array at 4.5 meter tow depth in deep water.

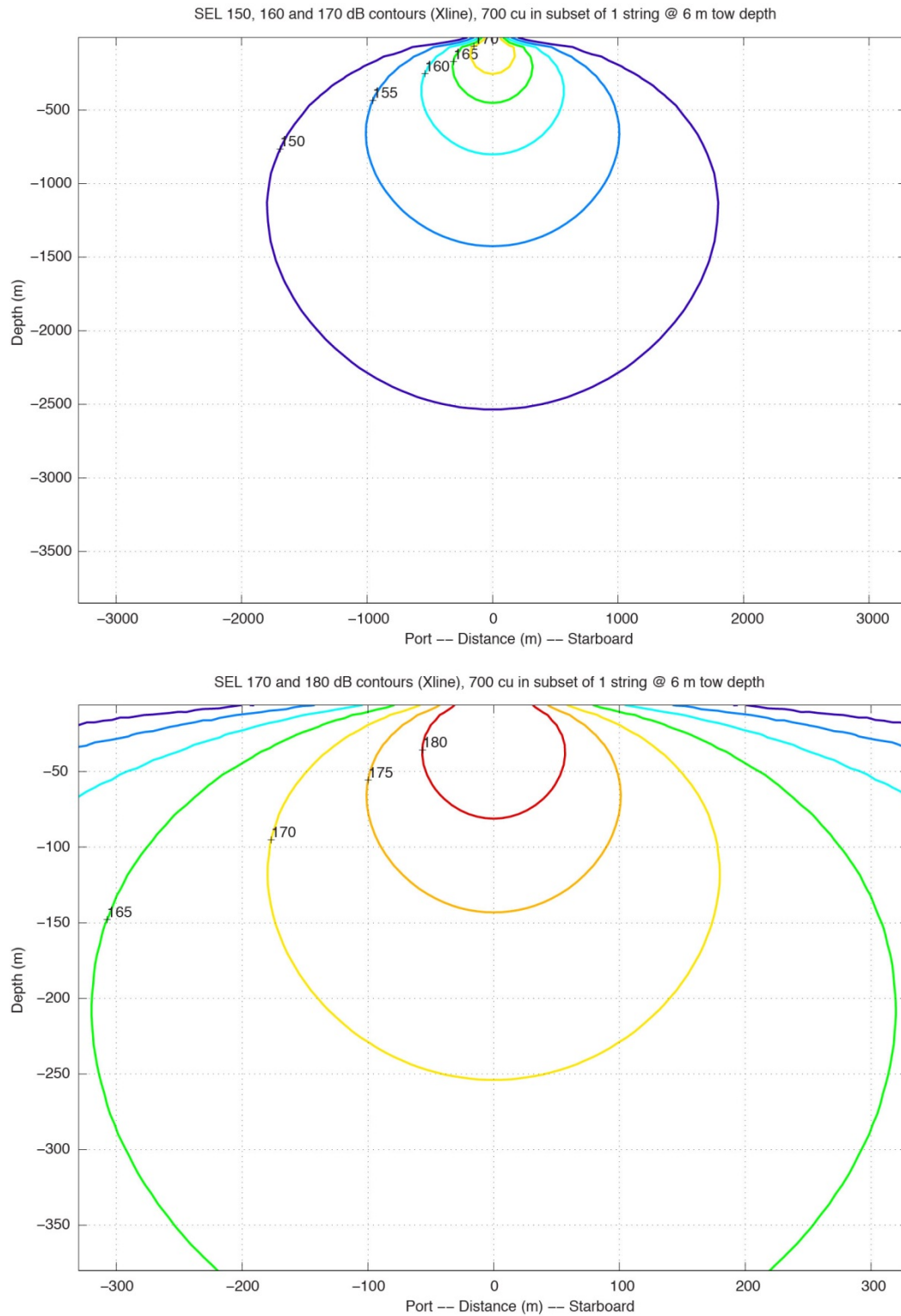


Figure 3. Modelled distances for the four-airgun array at six meter tow depth in deep water.

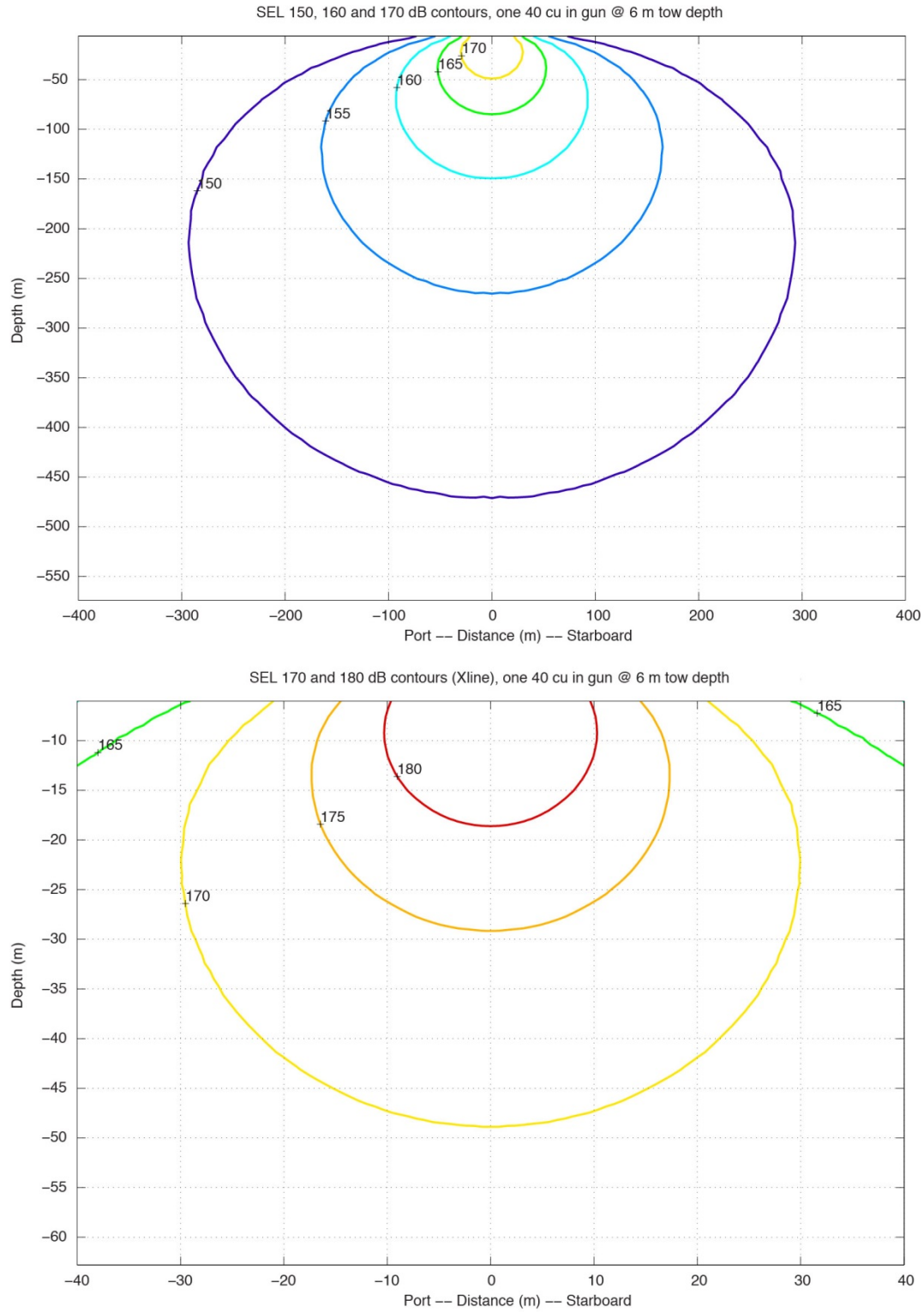


Figure 4. Modelled distances for the 40 in³ mitigation gun at six meter tow depth in deep water.

Table 3 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the four-airgun arrays and a single airgun. The 180 dB re 1 $\mu\text{Pa}_{\text{rms}}$ distance is the safety criteria as specified by NMFS (1995) as applicable to cetaceans under the MMPA. The 180 dB will be used as the exclusion zone (EZ) for marine mammals, as required by NMFS during most other recent L-DEO seismic projects (Holst and Beland 2008; Holst and Smultea 2008b; Holst et al. 2005a; Holt 2008; Smultea et al. 2004). The 180 dB isopleth would also be the EZ boundary for sea turtles. The 166 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns. The 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ distance is the distance at which MMPA take, by Level B harassment, is expected to occur.

Table 3. Predicted distances to which sound levels of 180, 166, and 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ could be received from the four-airgun arrays as well as the 40 in³ airgun in water depths under 100 m.

Source, volume, and tow depth	Predicted RMS radii (m)		
	180 dB	166 dB	160 dB
four-airgun array 700 in ³ @ 4.5 m	378	2,229	5,240
four-airgun array 700 in ³ @ 6 m	439	2,599	6,100
single Bolt airgun, 40 in ³ @ 6 m	100	424	995

2.2 NMFS Permits and Conservation Division's Incidental Harassment Authorization

The NMFS' Permits and Conservation Division is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment of marine mammals incidental to the planned seismic survey. The IHA will be valid from June 1, 2015 through August 31, 2015, and will authorize the incidental harassment of the following endangered species (among other species): blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*), humpback whales (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), sperm whales (*Physeter macrocephalus*), and other non-listed marine mammals. The proposed IHA identifies the following requirements that L-DEO must comply with as part of its authorization.

- A. Establish a safety radius corresponding to the anticipated 180-dB isopleth for full (700 in³) and single (40 in³) airgun operations.
- B. Use two, NMFS-approved, vessel-based PSVOs to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations, start-ups of airguns at night, and while the seismic array and streamers are being deployed and retrieved. Vessel crew will also assist in detecting marine mammals, when practical. Observers will have access to reticle binoculars (7 X 50 Fujinon), big-eye binoculars (25 X 150), optical range finders, and night vision devices. PSVOs shifts will last no longer than 4 hours at a time. PSVOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.
- C. Record the following information when a marine mammal is sighted:
 - i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace.
 - ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare.
 - iii. The data listed under ii. would also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.
- D. Visually observe the entire extent of the safety radius using PSVOs, for at least 30 min prior to starting the airgun (day or night). If PSVOs find a marine mammal within the safety zone, L-DEO must delay the seismic survey until the marine mammal has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the safety zone. If for any reason the entire radius cannot be seen for the entire 30 min (e.g. rough seas, fog, darkness), or if marine mammals are near, approaching or in the safety radius, the airguns may not be started up. If one airgun is already running at a source level of at least 180 dB, L-DEO may start subsequent guns without observing the entire safety radius for 30 min prior, provided no marine mammals are known to be near the safety

radius. In the event a North Atlantic right whale (*Eubalaena glacialis*) is visually sighted, the airgun array will be shut-down regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 min after the last documented whale visual sighting. If concentrations (six or more individuals) of blue, fin, humpback, sei, or sperm whales are observed, then the array will be powered down and the group avoided if possible if they do not appear to be traveling.

E. Use the passive acoustic monitoring system (PAM) to detect marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO and/or bioacoustician will monitor the PAM at all times in shifts of up to 6 h. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

F. Record the following when an animal is detected by the PAM:

- i. Contact the PSVO immediately (and initiate power or shut-down, if required);
- ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

G. Apply a “ramp-up” procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs will monitor the safety radius, and if marine mammals are sighted, a course/speed alteration, power-down, or shut-down will occur as though the full array were operational.

H. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the safety zone. If speed or course alteration is not safe or practical, or if after alteration the marine mammal still appears likely to enter the safety zone, further mitigation measures, such as power-down or shut-down, will be taken.

I. Shut-down or power-down the airguns upon marine mammal detection within, approaching, or entering the safety radius. A power-down means shutting down one or more airguns and reducing the safety radius to the degree that the animal is outside of it. Following a power-down, if the marine mammal approaches the smaller designated safety radius, the airguns must completely shut down. Airgun activity will not resume until the marine mammal has cleared the safety radius, which means it was visually observed to have left the safety radius, or has not been seen within the radius for 15 min (small odontocetes) or 30 min (mysticetes and large odontocetes). The array will not resume firing until 30 min after the last documented whale visual sighting. The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

J. To the maximum extent practicable, schedule seismic operations (*i.e.*, shooting airguns)

during daylight hours. Marine seismic operations may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored. No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSVO(s) on duty.

K. In the unanticipated event that any taking of a marine mammal in a manner prohibited by the proposed Authorization occurs, such as an injury, serious injury or mortality, and is judged to result from these activities, L-DEO will immediately cease operating all authorized sound sources and report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov as well as the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 (Mendy.Garron@noaa.gov). L-DEO will postpone the research activities until NMFS is able to review the circumstances of the take. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate and necessary, and notify L-DEO that they may resume the seismic survey operations.

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound sources used in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

L. In the unanticipated event that any cases of marine mammal injury or mortality are judged to result from these activities (*e.g.*, ship-strike, gear interaction, and/or entanglement), L-DEO will cease operating seismic airguns and report the incident to NMFS' Office of Protected Resources at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov as well as the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 (Mendy.Garron@noaa.gov) immediately. Airgun operation will then be postponed until NMFS is able to review the circumstances and work with L-DEO to determine whether modifications in the activities are appropriate and necessary. If the lead observer judged that the injury or mortality is not a result of the authorized activities, operations may continue.

M. L-DEO is required to comply with the Terms and Conditions of this Opinion's Incidental Take Statement issued to both the NSF and the NMFS' Office of Protected Resources.

In addition, the proposed IHA requires L-DEO to adhere to the following reporting requirements:

A. The Holder of this Authorization is required to submit a report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days after the

expiration of the IHA. This report must contain and summarize the following information:

- i. Dates, times, locations, heading, speed, weather, and associated activities during all seismic operations.
- ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shutdowns), observed throughout all monitoring activities.
- iii. An estimate of the number (by species) of marine mammals that:
 - a. Are known to have been exposed to the seismic activity (visual observation) at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 180 dB re 1 microPa (rms) for cetaceans with a discussion of any specific behaviors those individuals exhibited.
 - b. May have been exposed (modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 180 dB re 1 microPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.
- iv. A description of the implementation and effectiveness of the:
 - a. Terms and conditions of the Opinion's Incidental Take Statement.
 - b. Mitigation measures of the IHA. For the Opinion, the report will confirm the implementation of each term and condition and describe the effectiveness, as well as any conservation measures, for minimizing the adverse effects of the action on listed whales.

3 APPROACH TO THE ASSESSMENT

The NMFS approaches its section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *Exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *Response analyses*).

The final steps of our analyses – establishing the risks those responses pose to ESA-listed resources – are different for listed species and designated critical habitat (these represent our *Risk analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those “species” have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. The continued existence of these “species” depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that compose the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' “fitness,” or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When an individual is expected to experience reductions in fitness in response to an action's effects, those fitness reductions may reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we

would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental baseline* and *Status of listed resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of listed resources* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the best scientific and commercial evidence available to us. This evidence consists of the environmental assessment submitted by the NSF, monitoring reports submitted by past and present seismic survey operators, reports from NMFS Science Centers; reports prepared by natural resource agencies in states and other countries, reports from non-governmental organizations involved in marine conservation issues, the information provided by NMFS' Permits and Conservation Division when it initiates formal consultation, the general scientific literature, and our expert opinion.

We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and state agencies like the Bureau of Ocean Energy Management, U.S. Coast Guard, and U.S. Navy whose operations extend into the marine environment.

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 would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

3.1 Assessment approach applied to this consultation

In this particular assessment, we identified the potential stressors associated with the action and determined which were probable based upon previous seismic surveys. Of the probable stressors, we identified the species that are expected to co-occur with the effects of the action, particularly the acoustic isopleths of the airgun and other sound sources. Utilizing survey data from previous years and predictive environmental factors, density estimates per unit area of ESA-listed whales were multiplied by the area to be ensounded where effects were expected. Our primary concerns in this consultation revolve around exposure of listed individuals to anthropogenic sound sources, where those individuals may respond with behaviors that may result in fitness consequences (Francis and Barber 2013; Nowacek and Tyack 2013) (Figure 5). However, it should not be assumed that anthropogenic stressors lead to fitness consequences at the individual or population levels (New et al. 2013).

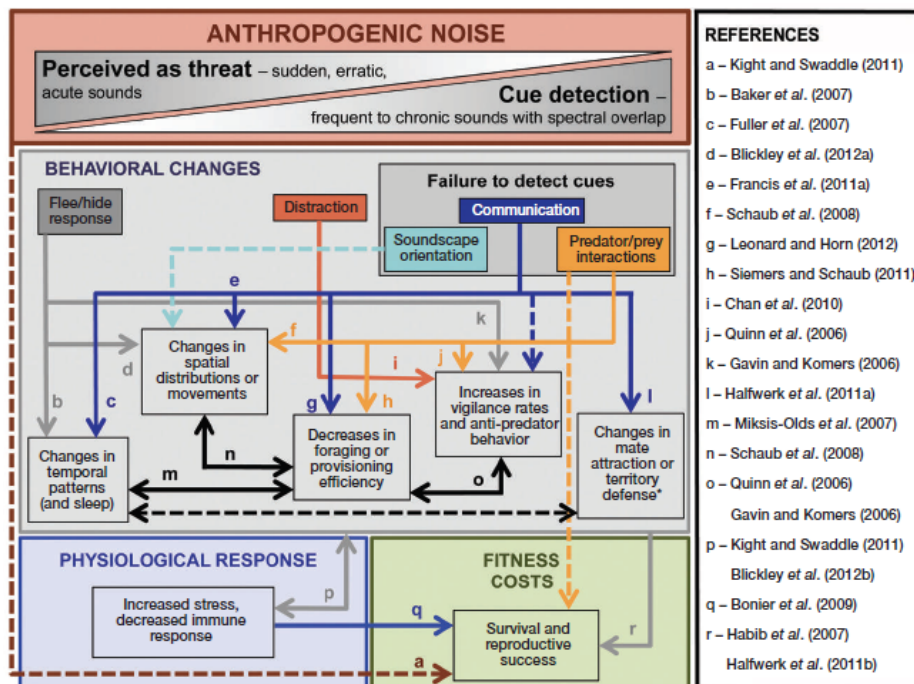


Figure 5. Conceptual framework of how anthropogenic noise impacts individuals and how those impacts may lead to fitness consequences.¹

¹ Figure taken from Francis *et al.* Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6):305-313.

In order to reach conclusions regarding whether proposed actions are likely to jeopardize ESA-listed species, we had to make several assumptions. These included:

- Baleen whales can generally hear low-frequency sound (Southall et al. 2007a) better than high frequencies (Southall et al. 2007a), as the former is primarily the range in which they vocalize. Humpback whales frequently vocalize with mid-frequency sound (Southall et al. 2007a) and are likely to hear at these frequencies as well. Because of this, we can partition baleen whales into two groups: those that are specialists at hearing low frequencies (e.g., fin, North Atlantic right, and sei whales) and those that hear at low- to mid-frequencies (blue and humpback whales). Toothed whales (such as sperm whales) are better adapted to hear mid- and high-frequency sound for the same reason (although this species also responds to low-frequency sound and is considered to hear at low-, mid-, and high frequencies; i.e., vocalization, as is assumed for baleen whales). Sperm whales are also assumed to have similar hearing qualities as other, better studied, toothed whales. Hearing in sea turtles is generally similar within the taxa, with data from loggerhead and green sea turtles being representative of the taxa as a whole.
- Species for which little or no information on response to sound at different received sound levels will respond similarly to their close taxonomic or ecological relatives (i.e., baleen whales respond similarly to each other; same for sea turtles).

4 ACTION AREA

The seismic survey will be conducted off the New Jersey coast, outside of state waters, and within the Exclusive Economic Zone of the U.S. The region in which the seismic survey will occur is between 39.6° and 39.4° N and 73.7° and 73.8° W (Figure 6). The region encompasses water depths from 20-75 m along roughly 3,920 km of trackline, including turns and other seismic operations. In addition, the applicant estimated a 25% increase in trackline due to equipment failures, a need to reshoot some areas, and other logistical impacts, increasing the expected trackline to 4,900 km. Responses to seismic sound sources by listed marine mammals occur within the 160 dB isopleths (modeled to be up to 6.1 km from the *Langseth*), increasing the area ensonified along the trackline, including overlapping areas, to 72,348 km². Responses to seismic sound sources by listed sea turtles occur within the 166 dB isopleths (modeled to be up to 2.599 km from the *Langseth*), increasing the area ensonified along the trackline, including overlapping areas but including 25% increase due to contingencies, to 25,470 km². We also assessed the vessel transit to and from port for potential effects.

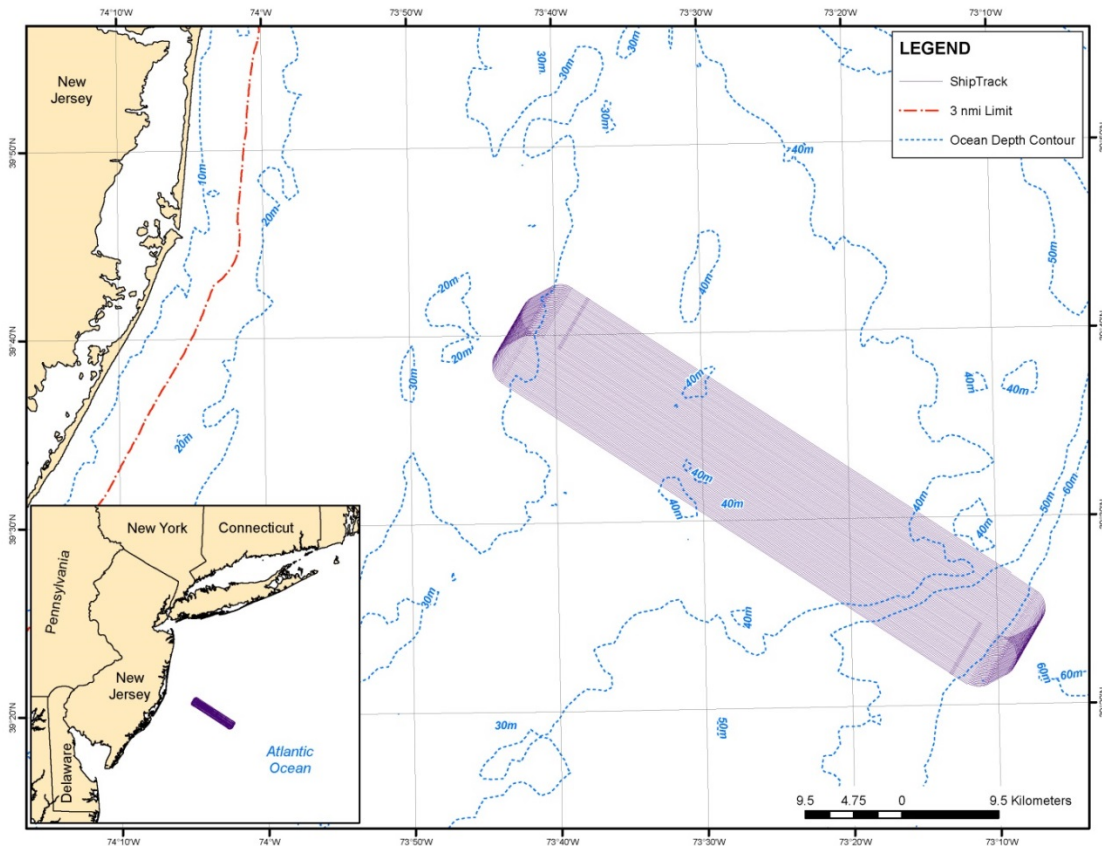


Figure 6. Proposed area for the marine seismic survey off New Jersey.

5 STATUS OF LISTED RESOURCES

The actions considered in this Opinion may affect species listed in **Table 4**, which are provided protection under the ESA.

Table 4. Species listed under the Endangered Species Act (ESA) in the action area that may experience adverse effects as a result of the proposed actions.

Species	ESA Status*	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (<i>Balaenoptera musculus</i>)	E - 35 FR 18319	-- --	07/1998
Fin Whale (<i>Balaenoptera physalus</i>)	E - 35 FR 18319	-- --	71 FR 38385
Humpback Whale (<i>Megaptera novaeangliae</i>)	E - 35 FR 18319	-- --	55 FR 29646
Sei Whale (<i>Balaenoptera borealis</i>)	E - 35 FR 18319	-- --	-- --
Sperm Whale (<i>Physeter macrocephalus</i>)	E - 35 FR 18619	-- --	75 FR 81584
North Atlantic Right Whale (<i>Eubalaena glacialis</i>)	E - 35 FR 18319	59 FR 28805	70 FR 32293
Sea Turtles			
Kemp's Ridley (<i>Lepidochelys kempii</i>)	E - 35 FR 18319	-- --	-- --
Loggerhead (<i>Caretta caretta</i>): Northeast Atlantic DPS	E - 76 FR 58868	79 FR 39855	63 FR 28359†
Green (<i>Chelonia mydas</i>)	T - 43 FR 32800	-- --	63 FR 28359†
Leatherback (<i>Dermochelys coriacea</i>)	E - 35 FR 8491	-- --	63 FR 28359

*E=Endangered; T=Threatened

†Recovery Plan pertains to the U.S. Pacific population of loggerhead sea turtles

†A recovery plan for leatherbacks in the U.S. Atlantic (i.e., within the action area) is not available. However, there is a Recovery plan in place for leatherbacks in the Pacific (63 FR 28359), although it is not directly applicable to this action area.

5.1 Species and Critical Habitat Not Considered Further

Although the area in which the seismic survey is proposed to occur is relatively close to shore, we do not believe that listed sturgeons are likely to be present in the action area. Both Atlantic and shortnose sturgeon occur in nearshore marine waters along the mid-Atlantic, but tagging studies have not found them to occur as far offshore as the proposed action area. We also do not expect Atlantic salmon to occur in the action area during the seismic survey. Thus, NMFS does not anticipate that the proposed seismic survey would incidentally take any listed sturgeons or Atlantic salmon. Hawksbill sea turtles have been known to rarely strand along New Jersey shores or further north. However, the lack of sighting or bycatch data, as well as the rarity of strandings, leads us to believe that hawksbill sea turtles are unlikely to be in the action area at the time of the proposed seismic survey. The biology and ecology of species with anticipated exposure below informs the effects analysis for this Opinion. Summaries of the global status and trends of each species presented provide a foundation for the analysis of species as a whole.

5.2 Species Considered Further in this Opinion

The species narrative that follows focuses on attributes of life history and distribution that influence the manner and likelihood that this species may be exposed to the proposed action, as well as the potential response and risk when exposure occurs. Consequently, the species'

narrative is a summary of a larger body of information on localized movements, population structure, feeding, diving, and social behaviors.

A summary of the status and trends of ESA-listed whales and sea turtles is presented here to provide a foundation for the analysis of the species as a whole. We also provide this brief summary of the species' status and trends as a point of reference for the jeopardy determination, made later in this Opinion. That is, we rely on a species' status and trend to determine whether an action's direct or indirect effects are likely to increase the species' probability of becoming extinct.

5.2.1 Blue whale

Subspecies. Several blue whale subspecies have been characterized from morphological and geographical variability, but the validity of blue whale subspecies designations remains uncertain (McDonald et al. 2006). The largest, the Antarctic or true blue whale (*Balaenoptera musculus intermedia*), occurs in the highest Southern Hemisphere latitudes (Gilpatrick and Perryman. 2009). During austral summers, "true" blue whales occur close to Antarctic ice. A slightly smaller blue whale, *B. musculus musculus*, inhabits the Northern Hemisphere (Gilpatrick and Perryman. 2009). The pygmy blue whale (*B. musculus breviceauda*), may be geographically distinct from *B. m. musculus* (Kato et al. 1995). Pygmy blue whales occur north of the Antarctic Convergence (60°-80° E and 66°-70° S), while true blue whales are found south of the Convergence (58° S) in the austral summer (Kasamatsu et al. 1996; Kato et al. 1995). A fourth subspecies, *B. musculus indica*, may exist in the northern Indian Ocean (McDonald et al. 2006), although these whales are frequently referred to as *B. m. breviceauda* (Anderson et al. 2012). Inbreeding between *B. m. intermedia* and *B. m. breviceauda* does occur (Attard et al. 2012).

Population structure. Little is known about population and stock structure² of blue whales. Studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Some suggest that as many as 10 global populations may exist, while other studies suggest that the species is composed of a single panmictic population (Gambell 1979; Gilpatrick and Perryman. 2009; Reeves et al. 1998). For management purposes, the International Whaling Commission (IWC) considers all Pacific blue whales to be a single stock, whereas under the MMPA, the NMFS recognizes four stocks of blue whales: western North Pacific Ocean, eastern North Pacific Ocean, Northern Indian Ocean, and Southern Hemisphere.

Until recently, blue whale population structure had not been tested using molecular or nuclear genetic analyses (Reeves et al. 1998). A recent study by Conway (2005) suggested that the global population could be divided into four major subdivisions, which roughly correspond to major ocean basins: eastern North and tropical Pacific Ocean, Southern Indian Ocean, Southern

"Populations" herein are a group of individual organisms that live in a given area and share a common genetic heritage. While genetic exchange may occur with neighboring populations, the rate of exchange is greater between individuals of the same population than among populations---a population is driven more by internal dynamics, birth and death processes, than by immigration or emigration of individuals. To differentiate populations, NMFS considers geographic distribution and spatial separation, life history, behavioral and morphological traits, as well as genetic differentiation, where it has been examined. In many cases, the behavioral and morphological differences may evolve and be detected before genetic variation occurs. In some cases, the term "stock" is synonymous with this definition of "population" while other usages of "stock" are not.

Ocean, and western North Atlantic Ocean.

North Atlantic. Blue whales are found from the Arctic to at least mid-latitude waters, and typically inhabit the open ocean with occasional occurrences in the U.S. Exclusive Economic Zone (EEZ) (Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Yochem and Leatherwood (1985) summarized records suggesting winter range extends south to Florida and the Gulf of Mexico. The U.S. Navy's Sound Surveillance System acoustic system has detected blue whales in much of the North Atlantic, including subtropical waters north of the West Indies and deep waters east of the U.S. Atlantic EEZ (Clark 1995). Blue whales are rare in the shelf waters of the eastern U.S. In the western North Atlantic, blue whales are most frequently sighted from the Gulf of St. Lawrence and eastern Nova Scotia and in waters off Newfoundland, during the winter (Sears et al. 1987). In the eastern North Atlantic, blue whales have been observed off the Azores, although Reiner et al. (1993) did not consider them common in that area. Observations of feeding have recently occurred over Ireland's western continental slope (Wall et al. 2009). No sightings have been made in the action area, although scattered rare sightings in the general region are documented (NSF 2014).

Age distribution. Blue whales may reach 70–80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

Reproduction. Gestation takes 10-12 months, followed by a 6-7 month nursing period. Sexual maturity occurs at 5-15 years of age and calves are born at 2-3 year intervals (COSEWIC 2002; NMFS 1998b; Yochem and Leatherwood 1985). Recent data from illegal Russian whaling for Antarctic and pygmy blue whales support sexual maturity at 23 m and 19-20 m, respectively (Branch and Mikhalev 2008). The mean intercalving interval in the Gulf of California is roughly two and half years (Sears et al. 2014). Once mature, females return to the same areas where they were born to give birth themselves (Sears et al. 2014).

Movement. Satellite tagging indicates that, for blue whales tagged off Southern California, movement is more linear and faster (3.7 km/h) while traveling versus while foraging (1.7 km/h)(Bailey et al. 2009). Residency times in what are likely prey patches averages 21 days and constituted 29% of an individual's time overall, although foraging could apparently occur at any time of year for tagged individuals (Bailey et al. 2009). Broad scale movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2009). Blue whales along Southern California were found to be traveling 85% of the time and milling 11% (Bacon et al. 2011). Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998a). In the eastern Central Atlantic, blue whales appear to migrate from areas along Greenland and Iceland to the Azores over and east of the Mid-Atlantic Ridge, apparently engaging in some random movement along the way (Anil et al. 2013).

Feeding. Data indicate that some summer feeding takes place at low latitudes in upwelling-modified waters, and that some whales remain year-round at either low or high latitudes (Clarke and Charif 1998b; Hucke-Gaete et al. 2004; Reilly and Thayer 1990; Yochem and Leatherwood 1985). Prey availability likely dictates blue whale distribution for most of the year (Burtenshaw et al. 2004; Clapham et al. 1999; Sears 2002 as cited in NMFS 2006a). The large size of blue whales requires higher energy requirements than smaller whales and potentially prohibits fasting

Mate et al. (1999). Blue whales typically occur alone, or in groups of two or three and up to five animals (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and MacAskie 1969; Ruud 1956; Slijper 1962). (Corkeron et al. 1999; Shirihai 2002). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991). While feeding, blue whales show slowed and less obvious avoidance behavior than when not feeding (Sears et al. 1983 as cited in NMFS 2005b).

Vocalization and hearing. Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see Cummings and Thompson 1971; Cummings and Thompson 1977; Edds-Walton 1997b; Edds 1982; McDonald et al. 1995a; Thompson and Friedl 1982). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1 μ Pa, but may reach 195 dB re 1 μ Pa (Aburto et al. 1997; Clark and Ellison 2004; Ketten 1998b; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μ Pa_{rms} in the 17-30 Hz range and pygmy blue whale calls at 175 ± 1 dB re 1 μ Pa_{rms} in the 17-50 Hz range. Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings et al. 1972; Cummings and Thompson 1971; Cummings and Thompson 1977; Cummings and Thompson 1994; Rivers 1997; Thompson et al. 1996). As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources (Edds-Walton 1997a; Payne and Webb 1971; Thompson et al. 1992a). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure. Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females, competing with other males, or both. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function.

Status and trends. Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973.

Table 5 contains historic and current estimates of blue whales by region. Globally, blue whale abundance has been estimated at between 5,000-13,000 animals (COSEWIC 2002; Yochem and Leatherwood 1985); a fraction of the 200,000 or more that are estimated to have populated the oceans prior to whaling (Maser et al. 1981; U.S. Department of Commerce 1983). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how the risk to the affected population(s) bears on the status of the species as a whole.

Table 5. Summary of past and present blue whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Current estimate	95% CI	Source
Global	~~	200,000	~~	11,200-13,000	~~	(DOC 1983; Maser et al. 1981)
	~~	~~	~~	5,000-12,000	~~	(COSEWIC 2002)
North Atlantic	Basinwide	1,100-1,500	~~	100-555	~~	(Braham 1991; Gambell 1976)
	~~			1,000-2,000		(Sigurjonsson 1995)
	NMFS-western North Atlantic stock	~~	~~	440	~~	(Waring et al. 2013)
	Central and northeast Atlantic	~~	~~	855	351-1,589	(Pike et al. 2009b)

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

North Atlantic. Commercial hunting had a severe effect on blue whales, such that they remain rare in some formerly important habitats, notably in the northern and northeastern North Atlantic (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) estimated that at least 11,000 blue whales were harvested from all whaling areas from the late-nineteenth to mid-twentieth centuries.

Current trends are unknown, although an increasing annual trend of 4.9% was reported for 1969–1988 off western and southwestern Iceland (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) concluded that the blue whale population had been increasing since the late 1950s. In the northeastern Atlantic, blue whales are most common west and south of Iceland and may be the largest concentration of blue whales in the North Atlantic (Pike et al. 2009b). In this area, the population may be recovering at a rate of 4-5% (Pike et al. 2009b). Punt (2010) estimated the rate of increase for blue whales in the central North Atlantic to be 9% annually (3.83 standard error) between 1987 and 2001.

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

Anthropogenic threats. Blue whales have faced threats from several historical and current sources. Blue whale populations were severely depleted due to historical whaling activity.

Increasing noise in the ocean may impair blue whale behavior. The general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011). Either due to ship strike, vessel noise, whale watching, or a combination of these factors displacement from preferred habitat may be occurring off Sri Lanka (Ilangakoon 2012).

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

5.3 Fin whale

Subspecies. There are two recognized subspecies of fin whales, *Balaenoptera physalus physalus*, which occurs in the North Atlantic Ocean, and *B. p. quoyi*, which occurs in the Southern Ocean. These subspecies and North Pacific fin whales appear to be organized into separate populations, although there is a lack of consensus in the published literature as to population structure.

Population structure. Population structure has undergone only a rudimentary framing. Genetic studies by Bérubé et al. (1998) indicate that there are significant genetic differences among fin whales in differing geographic areas (Sea of Cortez, Gulf of St. Lawrence, and Gulf of Maine). Further, individuals in the Sea of Cortez may represent an isolated population from other eastern North Pacific fin whales (Berube et al. 2002). Even so, mark-recapture studies also demonstrate that individual fin whales migrate between management units designated by the IWC (Mitchell 1974; Sigujónsson and Gunnlaugsson 1989).

North Atlantic. Fin whales are common off the Atlantic coast of the U.S. in waters immediately off the coast seaward to the continental shelf (about the 1,800 m contour). Fin whales occur during the summer from Baffin Bay to near Spitsbergen and the Barents Sea, south to Cape Hatteras in North Carolina and off the coasts of Portugal and Spain (Rice 1998a). In areas north of Cape Hatteras, fin whales account for about 46% of the large whales observed in 1978-1982 surveys (CETAP 1982). Little is known about the winter habitat of fin whales, but in the western North Atlantic, the species has been found from Newfoundland south to the Gulf of Mexico and Greater Antilles, and in the eastern North Atlantic their winter range extends from the Faroes and Norway south to the Canary Islands. Fin whales in the eastern North Atlantic have been found in highest densities in the Irminger Sea between Iceland and Greenland (Víkingsson et al. 2009). The singing location of fin whales in the Davis Strait and Greenland has been correlated with sea ice fronts; climate change may impact fin whale distribution and movement by altering sea ice conditions (Simon et al. 2010). A general fall migration from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies has been

theorized (Clark 1995). Historically, fin whales were by far the most common large whale found off Portugal (Brito et al. 2009).

Fin whales are also endemic to the Mediterranean Sea, where (at least in the western Mediterranean), individuals tend to aggregate during summer and disperse in winter over large spatial scales (Cotte et al. 2009), although this seasonal trend is reversed in the Bonifacio Strait (Arcangeli et al. 2013a). Mediterranean fin whales are genetically distinct from fin whales in the rest of the North Atlantic at the population level (Berube et al. 1999). However, some fin whales from the northeastern North Atlantic have been tracked into the Mediterranean during winter and overlap in time and space with the Mediterranean population may exist (Castellote et al. 2010). Individuals also tend to associate with colder, saltier water, where steep changes in temperature, and where higher northern krill densities would be expected (Cotte et al. 2009). A genetically distinct population resides year-round in the Ligurian Sea (IWC 2006). Fin whales seem to track areas of high productivity in the Mediterranean, particularly along coastal areas of France, northern Italy, and the southern and middle Adriatic (Druon et al. 2012). Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Age distribution. Aguilar and Lockyer (1987) suggested annual natural mortality rates in northeast Atlantic fin whales may range from 0.04 to 0.06. Fin whales live 70-80 years (Kjeld et al. 2006).

Reproduction. Fin whales reach sexual maturity between 5-15 years of age (COSEWIC 2005; Gambell 1985a; Lockyer 1972). Mating and calving occurs primarily from October-January, gestation lasts ~11 months, and nursing occurs for 6-11 months (Boyd et al. 1999; Hain et al. 1992). The average calving interval in the North Atlantic is estimated at about 2-3 years (Aglar et al. 1993; Christensen et al. 1992a). The location of winter breeding grounds is uncertain but mating is assumed to occur in pelagic mid-latitude waters (Perry et al. 1999). This was recently contradicted by acoustic surveys in the Davis Strait and off Greenland, where singing by fin whales peaked in November through December; the authors suggested that mating may occur prior to southbound migration (Simon et al. 2010). Although seasonal migration occurs between presumed foraging and breeding locations, fin whales have been acoustically detected throughout the North Atlantic Ocean and Mediterranean Sea year-round, implying that not all individuals follow a set migratory pattern (Notarbartolo-Di-Sciara et al. 1999; Simon et al. 2010). Reductions in pregnancy rates appear correlated with reduced blubber thickness and prey availability (Williams et al. 2013).

Movement. In the eastern Central Atlantic, fin whales appear to migrate from areas along Iceland to the Azores east of the Mid-Atlantic Ridge, apparently traveling directly without random movement patterns in between (Anil et al. 2013).

Behavior. Fin whales along Southern California were found to be traveling 87% of the time and milling 5% in groups that averaged 1.7 individuals (Bacon et al. 2011). Fin whales tend to avoid tropical and pack-ice waters, with the high-latitude limit of their range set by ice and the lower-latitude limit by warm water of approximately 15° C (Sergeant 1977). Fin whale concentrations generally form along frontal boundaries or mixing zones between coastal and oceanic waters, which corresponds roughly to the 200 m isobath (the continental shelf edge (Cotte et al. 2009; Nasu 1974)).

Feeding. Fin whales in the North Atlantic eat pelagic crustaceans (mainly krill and schooling fish such as capelin, herring, and sand lance (Borobia and Béland 1995; Christensen et al. 1992a; Hjort and Ruud 1929; Ingebrigtsen 1929; Jonsgård 1966; Mitchell 1974; Overholtz and Nicolas 1979; Sergeant 1977; Shirihai 2002; Watkins et al. 1984)). Fin whales frequently forage along cold eastern current boundaries (Perry et al. 1999). Feeding may occur in waters as shallow as 10 m when prey are at the surface, but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Gaskin 1972; Nature Conservancy Council 1979 as cited in ONR 2001; Panigada et al. 2008; Sergeant 1977). While foraging, fin whales in the Mediterranean Sea have been found to move through restricted territories in a convoluted manner (Lafortuna et al. 1999). Fin whales in the central Tyrrhenian Sea appear to ephemerally exploit the area for foraging during summer, particularly areas of high primary productivity (Arcangeli et al. 2013b).

Vocalization and hearing. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992a; Watkins 1981; Watkins et al. 1987b). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Croll et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995b) reported the most common sound as a 1 sec vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns during winter. Au (2000b) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cumplings and Thompson 1994; Edds 1988; Watkins 1981). Source levels for fin whale vocalizations are 140-200 dB re $1\mu\text{Pa}\cdot\text{m}$ (Clark and Ellison. 2004; Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987b). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998a). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995b). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Although their function is still debated, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997a; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins et al. 1987a), while the individual counter-calling data of McDonald et al. (1995b) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992b).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Status and trends. Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available (**Table 6**). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how the risk to the affected population(s) bears on the status of the species as a whole. Historically, worldwide populations were severely depleted by commercial whaling, with

more than 700,000 whales harvested in the twentieth century (Cherfas 1989b; Cherfas 1989a).

Table 6. Summary of past and present fin whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	>464,000	~~	119,000	~~	(Braham 1991)
North Atlantic	Basinwide	30,000-50,000	~~	~~	~~	(Sergeant 1977)
	~~	360,000	249,000-481,000	~~	~~	(Roman and Palumbi 2003)
	~~			>50,000		(Sigurjonsson 1995)
	Eastern North Atlantic			25,000		(2009) circa 2001
	Central and northeastern Atlantic	~~	~~	30,000	23,000-39,000	(IWC 2007)
	Western North Atlantic	~~	~~	3,590-6,300	~~	(Braham 1991)
	NMFS-western North Atlantic stock	~~	~~	3,985	CV=0.24	(NMFS 2008; Waring et al. 2012)(NMFS 2008; Waring et al. 2012)
	Northeastern U.S. Atlantic cont'l shelf	~~	~~	2,200-5,000	~~	(Hain et al. 1992; Waring et al. 2000)
	IWC-Newfoundland-Labrador stock	~~	~~	13,253	0-50,139*	(IWC 1992)
	Bay of Biscay			7,000-8,000		(Goujon et al. 1994)
IWC-British Isles, Spain, and Portugal stock	10,500	9,600-11,400	4,485	3,369-5,600	(Braham 1991)	
	~~	~~	17,355	10,400-28,900	(Buckland et al. 1992)	
	IWC-east Greenland to Faroe Islands	~~	~~	22,000	16,000-30,000	(IWC 2014)

IWC-west Greenland stock	~~	~~	4,500	1,900- 10,000	(IWC 2014)
-----------------------------	----	----	-------	------------------	------------

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

North Atlantic. Over 48,000 fin whales were caught between 1860-1970 (Braham 1991). Although protected by the IWC, from 1988-1995 there have been 239 fin whales harvested from the North Atlantic. Recently, Iceland resumed whaling of fin whales despite the 1985 moratorium imposed by the IWC. Vikingsson et al. (2009) concluded that actual numbers were likely higher due to negative bias in their analysis, and that the population(s) were increasing at 4% annually. The abundance of fin whales in the Baffin Bay-Davis Strait summer feeding area is believed to be increasing (Heide-Jorgensen et al. 2010).

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

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

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

Climate change also presents a potential threat to fin whales, particularly in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

5.4 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 aggregate 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).

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). 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 (Cerchio et al. 2010; Reeves et al. 2002; 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. Dozens of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Reproduction and growth. Humpback whale calving and breeding generally occurs during winter at lower latitudes. Gestation takes about 11 months, followed by a nursing period of up to one year (Baraff and Weinrich 1993). Sexual maturity is reached at between 5-7 years of age in the western North Atlantic, but may take as long as 11 years in the North Pacific, and perhaps over 11 years (e.g., southeast 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 appear to return to breeding grounds more frequently than do females (Herman et al. 2011). Larger females tend to produce larger calves that may have a greater chance of survival (Pack et al. 2009). Females appear to preferentially select larger-sized males (Pack et al. 2012). In some Atlantic areas, females tend to prefer shallow nearshore waters for calving and rearing, even when these areas are extensively trafficked by humans (Picanco et al. 2009). Offspring appear to return to the same breeding areas at which they were born one they are independent (Baker et al. 2013).

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 concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992; Witteveen et al. 2011). The principal fish prey in the western North Atlantic are sand lance, herring, and capelin (Kenney et al. 1985b). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-

latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). 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 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 mothers brought them to 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).

Vocalization and hearing. Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au 2000b; Au et al. 2006; Frazer and Mercado 2000; Payne 1970; Richardson et al. 1995c; Winn et al. 1970). Both mature and immature males sing in breeding areas (Herman et al. 2013). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack and Whitehead 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack and Whitehead 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μ Pa at 1 m; (Au 2000b; Erbe 2002a; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986; Vu et al. 2012). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas, possibly due to foraging (Richardson et al. 1995c; Vu et al. 2012). During migration, social vocalizations are generated at 123 to 183 dB re 1 μ Pa at 1 m with a median of 158 dB re 1 μ Pa at 1 m (Dunlop et al. 2013).

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 1985) argued that 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 of 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 7** provides estimates of historic and current abundance for ocean regions.

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 due to 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, which is supported by 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 SE). Pike et al. (2009a) suggested that the eastern and northeastern waters off Iceland are areas of significant humpback utilization for feeding, estimating nearly 5,000 whales in 2001 and proposing an annual growth rate of 12% for the area.

Table 7. Summary of past and present humpback whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% 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	~~	~~	11,600	10,000-13,000	(IWC 2014)
	Western North Atlantic from Davis Strait, Iceland, to the West Indies	>4,685*	~~	~~	~~	*circa 1865; (Mitchell and Reeves 1983)
	West Greenland	~~	~~	2,154	CV=0.36	(Heide-Jorgensen et al. 2012)
	Iceland	~~	~~	5,000	~~	(Pike et al. 2009a)
	NMFS-Gulf of Maine stock	~~	~~	847	CV=0.55	(Waring et al. 2012)
	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) <i>in</i> (Waring et al. 2004)

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

The authors suggest that humpback whales in the area had probably recovered from whaling.

However, recent data suggest that 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 appear to be increasing at a rate of 9.4% annually (Heide-Jorgensen et al. 2012).

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

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 represent major threats to humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for several species being listed as endangered.

Organochlorines, including PCB and DDT, have been identified in humpback whale blubber (Gauthier et al. 1997b). Higher PCB levels have been observed in western Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010); eastern Atlantic individuals fall between these two in contaminant burden (Ryan et al. 2014). Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). 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 (Metcalf et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

5.5 North Atlantic right whale

Population. All North Atlantic right whales compose a single population. Although not all individuals undergo the same migratory pattern, no subpopulation structuring has been identified.

Distribution. Right whales occur in sub-polar to temperate waters in all major ocean basins in the world, with a clear migratory pattern of high latitudes in summer and lower latitudes in

winter (Cummings 1985; Perry et al. 1999; Rice 1998b). The historical range of North Atlantic right whales extended as far south as Florida and northwestern Africa, and as far north as Labrador, southern Greenland, Iceland, and Norway (Cummings 1985; Reeves et al. 1978; Rice 1998b). Recent sightings have been made through some of the broader historical range, including Iceland, Greenland, Norway, and the Azores (Hamilton et al. 2009; Hamilton et al. 2007; Jacobsen et al. 2004; Silva et al. 2012). Additional rare sightings have been made in the Gulf of Mexico (Moore and Clark 1963; Schmidly et al. 1972). Most sightings in the western North Atlantic are concentrated within five primary habitats or high-use areas: coastal waters of the southeastern U.S., Cape Cod and Massachusetts Bays, the Great South Channel, the Bay of Fundy, and the Scotian Shelf (Winn et al. 1986). In 1994, the first three of these areas were designated as critical habitat for the North Atlantic right whale.

North Atlantic right whales have been observed from the mid-Atlantic Bight northward through the Gulf of Maine year-round, but are primarily found along the northeast U.S. during summer and Florida during winter, with migratory routes in between. In New England, peak abundance of North Atlantic right whales in feeding areas occurs in Cape Cod Bay beginning in late winter. In early spring (late February to April), peak North Atlantic right whale abundance occurs in Jordan and Wilkinson Basins to the Great South Channel (Kenney et al. 1995; Nichols et al. 2008; Pace III and Merrick 2008). In late June and July, North Atlantic right whale distribution gradually shifts to the northern edge of Georges Bank. In late summer (August) and fall, much of the population is found in waters in the Bay of Fundy, the western Gulf of Maine and around Roseway Basin (Kenney et al. 2001; Kenney et al. 1995; Pace III and Merrick 2008; Winn et al. 1986). However, year-to-year variation in space and time are known and likely result from patchy prey distribution (Nichols et al. 2008). Variation in the abundance and development of suitable food patches appears to modify the general patterns of movement by reducing peak numbers, stay durations, and specific locales (Brown et al. 2001; Kenney 2001). In particular, large changes in the typical pattern of food abundance will dramatically change the general pattern of North Atlantic right whale habitat use (Kenney 2001). Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Migration and movement. North Atlantic right whales exhibit extensive migratory patterns, traveling along the eastern seaboard of the U.S. and Canada between calving grounds off Georgia and Florida to northern feeding areas off the northeast U.S. and Canada in March/April and the reverse direction in November/December. The longest tracking of a North Atlantic right whale was a migration of 1,200 miles in 23 days the Bay of Fundy to Georgia (Mate and Baumgartner 2001). Migrations are typically within 30 nautical miles of the coastline and in waters less than 160 feet deep. Although this pattern is well-known, most of the population, particularly the males and non-pregnant females, is not found in the calving area and may not follow this pattern. It is unknown where the majority of the non-calving population spends the winter. Whales may remain in their foraging habitat during winter (Morano et al. 2012).

There have been a few recent sightings of North Atlantic right whales far offshore, including those from Dutch ships indicating some individuals occur between 40° and 50° N, in waters influenced by the North Atlantic Current (the broad, eastward-flowing extension of the Gulf Stream). Right whales have been sighted offshore (greater than 30 miles) during surveys flown off the coast of northeastern Florida and southeastern Georgia from 1996 to 2001. These include three sightings in 1996, one in 1997, 13 in 1998, six in 1999, 11 in 2000, and six in 2001 (within

each year, some were repeat sightings). Mate et al. (1997) recorded radio-tagged animals making extensive movements from the Gulf of Maine into deeper waters off the continental shelf (Mate et al. 1997). The frequency with which North Atlantic right whales occur in offshore waters in the southeastern U.S. remains unclear. Occasionally, individuals are observed in distant locations, including the Gulf of Mexico, Bermuda, Azores, the Gulf of St. Lawrence, Newfoundland, Greenland, Iceland, and northern Norway (an area known as a historical North Atlantic right whale feeding area Silva et al. 2012; Smith et al. 2006). The Norwegian sighting (September 1992) represents one of only two sightings this century of a right whale in Norwegian waters, and the first since 1926. Together, these long-range matches indicate an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described.

Reproduction, growth, and demography. Data through the 1990s suggests that mean calving interval increased since 1992 from 3.67 years to more than five years, a significant trend that hampers North Atlantic right whale recovery (Best et al. 2001a; Kraus et al. 2007). This reproductive rate was approximately half that reported from studied populations of southern right whales (Best et al. 2001b). This has been attributed to several possible causes, including higher abortion or perinatal losses (Browning et al. 2009). An analysis of the age structure of North Atlantic right whales suggests that the population contains a smaller proportion of juvenile whales than expected, which may reflect lowered recruitment and/or high juvenile mortality (Best et al. 2001a; Hamilton et al. 1998). In addition, it is possible that the apparently low reproductive rate is due in part to unstable age structure or to reproductive senescence on the part of some females. However, knowledge on either factor is poor. Even though investment in calves is high for North Atlantic right whales, an incident of calf exchange (probably accidentally and soon after birth) and subsequent adoption through weaning has been found (Frasier et al. 2010). Although North Atlantic right whales historically separated from their calves within one year, a shift appears to have taken place around 2001 where mothers (particularly less experienced mothers) return to wintering grounds with their yearling at a much greater frequency (71% overall)(Hamilton and Cooper. 2010). The significance of this change is unknown.

Calves reach roughly three-quarters of their adult body size by the time they wean at 12 months, roughly doubling their original body size and gaining about 36 kg daily (Fortune et al. 2012).

Habitat. Available evidence from North Atlantic right whale foraging and habitat studies shows that North Atlantic right whales focus foraging activities where physical oceanographic features such as water depth, current, and mixing fronts combine to concentrate copepods (Baumgartner et al. 2003; Davies et al. 2014; Mayo and Marx 1990; Murison and Gaskin 1989; Wishner et al. 1988).

Feeding. North Atlantic right whales fast during the winter and feed during the summer, although some may opportunistically feed during migration. North Atlantic right whales use their baleen to sieve copepods from dense patches, found in highly variable and spatially unpredictable locations in the Bay of Fundy, Roseway Basin, Cape Cod Bay, the Great South Channel, and other areas off of northern U.S. and Canada (Pendleton et al. 2009). The primary prey of North Atlantic right whales is zooplankton, especially shrimp-like copepods such as *Calanus* (Beardsley et al. 1996; Kenney et al. 1985a). North Atlantic right whales feed largely by skimming these prey from the ocean surface (Mayo and Marx 1990; Pivorunas 1979), but may feed anywhere in the water column (Goodyear 1993; Watkins and Schevill 1976; Watkins and

Schevill 1979; Winn et al. 1995). Feeding behavior has only been observed in northern areas and not on calving grounds or during migration (Kraus et al. 1993).

Vocalization and hearing. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey patch presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300-600 Hz range with up- and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hz and above 900 Hz were rare (Vanderlaan et al. 2003). Calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100-400 Hz (Gillespie and Leaper 2001). Gunshots appear to be a largely or exclusively male vocalization (Parks et al. 2005b). Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 m of the surface (Matthews et al. 2001). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 μ Pa p-p (Hotchkiss et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar to their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). North Atlantic right whales produce a variety of calls from 159-192 dB re: 1 μ Pa while in surface active groups on breeding grounds (Tryonis et al. 2013). Source levels for these calls in surface active groups range from 137-162 dB rms re: 1 μ Pa-m, except for gunshots, which are 174-192 dB rms re: 1 μ Pa-m (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves (Parks and Clark 2007). Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks and Clark 2007; Parks et al. 2005a; Parks et al. 2007a; Parks et al. 2011a; Parks et al. 2010; Parks et al. 2012b; Parks et al. 2006), particularly the peak frequency (Parks et al. 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004b).

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

Status and trends. The Northern right whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. The early listing included both the North Atlantic and the North Pacific populations, although subsequent genetic studies conducted by Rosenbaum (2000) resulted in strong evidence that North Atlantic and North Pacific right whales are separate species. Following a comprehensive status review, NMFS concluded that North Atlantic and North Pacific right whales are separate species. In March 2008, NMFS published a final rule listing North Pacific and North Atlantic right whales as separate species (73 FR 12024).

North Atlantic right whales were formerly abundant, with an estimated 5,500 individuals present in the 16th century throughout the North Atlantic (Reeves 2001; Reeves et al. 2007). However, genetic evidence suggests a much larger historical population size of 112,000 individuals (95 % CI 45,000–235,000)(Ruegg et al. 2013). A review of the photo-id recapture database in June 2006, indicated that only 313 individually recognized North Atlantic right whales were observed during 2001. Recent additions to the photo-ID catalog lead to a minimum population estimate of 444 individuals (Waring et al. 2013). This represents a nearly complete census, and the estimated minimum population size. However, no estimate of abundance with an associated coefficient of variation has been calculated for the population. Furthermore, 55% of fathers have not been genetically identified, suggesting the population may be significantly larger than presently thought (Frasier 2005). This also suggests the occurrence of right whales in as yet unidentified habitats (Frasier 2005). The population growth rate reported for the period 1986 to 1992 by Knowlton et al. (1994) was 2.5%, suggesting the stock was showing signs of slow recovery. However, work by Caswell et al. (1999) suggested that crude survival probability declined from about 0.99 in the early 1980's to about 0.94 in the late 1990s. Additional work conducted in 1999 showed that survival had indeed declined in the 1990s, particularly for adult females (Best et al. 2001a). Another workshop in September 2002 further confirmed the decline in this population (Clapham 2002). The best available estimate of population trajectory suggests the population is increasing at a rate of 2.6% over the 1990-2009 timeframe (Waring et al. 2013).

Natural threats. Several researchers have suggested that the recovery of North Atlantic right whales has been impeded by competition with other whales for food (Rice 1974; Scarff 1986). Mitchell (1975) analyzed trophic interactions among baleen whales in the western North Atlantic and noted that the foraging grounds of North Atlantic right whales overlapped with the foraging grounds of sei whales. Both species feed preferentially on copepods. Mitchell (1975) argued that the North Atlantic right whale population had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that competition with the sei whale population impedes or prevents the recovery of the right whale population. Shark predation has been repeatedly documented on right whales calves along the southeastern U.S., some of which may be fatal (Taylor et al. 2013).

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

Anthropogenic threats. Several human activities are known to threaten North Atlantic right whales: whaling, commercial fishing, shipping, and environmental contaminants. Historically, whaling represented the greatest threat to every population of right whales and was ultimately responsible for listing right whales as an endangered species. As its legacy, whaling reduced North Atlantic right whales to about 300 individuals in the western North Atlantic Ocean; the number of North Atlantic right whales in the eastern North Atlantic Ocean is probably much smaller, if present at all.

Concern also exists over climate change and its effect on the ability of North Atlantic right

whales to recover (Greene et al. 2003b). Specifically, the variations in oceanography resulting from current shifts and water temperatures can significantly affect the occurrence of the North Atlantic right whale's primary food, copepod crustaceans. If climate changes such that current feeding areas cannot sustain North Atlantic right whales, the population may have to shift to reflect changes in prey distribution, pursue other prey types, or face prey shortage. Changes in calving intervals with sea surface temperature have already been documented for southern right whales (Leaper et al. 2006).

North Atlantic right whales, as with many marine mammals, are exposed to numerous toxins in their environment, many of which are introduced by humans. Levels of chromium in North Atlantic right whale tissues are sufficient to be mutagenic and cause cell death in lung, skin, or testicular cells and are a concern for North Atlantic right whale recovery (Chen et al. 2009; Wise et al. 2008). The organochlorines DDT, DDE, PCBs, dieldrin, chlordane, HCB, and heptachlor epoxide have been isolated from blubber samples and reported concentrations may underestimate actual levels (Woodley et al. 1991). Mean PCB levels in North Atlantic right whales are greater than any other baleen whale species thus far measured, although less than one-quarter of the levels measured in harbor porpoises (Gauthier et al. 1997a; Van Scheppingen et al. 1996). Organochlorines and pesticides, although variable in concentration by season, do not appear to currently threaten North Atlantic right whale health and recovery (Weisbrod et al. 2000). Flame retardants such as polybrominated diphenyl ethers (known to be carcinogenic) have also been measured in North Atlantic right whales (Montie et al. 2010).

5.6 Sei whale

Population designations. The population structure of sei whales is unknown and populations herein assume (based upon migratory patterns) population structuring is discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Atlantic. In the western North Atlantic, a major portion of the sei whale population occurs in northern waters, potentially including the Scotian Shelf, along Labrador and Nova Scotia, south into the U.S. EEZ, including the Gulf of Maine and Georges Bank (Mitchell and Chapman 1977; Waring et al. 2004). These whales summer in northern areas before migrating south to waters along Florida, in the Gulf of Mexico, and the northern Caribbean Sea (Gambell 1985b; Mead 1977). Sei whales may range as far south as North Carolina. In the U.S. EEZ, the greatest abundance occurs during spring, with most sightings on the eastern edge of Georges Bank, in the Northeast Channel, and in Hydrographer Canyon (CETAP 1982). In 1999, 2000, and 2001, the NMFS aerial surveys found sei whales concentrated along the northern edge of Georges Bank during spring (Waring et al. 2004). Surveys in 2001 found sei whales south of Nantucket along the continental shelf edge (Waring et al. 2004). During years of greater prey abundance (e.g., copepods), sei whales are found in more inshore waters, such as the Great South Channel (1987 and 1989), Stellwagen Bank (1986), and the Gulf of Maine (Payne et al. 1990a; Schilling et al. 1992). In the eastern Atlantic, sei whales occur in the Norwegian Sea, occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b; Jonsgård and Darling 1977). Sei whales have rarely been sighted along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Movement. The migratory pattern of this species is thought to encompass long distances from

high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

Reproduction. Very little is known regarding sei whale reproduction. Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at 6-9 months, and the calving interval is about 2-3 years (Gambell 1985b; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). Of 32 adult female sei whales harvested by Japanese whalers, 28 were found to be pregnant while one was pregnant and lactating during May-July 2009 cruises in the western North Pacific (Tamura et al. 2009).

Feeding. Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2006). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009; Mizroch et al. 1984; Rice 1977).

Vocalization and hearing. Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 sec duration and tonal and upswEEP calls in the 200-600 Hz range of 1-3 sec durations (McDonald et al. 2005). Source levels of 189 ± 5.8 dB re $1 \mu\text{Pa}$ at 1m have been established for sei whales in the northeastern Pacific (Weirathmueller et al. 2013). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007a). The first variation consisted of sweeps from 100 to 44 Hz, over 1.0 sec. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007b) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 to 21 Hz over 1.3 sec. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters. Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 ms) FM sweeps between 1.5-3.5 kHz (Thomson and Richardson 1995).

Status and trends. The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. Consideration of the status of populations outside of 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 8** provides estimates of historic and current abundance for ocean regions.

North Atlantic. No information on sei whale abundance exists prior to commercial whaling (Perry et al. 1999). Between 1966 and 1972, whalers from land stations on the east coast of Nova Scotia engaged in extensive hunts of sei whales on the Nova Scotia shelf, killing about 825 individuals (Mitchell and Chapman 1977). In 1974, the North Atlantic stock was estimated to number about 2,078 individuals, including 965 whales in the Labrador Sea group and 870 whales in the Nova Scotia group (Mitchell and Chapman 1977). In the northwest Atlantic, Mitchell and Chapman (1977) estimated the Nova Scotia stock to contain 1,393-2,248 whales; an

aerial survey program conducted from 1978 to 1982 on the continental shelf and edge between Cape Hatteras, North Carolina, and Nova Scotia generated an estimate of 280 sei whales (CETAP 1982). These two estimates are more than 30 years out of date and likely do not reflect the current true abundance; in addition, the CETAP estimate has a high degree of uncertainty and is considered statistically unreliable (Perry et al. 1999; Waring et al. 2004; Waring et al. 1999). The total number of sei whales in the U.S. Atlantic EEZ remains unknown (Waring et al. 2006). Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103.

Table 8. Summary of past and present sei whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	--	>105,000	--	25,000	--	(Braham 1991)
North Atlantic	Basinwide	--	--	>4000	--	(Braham 1991)
	~~			>13,500		(Sigurjonsson 1995)
	NMFS-Nova Scotia stock	--	--	386	--	(NMFS 2008; Waring et al. 2012)
	Northeast Atlantic	--	--	10,300	0.268	(Cattanach et al. 1993)

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

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

Anthropogenic threats. Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas.

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

5.7 Sperm whale

Populations. There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). Chemical analysis also suggest significant differences in diet for animals captured in different regions of

the North Atlantic. However, vocal dialects indicate parent-offspring transmission that support differentiation in populations (Rendell et al. 2011). Therefore, population-level differences may be more extensive than are currently understood.

The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawaii; (Perry et al. 1999; Waring et al. 2004)). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead et al. 2008). Matrilinear groups in the eastern Pacific share nuclear DNA within broader clans, but North Atlantic matrilinear groups do not share this genetic heritage (Whitehead et al. 2012).

North Atlantic. In the western North Atlantic, sperm whales range from Greenland south into the Gulf of Mexico and the Caribbean, where they are common, especially in deep basins off of the continental shelf (Romero et al. 2001; Wardle et al. 2001). The northern distributional limit of female/immature pods is probably around Georges Bank or the Nova Scotian shelf (Whitehead et al. 1991). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Hansen et al. 1996; Mullin et al. 1994). Sperm whale distribution follows a distinct seasonal cycle, concentrating east-northeast of Cape Hatteras in winter and shifting northward in spring when whales are found throughout the mid-Atlantic Bight. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the Mid-Atlantic Bight. A long-term study of sperm whales along Dominica, West Indies supports 17 discreet groups habituating this area (Gero et al. 2013). In the eastern Atlantic, mature male sperm whales have been recorded as far north as Spitsbergen (Øien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature males predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992a; Christensen et al. 1992b; Gunnlaugsson and Sigurjónsson 1990; Øien 1990). Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Movement. Mature males range between 70° N in the North Atlantic and 70° S in the Southern Ocean (Perry et al. 1999; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50° N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring et al. 1993) where adult males join them to breed. Males identified in the Azores have been resighted in Norwegian waters (Steiner et al. 2012). Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead et al. 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred kilometers are common (i.e. between the Galapagos Islands and the Pacific coastal

Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Habitat. Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989a). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet and Whitehead 1996; Jaquet et al. 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000a; Davis et al. 2000b; Davis et al. 2000c; Davis et al. 2002; Wormuth et al. 2000). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993). Sperm whales over George's Bank were associated with surface temperatures of 23.2-24.9° C (Waring et al. 2003).

Reproduction. Female sperm whales become sexually mature at an average of 9 years or 8.25-8.8 m (Kasuya 1991). Males reach a length of 10 to 12 m at sexual maturity and take 9-20 years to become sexually mature, but require another 10 years to become large enough to successfully breed (Kasuya 1991; Würsig et al. 2000). Mean age at physical maturity is 45 years for males and 30 years for females (Waring et al. 2004). Adult females give birth after roughly 15 months of gestation and nurse their calves for 2-3 years (Waring et al. 2004). The calving interval is estimated to be every 4-6 years between the ages of 12 and 40 (Kasuya 1991; Whitehead et al. 2008). It has been suggested that some mature males may not migrate to breeding grounds annually during winter, and instead may remain in higher latitude feeding grounds for more than one year at a time (Whitehead and Arnborn 1987).

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

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals; 7-9 along Dominica) versus the Pacific (25-30 individuals)(Gero et al. 2013; Jaquet and Gendron 2009). Groups may be stable for long periods, such as for 80 days in the Gulf of California (Jaquet and Gendron 2009). Males start

leaving these family groups at about six years of age, after which they live in “bachelor schools,” but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Feeding. Sperm whales appear to feed regularly throughout the year (NMFS 2006b). It is estimated they consume about 3-3.5% of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989a). A large proportion of a sperm whale’s diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1996; Clarke 1980b; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Rice 1989a). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989a). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species also frequently eaten by northern bottlenose whales (Clarke 1997).

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

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

Status and trends. Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available.

Consideration of the status of populations outside of the action area is important under the present analysis to determine how the risk to the affected population(s) bears on the status of the species as a whole. Table 9 contains historic and current estimates of sperm whales by region. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003). Small changes in reproductive parameters, such as the loss of adult females, can significantly alter the population trajectory of sperm whale populations (Chiquet et al. 2013).

Table 9. Summary of past and present sperm whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	~~	~~	900,000	~~	(Würsig et al. 2000)
	~~	1,110,000	672,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002)
North Atlantic	Basinwide-females	224,800	~~	22,000	~~	(Gosho et al. 1984; Würsig et al. 2000)
	Northeast Atlantic, Faroes, Iceland, and U.S. East coast	~~	~~	13,190	~~	(Whitehead 2002)
	NMFS-North Atlantic stock	>4,685*	~~	4,804	1,226-8,382*	(Waring et al. 2012)
	Iceland	~~	~~	1,234	823-1,645*	(Gunnlaugsson and Sigurjónsson 1990)
	Faroe Islands	~~	~~	308	79-537*	(Gunnlaugsson and Sigurjónsson 1990)
	Norwegian Sea	~~	~~	5,231	2,053-8,409*	(Christensen et al. 1992b)
	Northern Norway to Spitsbergen	15,000	~~	2,548	1,200-3,896*	(Øien 1990)

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

North Atlantic. 190,000 sperm whales were estimated to have been in the entire North Atlantic, but CPUE data from which this estimate is derived are unreliable according to the IWC (Perry et al. 1999). The total number of sperm whales in the western North Atlantic is unknown (Waring

et al. 2008). Sperm whale were widely harvested from the northeastern Caribbean (Romero et al. 2001) and the Gulf of Mexico where sperm whale fisheries operated during the late 1700s to the early 1900s (NMFS 2006b; Townsend 1935).

Natural threats. Sperm whales are known to be occasionally predated upon by killer whales (Arnbom et al. 1987; Jefferson and Baird 1991; Pitman et al. 2001) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989b; Weller et al. 1996; Whitehead 1995). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes of strandings remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic threats. Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). All of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947-1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov and Zemsky 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

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

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

Stephanis et al. 2013).

5.8 Green sea turtle

Populations. Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 10).

Table 10. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman et al. 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)

Distribution. Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters. Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Growth and reproduction. Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal et al. 2000; Seminoff et al. 2002b). Hart et al. (2013a) found growth rates of green sea turtles in the U.S. Virgin Islands to range from 0-9.5 cm annually (mean of 4.1, SD 2.4). The largest growth rates were in the 30-39 cm class. If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark et al. 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid-size classes) in the Pacific, although this is not always the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff et al. 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from ~20-40 years or more (Balazs 1982; Chaloupka et al. 2004; Chaloupka and Musick 1997; Frazer and Ehrhart 1985a; Hirth 1997; Limpus and Chaloupka 1997; Seminoff et al. 2002b; Zug et al. 2002; Zug and Glor 1998). Estimates of reproductive longevity range from 17 to 23 years (Carr et al. 1978; Chaloupka et al. 2004; Fitzsimmons et al. 1995). Considering that mean duration between females returning to nest

ranges from 2 to 5 years (Hirth 1997), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, whereas males may mate every year (Balazs 1983). Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a “frenzy” of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer et al. 2009; Okuyama et al. 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow et al. 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari et al. 2005; Tiwari et al. 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng et al. 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009). Green sea turtles often return to the same foraging areas following nesting migrations (Broderick et al. 2006; Godley et al. 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley et al. 2003; Makowski et al. 2006; Seminoff and Jones 2006; Seminoff et al. 2002a; Taquet et al. 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier et al. 2003).

In general, survivorship tends to be lower for juveniles and subadults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff et al. 2003; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal et al. 2003; Campbell and Lagueux 2005).

Migration and movement. Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr et al. 1978; Meylan et al. 1990). At approximately 20-25 cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas (Bjorndal 1997). Green sea turtles spend the majority of their lives in coastal foraging grounds (MacDonald et al. 2012). These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. Although green sea turtles in tropical areas seem to undergo a sudden, permanent switch in habitat from oceanic to neritic habitats, individuals in more temperate areas seem to utilize a wider array of habitats dependent upon oceanographic conditions (González Carman et al. 2012). There is some evidence that individuals move from shallow seagrass beds during the

day to deeper areas at night (Hazel 2009). However, avoidance of areas of greater than 10 m when moderate depths of 5-10 m with sea grass beds has been found, with speed and displacement from capture locations being similar at night as during the daytime (Senko et al. 2010a). East Pacific adults migrate along coastal corridors between Central American nesting and foraging locations (Blanco et al. 2012).

Habitat. Green turtles appear to prefer waters that usually remain around 20° C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18° C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juvenile green sea turtles along the Pacific Baja coast (Senko et al. 2010b).

Feeding. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley et al. 1998; Hart et al. 2013b; Hatase et al. 2006; Heithaus et al. 2002; Parker and Balazs in press; Seminoff et al. 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable matter replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona et al. 2009). This transition may occur rapidly starting at 30 cm carapace length, but animal prey continue to constitute an important nutritional component until individuals reach about 62 cm (Cardona et al. 2010). Foraging within seagrass ecosystems by green sea turtles can be significant enough to alter habitat and ecological parameters, such as species composition (Lal et al. 2010). Although populations can consume a variety of prey and be considered generalists as a whole, individuals maintain a highly-selective diet over long time frames (Vander Zanden et al. 2013).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found green sea turtle juveniles capable of hearing underwater sounds at frequencies of 50-1,600 Hz (maximum sensitivity at 200-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994a). Based upon auditory brainstem responses green sea turtles have been measured to hear in the 50-1600 Hz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200-400 Hz for the green turtle with a range of 100-500 Hz (Moein Bartol and Ketten 2006; Ridgway et al. 1969) and around 250 Hz or below for juveniles (Bartol et al. 1999). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever

and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Federal listing of the green sea turtle occurred on July 28, 1978, with all populations listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are endangered (43 FR 32800).

Consideration of the status of populations outside of 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. No trend data are available for almost half of important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

Based on the mean annual reproductive effort, 108,761-150,521 females nest each year among 46 worldwide sites. Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are decreasing. Long-term continuous datasets of 20 years are available for 11 sites, all of which are either increasing or stable. Despite the apparent global increase in numbers, the positive overall trend should be viewed cautiously because trend data are available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004b).

Atlantic Ocean. Primary sites for green sea turtle nesting in the Atlantic/Caribbean include: (1) Yucatán Peninsula, Mexico; (2) Tortuguero, Costa Rica; (3) Aves Island, Venezuela; (4) Galibi Reserve, Suriname; (5) Isla Trindade, Brazil; (6) Ascension Island, United Kingdom; (7) Bioko Island, Equatorial Guinea; and (8) Bijagos Archipelago, Guinea-Bissau (NMFS and USFWS 2007a). Nesting at all of these sites was considered to be stable or increasing with the exception of Bioko Island and the Bijagos Archipelago where the lack of sufficient data precludes a meaningful trend assessment for either site (NMFS and USFWS 2007a). Seminoff (2004a) reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic. Seminoff (2004a) concluded that all sites in the central and western Atlantic showed increased nesting, with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007a).

By far, the most important nesting concentration for green sea turtles in the western Atlantic is in Tortuguero, Costa Rica (NMFS and USFWS 2007a). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007a). The number of females nesting per year on beaches in the Yucatán, at Aves Island, Galibi Reserve, and Isla Trindade number in the hundreds to low thousands, depending on the site (NMFS and USFWS 2007a).

The vast majority of green sea turtle nesting within the southeastern U.S. occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Green sea turtle nesting in Florida has been

increasing since 1989 (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute Index Nesting Beach Survey Database). Since establishment of index beaches in 1989, the pattern of green turtle nesting shows biennial peaks in abundance with a generally positive trend during the ten years of regular monitoring. This is perhaps due to increased protective legislation throughout the Caribbean (Meylan et al. 1995). A total statewide average (all beaches, including index beaches) of 5,039 green turtle nests were laid annually in Florida between 2001 and 2006, with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a). Data from index nesting beaches substantiate the dramatic increase in nesting. In 2007, there were 9,455 green turtle nests found just on index nesting beaches, the highest since index beach monitoring began in 1989. The number fell back to 6,385 in 2008, further dropping under 3,000 in 2009, but that consecutive drop was a temporary deviation from the normal biennial nesting cycle for green turtles, as 2010 saw an increase back to 8,426 nests on the index nesting beaches (FWC Index Nesting Beach Survey Database). Occasional nesting has been documented along the Gulf coast of Florida (Meylan et al. 1995). More recently, green turtle nesting occurred on Bald Head Island, North Carolina; just east of the mouth of the Cape Fear River; on Onslow Island; and on Cape Hatteras National Seashore. In 2010, a total of 18 nests were found in North Carolina, six nests in South Carolina, and six nests in Georgia (nesting databases maintained on www.seaturtle.org). Increased nesting has also been observed along the Atlantic coast of Florida, on beaches where only loggerhead nesting was observed in the past (Pritchard 1997). Recent modeling by Chaloupka et al. (2008a) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9%, and the Tortuguero, Costa Rica, population growing at 4.9%.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of the southeastern U.S. However, information on incidental captures of immature green sea turtles at the St. Lucie Power Plant in St. Lucie County, Florida, shows that the annual number of immature green sea turtles captured by their offshore cooling water intake structures has increased significantly. Green sea turtle annual captures averaged 19 for 1977-1986, 178 for 1987-1996, and 262 for 1997-2001 (Florida Power and Light Company St. Lucie Plant 2002). More recent unpublished data shows 101 captures in 2007, 299 in 2008, 38 in 2009 (power output was cut—and cooling water intake concomitantly reduced—for part of that year) and 413 in 2010. Ehrhart et al. (2007) documented a significant increase in in-water abundance of green turtles in the Indian River Lagoon area.

Natural threats. Herons, gulls, dogfish, and sharks prey upon hatchlings. Adults face predation primarily by sharks and to a lesser extent by killer whales. Predators (primarily of eggs and hatchlings) also include dogs, pigs, rats, crabs, sea birds, reef fishes, and groupers (Bell et al. 1994; Witzell 1981).

For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47-69% in some foraging areas (Murakawa et al. 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work et al. 2009). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint et al. 2009). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of

90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramirez et al. 2014).

All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can be lethal.

Anthropogenic threats. Major anthropogenic impacts to the nesting and marine environment affect green sea turtle survival and recovery. At nesting beaches, green sea turtles rely on intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper et al. 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34), although mortality appears to have resulted in three cases (Tourinho et al. 2009). Low-level bycatch has also been documented in longline fisheries (Petersen et al. 2009). Further, the introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996). Very few green sea turtles are bycaught in U.S. fisheries (Finkbeiner et al. 2011).

Sea level rise may have significant impacts upon green turtle nesting on Pacific atolls. These low-lying, isolated locations could be inundated by rising water levels associated with global warming, eliminating nesting habitat (Baker et al. 2006; Fuentes et al. 2010). Fuentes et al. (2010) predicted that rising temperatures would be a much greater threat in the long term to the hatching success of sea turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010). Although the timing of loggerhead nesting depends upon sea-surface temperature, green sea turtles do not appear to be affected (Pike 2009).

Green sea turtles have been found to contain the organochlorines chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB (Gardner et al. 2003; Miao et al. 2001). Levels of PCBs found in eggs are considered far higher than what is fit for human consumption (Van de Merwe et al. 2009). The heavy metals copper, lead, manganese, cadmium, and nickel have also been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (Van de Merwe et al. 2009). These contaminants have the potential to cause

deficiencies in endocrine, developmental, and reproductive health, and depress immune function in loggerhead sea turtles (Keller et al. 2006; Storelli et al. 2007). Exposure to sewage effluent may also result in green sea turtle eggs harboring antibiotic-resistant strains of bacteria (Al-Bahry et al. 2009). DDE has not been found to influence sex determination at levels below cytotoxicity (Keller and McClellan-Green 2004; Podreka et al. 1998). To date, no tie has been found between pesticide concentration and susceptibility to fibropapillomatosis, although degraded habitat and pollution have been tied to the incidence of the disease (Aguirre et al. 1994; Foley et al. 2005). Flame retardants have been measured from healthy individuals (Hermanussen et al. 2008). It has been theorized that exposure to tumor-promoting compounds produced by the cyanobacteria *Lyngbya majuscula* could promote the development of fibropapillomatosis (Arthur et al. 2008). It has also been theorized that dinoflagellates of the genus *Prorocentrum* that produce the tumorigenic compound okadaic acid may influence the development of fibropapillomatosis (Landsberg et al. 1999).

5.9 Kemp's ridley sea turtle

Population. Kemp's ridley sea turtles are considered to consist of a single population, although expansion of nesting may indicate differentiation.

Distribution. The Kemp's ridley was formerly known only from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000a). However, recent records support Kemp's ridley sea turtles distribution extending into the Mediterranean Sea on occasion (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. Dozens of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Movement and migration. Tracking of post-nesting females from Rancho Nuevo and Texas beaches indicates that turtles move along coastal migratory corridors either to the north or south from the nesting beach (Byles 1989b; Byles and Plotkin 1994; Renaud 1995b; Renaud et al. 1996; Seney and Landry 2011; Shaver 1999; Shaver 2002) after remaining in the nesting area during the nesting period (Seney and Landry 2011). These migratory corridors appear to extend throughout the coastal areas of the Gulf of Mexico and most turtles appear to travel in waters less than roughly 50 m in depth. Turtles that headed north and east traveled as far as southwest Florida, whereas those that headed south and east traveled as far as the Yucatan Peninsula, Mexico (Morreale et al. 2007).

Kemp's ridleys in south Florida begin to migrate northward during spring. With each passing month, the waters to the north become warmer and turtles migrate further to Long Island Sound and even Nova Scotia in late summer (Bleakney 1955). During winter, individuals return south in response to local water temperatures; the turtles in the northernmost areas begin their southward movement first. By early November, turtles from New York and New Jersey merge with turtles from the Chesapeake Bay (Byles 1988; Keinath 1993; Lutcavage and Musick 1985; Renaud 1995b) and North Carolina inshore waters (Epperly et al. 1995a; Epperly et al. 1995b; Musick et al. 1994).

Following migration, Kemp's ridley sea turtles settle into resident feeding areas for several months (Byles and Plotkin 1994; Morreale et al. 2007). Females may begin returning along relatively shallow migratory corridors toward the nesting beach in the winter in order to arrive at the nesting beach by early spring.

During spring and summer, juvenile Kemp's ridleys occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida. In the fall, most Kemp's ridleys migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998a). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS et al. 2010). Satellite telemetry of males caught near Padre Island, Texas, indicates no migration, but year-round occurrence in nearshore waters less than 50 m deep (Shaver et al. 2005b). Many postnesting females from Rancho Nuevo migrate north to areas offshore of Texas and Louisiana (Marquez-M. 1994b). Farther south, some post-nesting females migrate from Rancho Nuevo to the northern and western Yucatán Peninsula in the southern Gulf of Mexico, which contains important seasonal foraging sites for adult females, such as the Bay of Campeche (Marquez-M. 1994b; Márquez 1990a; Pritchard and Marquez 1973).

Reproduction. Mating is believed to occur about three to four weeks prior to the first nesting (Rostal 2007), or late-March through early- to mid-April. It is presumed that most mating takes place near the nesting beach (Morreale et al. 2007; Rostal 2007). Females initially ovulate within a few days after successful mating and lay the first clutch approximately two to four weeks later; if a turtle nests more than once per season, subsequent ovulations occur within approximately 48 hours after each nesting (Rostal 2007).

Approximately 60% of Kemp's ridley nesting occurs along an 40 km stretch of beach near Rancho Nuevo, Tamaulipas, Mexico from April to July, with limited nesting to the north (100 nests along Texas in 2006) and south (several hundred nests near Tampico, Mexico in 2006 USFWS 2006). Nesting at this location may be particularly important because hatchlings can more easily migrate to foraging grounds (Putman et al. 2010). The Kemp's ridley sea turtle tends to nest in large aggregations or arribadas (Bernardo and Plotkin 2007). The period between Kemp's ridley arribadas averages approximately 25 days, but the precise timing of the arribadas is unpredictable (Bernardo and Plotkin 2007; Rostal et al. 1997). Like all sea turtles, Kemp's ridley sea turtles nest multiple times in a single nesting season. The most recent analysis suggests approximately 3.075 nests per nesting season per female (Rostal 2007). The annual average number of eggs per nest (clutch size) is 94 to 100 and eggs typically take 45 to 58 days to hatch, depending on temperatures (Marquez-M. 1994a; Rostal 2007; USFWS 2000; USFWS 2001; USFWS 2002; USFWS 2003; USFWS 2004; USFWS 2005; USFWS 2006). The period between nesting seasons for each female is approximately 1.8 to 2.0 years (Marquez et al. 1989; Rostal 2007; TEWG 2000a). The nesting beach at Rancho Nuevo may produce a "natural" hatchling sex ratio that is female-biased, which can potentially increase egg production as those turtles reach sexual maturity (Coyne and Landry Jr. 2007; Wibbels 2007).

Growth. Kemp's ridleys require approximately 1.5 to two (range 1-4) years to grow from a hatchling to a size of approximately 20 cm long, at which size they are capable of making a transition to a benthic coastal immature stage (Caillouet et al. 1995; Ogren 1989; Schmid 1998b; Schmid and Witzell 1997b; Snover et al. 2007a; TEWG 2000a; Zug et al. 1997). Based on the size of nesting females, it is assumed that turtles must attain a size of approximately 60 cm long prior to maturing (Marquez-M. 1994a). Growth models based on mark-recapture data suggest that a time period of seven to nine years would be required for this growth from benthic immature to mature size (Schmid and Witzell 1997b; Snover et al. 2007a). Currently, age to sexual maturity is believed to range from approximately 10 to 17 years for Kemp's ridleys (Caillouet Jr. et al. 1995; Schmid and Witzell 1997a; Snover et al. 2007b; Snover et al. 2007a). However, estimates of 10 to 13 years predominate in previous studies (Caillouet et al. 1995;

Schmid and Witzell 1997b; TEWG 2000a).

Habitat. Stranding data indicate that immature turtles in this benthic stage are found in coastal habitats of the entire Gulf of Mexico and U.S. Atlantic coast (Morreale et al. 2007; TEWG 2000a). Developmental habitats for juveniles occur throughout the entire coastal Gulf of Mexico and U.S. Atlantic coast northward to New England (Morreale et al. 2007; Schmid 1998b; Wibbels et al. 2005). Key foraging areas in the Gulf of Mexico include Sabine Pass, Texas; Caillou Bay and Calcasieu Pass, Louisiana; Big Gulley, Alabama; Cedar Keys, Florida; and Ten Thousand Islands, Florida (Carr and Caldwell 1956; Coyne et al. 1995; Ogren 1989; Schmid 1998b; Schmid et al. 2002; Witzell et al. 2005b). Foraging areas studied along the Atlantic coast include Pamlico Sound, Chesapeake Bay, Long Island Sound, Charleston Harbor, and Delaware Bay. Near-shore waters of 35 m or less provide the primary marine habitat for adults, although it is not uncommon for adults to venture into deeper waters (Byles 1989a; Mysing and Vanselow 1989; Renaud et al. 1996; Shaver et al. 2005a; Shaver and Wibbels 2007a).

Benthic coastal waters of Louisiana and Texas seem to be preferred foraging areas for Kemp's ridley sea turtles (particularly passes and beachfronts), although individuals may travel along the entire coastal margin of the Gulf of Mexico (Landry and Costa 1999; Landry et al. 1996; Renaud 1995a). Sightings are less frequent during winter and spring, but this is likely due to lesser sighting effort during these times (Keinath et al. 1996; Shoop and Kenney 1992b).

Feeding. Kemp's ridley diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks. Immature Kemp's ridleys off southwest Florida predate on benthic tunicates, a previously undocumented food source (Witzell and Schmid 2005).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994a). Juvenile Kemp's ridleys can hear from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz at thresholds of 110 dB re 1 μ Pa (Moein Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18319). Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990c; USFWS 1999).

During the mid-20th century, the Kemp's ridley was abundant in the Gulf of Mexico. Historic information indicates that tens of thousands of Kemp's ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). From 1978 through the 1980s, arribadas were 200 turtles or less, and by 1985, the total number of nests at Rancho Nuevo had dropped to approximately 740 for the entire nesting season, or a projection of roughly 234 turtles (TEWG 2000a; USFWS and NMFS 1992). Beginning in the 1990s, an increasing number of beaches in Mexico were being monitored for nesting, and the total number of nests on all beaches in Tamaulipas and Veracruz in 2002 was over 6,000; the rate of increase from 1985 ranged from

14-16% (Heppell et al. 2005; TEWG 2000a; USFWS 2002). In 2006, approximately 7,866 nests were laid at Rancho Nuevo with the total number of nests for all the beaches in Mexico estimated at about 12,000 nests, which amounted to about 4,000 nesting females based upon three nests per female per season (Rostal 2007; Rostal et al. 1997; USFWS 2006). Considering remigration rates, the population included approximately 7,000 to 8,000 adult female turtles at that time (Marquez et al. 1989; Rostal 2007; TEWG 2000a). The 2007 nesting season included an arribada of over 4,000 turtles over a three-day period at Rancho Nuevo (P. Burchfield, pers. comm. in NMFS and USFWS 2007b). The increased recruitment of new adults is illustrated in the proportion of first time nesters, which has increased from 6% in 1981 to 41% in 1994. Average population growth was estimated at 13% per year between 1991 and 1995 (TEWG 1998a). In 2008, there were 17,882 nests in Mexico (Gladys Porter Zoo 2008), and nesting in 2009 reached 21,144 (Burchfield 2010). In 2010, nesting declined significantly, to 13,302 but it is too early to determine if this is a one-time decline or if is indicative of a change in the trend. Preliminary estimates of 2011 and 2012 nesting supports 19,368 and 20,197 nests, respectively (back to 2009 levels)(Gallaway et al. 2013). Population modeling used by the TEWG (2000b) projected that Kemp's ridleys could reach the recovery plan's intermediate recovery goal of 10,000 nesters by the year 2015. Over one million hatchlings were released in 2011 and 2012 (Gallaway et al. 2013).

Nesting has also expanded geographically, with a Headstart program reestablishing nesting on South Padre Island starting in 1978. Growth remained slow until 1988, when rates of return started to grow slowly (Shaver and Wibbels 2007b). Nesting rose from 6 in 1996 to 128 in 2007, 195 in 2008, and 197 in 2009. Texas nesting then experienced a decline similar to that seen in Mexico for 2010, with 140 nests (National Park Service data, <http://www.nps.gov/pais/naturescience/strp.htm>), but nesting rebounded in 2011 with a record 199 nests (National Park Service data, <http://www.nps.gov/pais/naturescience/current-season.htm>). According to NMFS's FY11-12 ESA Report to Congress, Kemp's ridley sea turtle status is increasing.

Gallaway et al. (2013) estimated that nearly 189,000 female Kemp's ridley sea turtles over the age of two years were alive in 2012. Extrapolating based upon sex bias, the authors estimated that nearly a quarter million age two or older Kemp's ridleys were alive at this time.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects. Kemp's ridley sea turtles are particularly prone to this phenomenon along Cape Cod (Innis et al. 2009). From 2006-2011, the number of cold-stunned turtles on Cape Cod beaches averaged 115 Kemp's ridleys. The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramirez et al. 2014).

Anthropogenic threats. Population decline has been curtailed due to the virtual elimination of sea turtle and egg harvesting, as well as assistance in hatching and raising hatchlings (Headstart). However, habitat destruction remains a concern in the form of bottom trawling and shoreline development. Trawling destroys habitat utilized by Kemp's ridley sea turtles for feeding and construction activities can produce hazardous runoff. Bycatch is also a source of mortality for Kemp's ridley sea turtles (McClellan et al. 2009), with roughly three-quarters of annual mortality

attributed to shrimp trawling prior to turtle excluder device regulations (Gallaway et al. 2013). However, this has dropped to an estimated one-quarter of total mortality nearly 20 years after turtle excluder devices were implemented in 1990 (Gallaway et al. 2013). In 2010, due to reductions in shrimping effort and turtle excluder device use, shrimp-trawl related mortality appears to have dropped to 4% (1,884) of total mortality (65,505 individuals)(Gallaway et al. 2013). This increased to 3,300 individuals in 2012 (20% of total mortality)(Gallaway et al. 2013). Finkbeiner et al. (2011) estimated that annual bycatch interactions total at least 98,300 individuals annually for U.S. Atlantic fisheries (resulting in 2,700 mortalities or more). The vast majority of fisheries interactions with sea turtles in the U.S. are either Kemp's ridley's or loggerhead sea turtles (Finkbeiner et al. 2011).

Toxin burdens in Kemp's ridley sea turtles include DDT, DDE, PCBs, perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), chlordane, and other organochlorines (Keller et al. 2005; Keller et al. 2004a; Lake et al. 1994; Rybitski et al. 1995). These contaminants have the potential to cause deficiencies in endocrine, developmental and reproductive health, and are known to depress immune function in loggerhead sea turtles (Keller et al. 2006; Storelli et al. 2007a). Along with loggerheads, Kemp's ridley sea turtles have higher levels of PCB and DDT than leatherback and green sea turtles (Pugh and Becker 2001a). Organochlorines, including DDT, DDE, DDD, and PCBs have been identified as bioaccumulative agents and in greatest concentration in subcutaneous lipid tissue (Rybitski et al. 1995). Concentrations ranged from 7.46 $\mu\text{g}/\text{kg}$ to 607 $\mu\text{g}/\text{kg}$, with a mean of 252 $\mu\text{g}/\text{kg}$ in lipid tissue. Five PCB congeners composed most of the contaminants: 153/132, 138/158, 180, 118, and 187 in order of concentration. PCBs have also been identified in the liver, ranging in concentration from 272 ng/g to 655 ng/g of wet weight, values that are several fold higher than in other sea turtle species (Lake et al. 1994). However, concentrations are reportedly 5% of that which causes reproductive failure in snapping turtles. DDE was identified to range from 137 ng/g to 386 ng/g wet weight. Trans-nonachlor was found at levels between 129 ng/g and 275 ng/g wet weight. Blood samples may be appropriate proxies for organochlorines in other body tissues (Keller et al. 2004a). Perfluorinated compounds in the forms of PFOA and PFOS have been identified in the blood of Kemp's ridley turtles at concentrations of 39.4 ng/mL and 3.57 ng/mL , respectively (Keller et al. 2005). Perfluorinated carboxylic acids have also been detected. It is likely that age and habitat are linked to perfluorinated chemical bioaccumulation.

Oil can also be hazardous to Kemp's ridley turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981). Blood levels of metals are lower in Kemp's ridley sea turtles than in other sea turtles species or similar to them, with copper (215 ng/g to 1,300 ng/g), lead (0 to 34.3 ng/g), mercury (0.5 ng/g to 67.3 ng/g), silver (0.042 ng/g to 2.74 ng/g), and zinc (3,280 ng/g to 18,900 ng/g) having been identified (Innis et al. 2008; Orvik 1997). It is likely that blood samples can be used as an indicator of metal concentration. Mercury has been identified in all turtle species studied, but are generally an order of magnitude lower than toothed whales. The higher level of contaminants found in Kemp's ridley sea turtles are likely due to this species tendency to feed higher on the food chain than other sea turtles. Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

5.10 Leatherback sea turtle

Populations. Leatherbacks break into four nesting aggregations: Pacific, Atlantic, and Indian oceans, and the Caribbean Sea. Detailed population structure is unknown, but is likely dependent upon nesting beach location.

Atlantic Ocean. Previous genetic analyses of leatherbacks using only mitochondrial DNA (mtDNA) resulted in an earlier determination that within the Atlantic basin there are at least three genetically different nesting populations: the St. Croix nesting population (U.S. Virgin Islands), the mainland nesting Caribbean population (Florida, Costa Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton et al. 1999). Further genetic analyses using microsatellite markers in nuclear DNA along with the mtDNA data and tagging data has resulted in Atlantic Ocean leatherbacks now being divided into seven groups or breeding populations: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (TEWG 2007b).

Caribbean Sea. Nesting occurs in Puerto Rico, St. Croix, Costa Rica, Panama, Colombia, Trinidad and Tobago, Guyana, Suriname, and French Guiana (Bräutigam and Eckert 2006; Márquez 1990b; Spotila et al. 1996).

Distribution. Leatherbacks range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair et al. 1972; Greer et al. 1973; USFWS 1995). High-latitude leatherback range includes in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador, Argentina, and South Africa (Goff and Lien 1988; Hughes et al. 1998; Luschi et al. 2003; Luschi et al. 2006; Márquez 1990b; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000). Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014). Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27° C (CETAP 1982). Juvenile leatherbacks usually stay in warmer, tropical waters >21° C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James et al. 2005).

Growth and reproduction. It has been thought that leatherbacks reach sexual maturity somewhat faster than other sea turtles (except Kemp's ridley), with an estimated range of 3-6 (Rhodin 1985) or 13-14 years (Zug and Parham 1996). However, recent research suggests otherwise, with western North Atlantic leatherbacks possibly not maturing until as late as 29 years of age (Avens and Goshe 2007; Avens and Goshe 2008; Avens et al. 2009). Female leatherbacks nest frequently (up to 13, average of 5-7 nests per year and about every 2-3 years)(Eckert et al. 2012). The average number of eggs per clutch varies by region: Atlantic Ocean (85 eggs), western Pacific Ocean (85 eggs), eastern Pacific Ocean (65 eggs) and Indian Ocean (>100 eggs (Eckert et al. 2012)). However, up to ~30% of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs incubate for 55-75 days before hatching.

Habitat. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992a; Starbird et al. 1993). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy

features, current boundaries, and coastal retention areas (Benson et al. 2011b; Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U.S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby et al. 1994; Carretta and Forney 1993; Green et al. 1992; Green et al. 1993). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Areas above 30° N in the Atlantic appear to be popular foraging locations (Fossette et al. 2009b). Northern foraging areas were proposed for waters between 35° and 50° N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5° and 15° N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

Migration and movement. Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale et al. 1994). In a single year, a leatherback may swim more than 11,000 km to nesting and foraging areas throughout ocean basins (Benson et al. 2007a; Benson et al. 2011b; Benson et al. 2007b; Eckert 1998; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; Sale et al. 2006). Much of this travel may be due to movements within current and eddy features, moving individuals along (Sale and Luschi 2009). Return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events (generally within 100-300 km) (Benson et al. 2011a; Eckert et al. 2012), or range widely, presumably to feed on available prey (Byrne et al. 2009; Fossette et al. 2009a).

Fossette et al. (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40° N, 25-30° W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10° in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50° N. Individuals nesting in Caribbean Islands migrate to foraging areas off Canada (Richardson et al. 2012).

Genetic studies support the satellite telemetry data indicating a strong difference in migration and foraging fidelity between the breeding populations in the northern and southern hemispheres of the Atlantic Ocean (Dutton et al. 2013; Stewart et al. 2013). Genetic analysis of rookeries in Gabon and Ghana confirm that leatherbacks from West African rookeries migrate to foraging areas off South America (Dutton et al. 2013). Foraging adults off Nova Scotia, Canada, mainly originate from Trinidad and none are from Brazil, Gabon, Ghana, or South Africa (Stewart et al. 2013).

Leatherbacks occur along the southeastern U.S. year-round, with peak abundance in summer (TEWG 2007c). In spring, leatherback sea turtles appear to be concentrated near the coast, while

other times of the year they are spread out at least to the Gulf Stream. From August 2009 through August 2010 off Jacksonville, Florida, surveys sighted 48 leatherback sea turtles, while simultaneous vessel surveys sighted four leatherback sea turtles (U.S. Department of the Navy 2010).

Sex ratio. A significant female bias exists in all leatherback populations thus far studied. An examination of strandings and in-water sighting data from the U.S. Atlantic and Gulf of Mexico coasts indicates that 60% of individuals were female. Studies of Suriname nesting beach temperatures suggest a female bias in hatchlings, with estimated percentages of females hatched over the course of each season at 75.4, 65.8, and 92.2% in 1985, 1986, and 1987, respectively (Plotkin 1995). Binckley et al. (1998) found a heavy female bias upon examining hatchling gonad histology on the Pacific coast of Costa Rica, and estimated male to female ratios over three seasons of 0:100, 6.5:93.5, and 25.7:74.3. James et al. (2007) also found a heavy female bias (1.86:1) as well as a primarily large sub-adult and adult size distribution. Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005a).

Feeding. Leatherbacks may forage in high-invertebrate prey density areas formed by favorable oceanographic features (Eckert 2006; Ferraroli et al. 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell et al. 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found leatherback hatchlings capable of hearing underwater sounds at frequencies of 50-1,200 Hz (maximum sensitivity at 100-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994a).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Consideration of the status of populations outside of 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. Breeding females were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila et al. (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001b; NMFS 2001a)(Table 11).

Florida (March-July) and U.S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude

(NMFS/SEFSC 2001). This positive growth was seen within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007c). Trinidad supports an estimated 7,000 to 12,000 leatherbacks nesting annually (Stewart et al. 2013), which represents more than 80% of the nesting in the insular Caribbean Sea (Fournillier and Eckert 1999). Using both Bayesian modeling and regression analyses, the TEWG (2007c) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate (using nesting females as a proxy for population).

Table 11. Leatherback nesting population site location information where multiple-year surveys were conducted or trends are known (data type, years surveyed, annual number (nests, females, trend). Nesting population trend symbols: ▲ = increasing; ▼ = decreasing.

Location	Data: Nests, Females	Years	Annual number	Trend	Reference
Atlantic					
United States (Florida)	Nests	1979 - 2008	63-754	▲	Stewart et al. (2011)
Puerto Rico (Culebra)	Nests	1993 - 2012	395-32	▼	{C. Diez, Department of Natural and Environmental Resources of Puerto Rico, unpublished data in// NMFS and USFWS, 2013 #36241} Diez et al. (2010; Ramírez-Gallego et al. 2013)
Puerto Rico (other)	Nests	1993 - 2012	131- 1,291	▲	C. Diez, Department of Natural and Environmental Resources of Puerto Rico, unpublished data in// NMFS and USFWS (2013)
United States Virgin Islands (Sandy Point National Wildlife Refuge, St. Croix)	Nests	1986 - 2004	143- 1,008	▲ ¹	Dutton et. al. (2005); Turtle Expert Working Group (2007a)
British Virgin Islands	Nests	1986 - 2006	0-65	▲	McGowan et al. (2008) ;Turtle Expert Working Group (2007a)

¹ A more recent trend analysis was not found in the literature. However, trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

The Caribbean coast of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth largest known leatherback rookery in the world (Troeng et al. 2004). Examination of data from three index nesting beaches in the region (Tortuguero, Gandoca, and Pacuare in Costa Rica) using various Bayesian and regression analyses indicated that the nesting population likely was not growing during 1995-2005 (TEWG 2007c). Other modeling of the nesting data for Tortuguero indicates a 67.8% decline between 1995 and 2006 (Troëng et al. 2007).

In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 ranged between 469-882 nests, and the population has been growing

since 1978, with an overall annual growth rate of 1.1% (TEWG 2007c). At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has fluctuated from a few hundred nests to a high of 1,008 in 2001, and the average annual growth rate has been approximately 1.1% from 1986-2004 (TEWG 2007c). Overall increases are recorded for mainland Puerto Rico and St. Croix, as well as the U.S. Virgin Islands (Ramírez-Gallego et al. 2013). Trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

The Florida nesting stock comes ashore primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (NMFS 2011). Using data from the index nesting beach surveys, the TEWG (2007c) estimated a significant annual nesting growth rate of 1% between 1989 and 2005. Stewart et al. (2011) evaluated nest counts from 68 Florida beaches over 30 years (1979-2008) and found that nesting increased at all beaches with trends ranging from 3.1%-16.3% per year, with an overall increase of 10.2% per year. In 2007, a record 517 leatherback nests were observed on the index beaches in Florida, with 265 in 2008, and then an increase to a new record of 615 nests in 2009, and a slight decline in 2010 back to 552 nests (FWC Index Nesting Beach database). This up-and-down pattern is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting.

The most recent population estimate for leatherback sea turtles from the North Atlantic as a whole is between 34,000-90,000 adult individuals (20,000-56,000 adult females)(TEWG 2007c).

Annual survival probability (ca. 0.85) was constant over the 10-year period. Annual survival was lower than those estimated for Atlantic rookeries (Dutton et al. 2005; Rivalan et al. 2005). For the St. Croix, U.S. Virgin Islands population, the annual survival rate was approximately 0.893 (confidence interval = 0.87-0.92) for adult female leatherbacks at St. Croix (Dutton et al. 2005). Annual juvenile survival rate for St. Croix was estimated to be approximately 0.63, and the total survival rate from hatchling to first year of reproduction for a female hatchling was estimated to be between 0.004 and 0.02, given assumed age at first reproduction between 9 and 13 (Eguchi et al. 2006). In Florida, annual survival for nesting females was estimated to be 0.956 (Stewart 2007). Spotila et al. (1996) estimated the first year (from hatching) of survival for the global population to be 0.0625.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut et al. 2009b). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramírez et al. 2014).

Anthropogenic threats. Leatherback nesting and marine environments are facing increasing impacts through widespread development and tourism along nesting beaches (Hamann et al. 2006; Hernandez et al. 2007; Maison 2006; Santidrián Tomillo et al. 2007). Structural impacts to beaches include building and piling construction, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). In some areas, timber and marine

debris accumulation as well as sand mining reduce available nesting habitat (Bourgeois et al. 2009; Chacón Chaverri 1999; Formia et al. 2003; Laurance et al. 2008). Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois et al. 2009; Cowan et al. 2002; Deem et al. 2007; Witherington 1992; Witherington and Bjorndal 1991). Leatherbacks are much more likely to emerge and not nest on developed beaches and much more likely to emerge and nest on undeveloped stretches (Roe et al. 2013). Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Along the coast of Peru, 13% of 140 leatherback carcasses were found to contain plastic bags and film (Fritts 1982). A leatherback found stranded along the northern Adriatic had been weakened by plastic ingestion, likely leading to an infection that ultimately killed the individual (Poppi et al. 2012). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes et al. 2007b; James et al. 2006; McMahan and Hays 2006; Mrosovsky et al. 1984). Rising sea levels may also inundate nests on some beaches. Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide.

Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale et al. 2008; Fossette et al. 2009a; Gless et al. 2008; Petersen et al. 2009). Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace et al. 2010); many of these turtles are expected to be leatherbacks. Currently, the U.S. tuna and swordfish longline fisheries managed under the HMS FMP are estimated to capture 1,764 leatherbacks (no more than 252 mortalities) for each 3-year period starting in 2007 (NMFS 2004). While 2010 total estimates are not yet available, in 2009, 285.8 (95% CI: 209.6-389.7) leatherback sea turtles are estimated to have been taken in the longline fisheries managed under the HMS FMP based on the observed takes (Garrison and Stokes 2010). Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000. Half or more of the gravid turtles in Trinidad and Tobago waters may be killed (Lee Lum 2003), though many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001b).

We know little about the effects of contaminants on leatherback sea turtles. The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Along with these, lead has also been reported in high concentrations, potentially to the detriment of the individual (Perrault et al. 2013; Poppi et al. 2012). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant et al. 1999). Organochlorine pesticides have also been found (Mckenzie et al. 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport et al. 1990; Oros et al. 2009).

5.11 Loggerhead sea turtle- Northwest Atlantic DPS

Populations. Five groupings represent loggerhead sea turtles by major sea or ocean basin:

Atlantic, Pacific, and Indian oceans, as well as Caribbean and Mediterranean seas. As with other sea turtles, populations are frequently divided by nesting aggregation (Hutchinson and Dutton 2007). On September 22, 2011, the NMFS designated nine distinct population segments (DPSs) of loggerhead sea turtles: South Atlantic Ocean and southwest Indian Ocean as threatened as well as Mediterranean Sea, North Indian Ocean, North Pacific Ocean, northeast Atlantic Ocean, northwest Atlantic Ocean, South Pacific Ocean, and southeast Indo-Pacific Ocean as endangered (75 FR 12598). Recent ocean-basin scale genetic analysis supports this conclusion, with additional differentiation apparent based upon nesting beaches (Shamblin et al. 2014).

Western Atlantic nesting locations include The Bahamas, Brazil, and numerous locations from the Yucatán Peninsula to North Carolina (Addison 1997; Addison and Morford 1996; Marcovaldi and Chaloupka 2007). This group comprises five nesting subpopulations: Northern, Southern, Dry Tortugas, Florida Panhandle, and Yucatán. Additional nesting occurs on Cay Sal Bank (Bahamas), Cuba, the Bahamian Archipelago, Quintana Roo (Yucatan Peninsula), Colombia, Brazil, Caribbean Central America, Venezuela, and the eastern Caribbean Islands. Genetic studies indicate that, although females routinely return to natal beaches, males may breed with females from multiple populations and facilitate gene flow Bowen et al. (2005). In the eastern Atlantic, we know of five rookeries from Cape Verde, Greece, Libya, Turkey, and the western Africa coast.

Distribution. Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic Ocean. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters. Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Reproduction and growth. Loggerhead nesting is confined to lower latitude temperate and subtropical zones but absent from tropical areas (NMFS and USFWS 1991b; NRC 1990b; Witherington et al. 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, subadults, novice breeders, first-year emigrants, and mature breeders (Crouse et al. 1987). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura et al. 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (Avens et al. 2013; NMFS 2005a). Loggerheads in the Mediterranean, similar to those in the Atlantic, grow at roughly 11.8 cm/yr for the first six months and slow to roughly 3.6 cm/yr at age 2.5-3.5. As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale et al. 2009a; Casale et al. 2009b). Individually-based variables likely have a high impact on individual growth rates (Casale et al. 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations (Casale et al. 2009b; Frazer and Ehrhart 1985b; Frazer et al. 1994; NMFS 2001b; Witherington et al. 2006). However, based on data from tag returns, strandings, and nesting surveys, NMFS (2001b) estimated ages of maturity ranging from 20-38 years and benthic immature stage lasting from 14-32 years. Notably, data from several studies showed decreased growth rates of loggerheads in U.S. Atlantic waters from 1997-2007, corresponding to a period of 43% decline in Florida nest counts (Bjorndal et al. 2013).

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as in offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988a; NMFS

and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988a; Richardson et al. 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984), although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. The western Atlantic breeding season is March-August. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Nesting in the Gulf of Mexico does occur, although primarily in Florida, with rare nests along North and South Padre Island in Texas (Dodd 1988b; Hildebrand 1983).

Migration and movement. Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen et al. 2004; NMFS 2001b). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998b). In the Gulf of Mexico, larger females tend to disperse more broadly after nesting than smaller individuals, which tend to stay closer to their nesting locations (Girard et al. 2009). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. As water temperatures drop from October to December, most loggerheads emigrate from their summer developmental habitats to warmer waters south of Cape Hatteras, where they winter (Morreale and Standora 1998). For immature individuals, this movement occurs in two patterns: a north-south movement over the continental shelf with migration south of Cape Hatteras in winter and movement north along Virginia for summer foraging, and a not-so-seasonal oceanic dispersal into the Gulf Stream as far north as the 10-15° C isotherm (Mansfield et al. 2009). Wallace et al. (2009) suggested differences in growth rate based upon these foraging strategies. Long Island Sound, Core Sound, Pamlico Sound, Cape Cod Bay, and Chesapeake Bay are the most frequently used juvenile developmental habitats along the Northeast United States Continental Shelf Large Marine Ecosystem (Burke et al. 1991; Epperly et al. 1995a; Epperly et al. 1995b; Epperly et al. 1995c; Mansfield 2006; Prescott 2000; University of Delaware Sea Grant 2000). There is conflicting evidence that immature loggerheads roam the oceans in currents and eddies and mix from different natal origins or distribute on a latitudinal basis that corresponds with their natal beaches (Monzon-Arguello et al. 2009; Wallace et al. 2009). McCarthy et al. (2010) found that movement patterns of loggerhead sea turtles were more convoluted when sea surface temperatures were higher, ocean depths shallower, ocean currents stronger, and chlorophyll α levels lower. Satellite tracking of loggerheads from southeastern U.S. nesting beaches supports three dispersal modes to foraging areas: one northward along the continental shelf to the northeastern U. S., broad movement through the southeastern and mid-Atlantic U. S., and residency near breeding areas (Reina et al. 2012).

Gender, age, and survivorship. Although information on males is limited, several studies identified a female bias, although a single study has found a strong male bias (Dodd 1988a; NMFS 2001b; Rees and Margaritoulis 2004). Nest temperature seems to drive sex determination. Along Florida, males primarily derive from earlier-season nests (LeBlanc et al. 2012). Here, nests ranged from an average sex ratio of 55% female to 85% (LeBlanc et al. 2012).

Additionally, little is known about longevity, although Dodd (1988a) estimated the maximum female life span at 47-62 years. Heppell et al. (2003a) estimated annual survivorship to be 0.81 (southeast U.S. adult females), 0.78-0.91 (Australia adult females), 0.68-0.89 (southeast U.S. benthic juveniles, and 0.92 (Australia benthic juveniles). Another recent estimate suggested a survival rate of 0.41 or 0.60 (CIs 0.20-0.65 and 0.40-0.78, respectively), depending upon assumptions within the study (Sasso et al. 2011). Survival rates for hatchlings during their first year are likely very low (Heppell et al. 2003a; Heppell et al. 2003).

Feeding. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker et al. 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988a; Wallace et al. 2009). Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988; Hatase et al. 2002). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich et al. 2010; Vander Zanden et al. 2010).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994a; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994a). Bartol et al. (1999) reported effective hearing range for juvenile loggerhead turtles is from at least 250-750 Hz. Both yearling and two-year old loggerheads had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re 1 μ Pa and two-year-olds: about 86 dB re 1 μ Pa), with thresholds increasing rapidly above and below that frequency (Moein Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Loggerhead sea turtles were listed as threatened under the ESA of 1973 on July 28, 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine distinct population segments (DPSs) of loggerhead sea turtles (75 FR 12598).

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size (Bjorndal et al. 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1% of total population numbers. The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004).

The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located

on the Yucatán Peninsula of Mexico, Columbia, Cuba, and South Africa (EuroTurtle 2006 as cited in LGL Ltd. 2007; Márquez 1990b).

Among the five subpopulations, loggerhead females lay 53,000-92,000 nests per year in the southeastern U.S. and the Gulf of Mexico, and the total number of nesting females are 32,000-56,000. All of these are currently in decline or data are insufficient to assess trends (NMFS 2001b; TEWG 1998a). Loggerheads from western North Atlantic nesting aggregations may or may not feed in the same regions from which they hatch. Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise 25-59% of individuals foraging from Georgia up to the northeast U.S. (Bass et al. 1998; Norrgard 1995; Rankin-Baransky 1997; Sears 1994; Sears et al. 1995). Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10% of the loggerhead captures) and the Mediterranean Sea (where they represent ~45% of loggerhead sea turtles captured). About 4,000 nests per year are laid along the Brazilian coast (Ehrhart et al. 2003).

The northern recovery unit along Georgia, South Carolina, and North Carolina has a forty-year time-series trend showing an overall decline in nesting, but the shorter comprehensive survey data (20 years) indicate a stable population (Georgia Department of Natural Resources, North Carolina Wildlife Resource Commission, and South Carolina Department of Natural Resources nesting data located at www.seaturtle.org). NMFS scientists have estimated that the northern subpopulation produces 65% males (NMFS 2001b).

The peninsular Florida recovery unit is the largest loggerhead nesting assemblage in the northwest Atlantic. A near-complete nest census (all beaches including index nesting beaches) undertaken from 1989 to 2007 showed a mean of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females annually (NMFS and USFWS 2008). The statewide estimated total for 2010 was 73,702 (FWRI nesting database). An analysis of index nesting beach data shows a 26% nesting decline between 1989 and 2008, and a mean annual rate of decline of 1.6% despite a large increase in nesting for 2008, to 38,643 nests (FWRI nesting database)(NMFS and USFWS 2008; Witherington et al. 2009). In 2009, nesting levels, while still higher than the lows of 2004, 2006, and 2007, dropped below 2008 levels to approximately 32,717 nests, but in 2010, a large increase was seen, with 47,880 nests on the index nesting beaches (FWRI nesting database). The 2012³ index nesting number is the largest since 2000. Nesting counts in 2013 and 2014 were lower than 2012, but still roughly equivalent to counts in 2000. With the addition of data through 2010, the nesting trend for the northwestern Atlantic DPS is slightly negative and not statistically different from zero (no trend) (NMFS and USFWS 2010).

Because of its size, the South Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS 2006e; NMFS and USFWS 1991b). The South Florida population increased at ~5.3% per year from 1978-1990, and was initially increasing at 3.9-4.2% after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate

3 <http://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/>

surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3% (FFWCC 2007a; FFWCC 2007b; Witherington et al. 2009). This is likely due to a decline in the number of nesting females within the population (Witherington et al. 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in Southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size⁴. Loggerhead nesting is thought to consist of just 60 nesting females in the Caribbean and Gulf of Mexico (NMFS 2006c). Based upon the small sizes of almost all nesting aggregations in the Atlantic, the large numbers of individuals killed in fisheries, and the decline of the only large nesting aggregation, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic are only slightly lower than those of populations in the Pacific.

Zurita et al. (2003) found a statistically significant increase in the number of nests on seven of the beaches on Quintana Roo, Mexico, from 1987-2001, where survey effort was consistent during the period. However, nesting has declined since 2001, and the previously reported increasing trend appears to have been temporary (NMFS and USFWS 2008).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can pose lethal effects. In January 2010, an unusually large cold-stunning event occurred throughout the southeast U. S., with well over 3,000 sea turtles (mostly greens but also hundreds of loggerheads) found cold-stunned. Most survived, but several hundred were found dead or died after being discovered in a cold-stunned state. Eggs are commonly eaten by raccoons and ghost crabs along the eastern U.S. (Barton and Roth 2008). In the water, hatchlings are hunted by herons, gulls, dogfish, and sharks. Heavy loads of barnacles are associated with unhealthy or dead stranded loggerheads (Deem et al. 2009). Brevetoxin-producing algal blooms can result in loggerhead sea turtle death and pathology, with nearly all stranded loggerheads in affected areas showing signs of illness or death resulting from exposure (Fauquier et al. 2013). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramirez et al. 2014).

Anthropogenic threats. Anthropogenic threats impacting loggerhead nesting habitat are numerous: coastal development and construction, placement of erosion control structures, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach nourishment, beach pollution, removal of native vegetation, and planting of non-native vegetation (Baldwin 1992; Margaritoulis et al. 2003; Mazaris et al. 2009b; USFWS 1998). Surprisingly, beach nourishment also hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock et al. 2009). Loggerhead sea turtles face numerous threats in the marine environment as well, including oil and gas exploration, marine pollution, trawl, purse seine, hook and line, gill net, pound net, longline, and trap fisheries,

⁴ While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern.

underwater explosions, dredging, offshore artificial lighting, power plant entrapment, entanglement in debris, ingestion of marine debris, marina and dock construction and operation, boat collisions, and poaching. At least in the Mediterranean Sea, anthropogenic threats appear to disproportionately impact larger (more fecund) loggerheads (Bellido et al. 2010).

Marine debris ingestion is a widespread issue for loggerhead sea turtles. More than one-third of loggerheads found stranded or bycaught had ingested marine debris in a Mediterranean study, with possible mortality resulting in some cases (Lazar and Gračan 2010). Another study in the Tyrrhenian Sea found 71% of stranded and bycaught sea turtles had plastic debris in their guts (Campani et al. 2013). Another threat marine debris poses is to hatchlings on beaches escaping to the sea. Two thirds of loggerheads contacted marine debris on their way to the ocean and many became severely entangled or entrapped by it (Triessnig et al. 2012).

Climate change may also have significant implications on loggerhead populations worldwide. In addition to potential loss of nesting habitat due to sea level rise, loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1°-2° C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes et al. 2007a). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin et al. 2009). Sea surface temperatures on loggerhead foraging grounds correlate to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris et al. 2009a; Schofield et al. 2009). Increasing ocean temperatures may also lead to reduced primary productivity and eventual food availability. This has been proposed as partial support for reduced nesting abundance for loggerhead sea turtles in Japan; a finding that could have broader implications for other populations in the future if individuals do not shift feeding habitat (Chaloupka et al. 2008b). Warmer temperatures may also decrease the energy needs of a developing embryo (Reid et al. 2009). Pike (2014) estimated that loggerhead populations in tropical areas produce about 30% fewer hatchlings than do populations in temperate areas. Historical climactic patterns have been attributed to the decline in loggerhead nesting in Florida, but evidence for this is tenuous (Reina et al. 2013).

Tissues taken from loggerheads sometimes contain very high levels of organochlorines chlorobiphenyl, chlordanes, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT, and PCB (Alava et al. 2006; Corsolini et al. 2000; Gardner et al. 2003; Guerranti et al. 2013; Keller et al. 2005; Keller et al. 2004a; Keller et al. 2004b; McKenzie et al. 1999; Monagas et al. 2008; Oros et al. 2009; Perugini et al. 2006; Rybitski et al. 1995; Storelli et al. 2007b). It appears that levels of organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2004c; Keller et al. 2006; Oros et al. 2009). These contaminants could cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007b). It is likely that the omnivorous nature of loggerheads makes them more prone to bioaccumulating toxins than other sea turtle species (Godley et al. 1999; McKenzie et al. 1999). PAH pollution from petroleum origins has been found in Cape Verde loggerheads, where marine oil and gas extraction is not undertaken (Camacho et al. 2012).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Anan et al. 2001; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). These metals

likely pass to turtles from plants and seem to have high transfer coefficients (Anan et al. 2001; Celik et al. 2006; Talavera-Saenz et al. 2007). Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley et al. 1999; Pugh and Becker 2001b). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds.

Also of concern is the spread of antimicrobial agents from human society into the marine environment. Loggerhead sea turtles may harbor antibiotic-resistant bacteria, which may have developed and thrived as a result of high use and discharge of antimicrobial agents into freshwater and marine ecosystems (Foti et al. 2009).

ENVIRONMENTAL BASELINE

By regulation, the environmental baseline for ESA section 7 consultation includes the past and present impacts of all state, federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR §402.02). The *Environmental Baseline* for this Opinion includes the effects of several activities potentially affecting the survival and recovery of ESA-listed species in the action area.

5.12 Climate change

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 will address these effects in the relevant species-specific section.

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 0.74° 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 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 anomalously warm in recent years (Blunden and Arndt 2013). The ocean along the U.S. 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. As described in the *Status of Listed Resources* for each sea turtle species, temperature regimes are generally leading towards female-biased nests. This can result in heavily feminized populations incapable of fertilization of available females (Laloë et al. 2014). This is not considered to be an imminent threat and presently has the advantage of shifting the natural rates of population growth higher (Laloë et al. 2014). 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 upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most 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 listed 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 Elliott. 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 sea 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 particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon 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 non-tropical 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 about 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). However, 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 and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with 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. However, these declines resulted, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older krill age classes, which lowered the number of predators krill could sustain. The authors concluded that 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 due to climate change have been suggested 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 like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is 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. 1990b). 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).

Foraging is not the only potential aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that 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. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). 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 Elliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Elliott. 2009).

Sims et al. (2001) found the timing of squid peak abundance in the English Channel advanced by 120-150 days in the warmest years compared with the coldest. Bottom water temperatures correlated with the extent of squid movement, and temperature increases over the five months before and during the month of peak squid movement did not differ between early and late years.

These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which climatic changes association with the North Atlantic Oscillation mediate. Cephalopods dominate the diet of sperm whales, who would likely re-distribute following changes in the distribution and abundance of their prey. If, however, cephalopod populations collapse or decline dramatically, sperm whales would likely decline as well. Long-term shifts of sperm whale prey in the California Current have also been attributed to the re-distribution of their 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.

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Johnson et al. 2011; Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Blunden and Arndt 2013; Poloczanska et al. 2009). Ocean temperatures around Iceland are linked with alterations in the continental shelf ecosystem there, including shifts in minke whale diet (Víkingsson et al. 2014).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40% increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. The current pace is nearly double this, with a 20-year trend of 3.2 mm/year (Blunden and Arndt 2013). This is largely due to thermal expansion of water, with minor contributions from melt water (Blunden and Arndt 2013). Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). In addition, flatter beaches preferred by smaller sea turtle species would be inundated sooner than would steeper beaches preferred by larger species (Hawkes et al. 2014). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009a). Storms may also cause direct harm to sea turtles, causing “mass” strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Smaller individuals likely experience increased predation (Fuentes et al. 2009b).

Climatic shifts also occur due to natural phenomena. In the North Atlantic, this primarily concerns fluctuations in the 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. 2002a). This interaction

affects sea surface temperatures, wind patterns, and oceanic circulation in the North Atlantic (Stenseth et al. 2002a). The NAO shifts between positive and negative phases, with a positive phase having persisted since 1970 (Hurrell 1995). North Atlantic conditions experienced during positive NAO phases include warmer than average winter weather in central and eastern North America and Europe and colder than average temperatures in Greenland and the Mediterranean Sea (Visbeck 2002). Effects are most pronounced during winter (Taylor et al. 1998). The NAO is significant for North Atlantic right whales due to 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. 2001b; Greene and Pershing 2004; Greene et al. 2003a). This subsequently impacts the nutritional state of North Atlantic right whales and the rate at which sexually mature females can produce calves (Greene et al. 2003a).

5.13 Habitat degradation

A number of factors may be directly or indirectly affecting listed species in the action area by degrading habitat. These include ocean noise and fisheries impacts.

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 the last six decades in some areas, primarily due to 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), among other effects (Eriksen and Pakkenberg 2013; Francis and Barber 2013). For species inhabiting Arctic waters, vessel and industrial noise may become much more problematic as oil and gas development and commercial shipping lanes through ice-free areas expand and intensify (Reeves et al. 2014). Vessels pose not only a risk of ship strike, but also impede the ability of whales to communicate. Hatch et al. (2012) estimated that roughly two-thirds of a right whales' communication space may be lost due to current ocean noise levels, which have greatly increased due to shipping noise. Shipping noise is also linked with increased stress levels in right whales (Rolland et al. 2012a).

Marine debris is another significant concern for listed species and their habitats. Marine debris has been discovered to be accumulating in gyres throughout the oceans. Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008. More than 60% of 6,136 surface plankton net tows collected small, buoyant plastic pieces. The data identified an accumulation zone east of Bermuda that is similar in size to the accumulation zone in the Pacific Ocean. Over half of cetacean species (including humpback, fin, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014).

Ingestion of marine debris can have fatal consequences even for large whales as well as sea turtles. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract. A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). Further incidents may occur but remain undocumented when

carcasses do not strand.

For sea turtles, marine debris is a problem due primarily to individuals ingesting debris and blocking the digestive tract, causing death or serious injury (Laist et al. 1999; Lutcavage et al. 1997a). Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives; this figure is supported by data from Lazar and Gračan (Lazar and Gračan 2010), who found 35% of loggerheads had plastic in their gut. One study found 37% of dead leatherback turtles had ingested various types of plastic (Mrosofsky et al. 2009). A Brazilian study found that 60% of stranded green sea turtles had ingested marine debris (primarily plastic and oil; (Bugoni et al. 2001)). Loggerhead sea turtles had a lesser frequency of marine debris ingestion. Plastic is possibly ingested out of curiosity or due to confusion with prey items; for example, plastic bags can resemble jellyfish (Milton and Lutz 2003). Marine debris consumption has been shown to depress growth rates in post-hatchling loggerhead sea turtles, elongating the time required to reach sexual maturity and increasing predation risk (McCauley and Bjorndal 1999). Sea turtles can also become entangled and die in marine debris, such as discarded nets and monofilament line (Laist et al. 1999; Lutcavage et al. 1997a; NRC 1990a; O'Hara et al. 1988). This fundamentally reduces the reproductive potential of affected populations, many of which are already declining (such as loggerhead and leatherback sea turtle populations in the action area).

5.14 Dredging

Marine dredging vessels are common within U.S. coastal waters. Although the underwater noises from dredge vessels are typically continuous in duration (for periods of days or weeks at a time) and strongest at low frequencies, they are not believed to have any long-term effect on sea turtles. However, the construction and maintenance of federal navigation channels and dredging in sand mining sites have been identified as sources of sea turtle mortality and are currently being undertaken along the U.S. east coast, such as in Port Everglades, Florida. Hopper dredges in the dredging mode are capable of moving relatively quickly compared to sea turtle swimming speed and can thus overtake, entrain, and kill sea turtles as the suction draghead(s) of the advancing dredge overtakes the resting or swimming turtle. Entrained sea turtles rarely survive. Relocation trawling frequently occurs in association with dredging projects to reduce the potential for dredging to injure or kill sea turtles (Dickerson et al. 2007).

5.15 Seismic surveys

During October and November 2003, the NSF 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 in³.

There have also been numerous prior seismic surveys from 1979 to 2002. These include surveys with a six airgun, 1,350 in³ array in 1990; a single, 45 in³ GI gun in 1996 and 1998; and two 45 in³ GI guns in 2002 (NSF 2014). Impacts to listed species were not identified.

The proposed seismic survey was originally scheduled for July and August of 2014. However, due to 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). During this time, 29 sea turtles were observed (10 were loggerhead, and the rest were unidentified hard-shelled turtles within the 166 dB isopleth). Most sea turtle detections (13 of 19) were made while airguns were on, while the humpback whale was sighted while airguns were off. Eight sea turtle detections

resulted in shutdowns. Two sightings of mysticetes, including one for a humpback whale, were also made.

During August and September 2014, the U.S. Geological Survey funded a seismic survey along the U.S. eastern seaboard from roughly Massachusetts to South Carolina aboard the *Langseth*. The 6,600 in³, 40-airgun array was operational for 357 hours and used the same sonars that will be used during the proposed seismic survey. Although loggerhead sea turtles and sperm whales were observed, no listed whales or sea turtles were observed within the 160 dB re 1 μ Pa exclusion zone. Almost all observations of the 20 marine mammal and sea turtle detections were made while the airguns were off. This project is composed of two cruises, the second of which will occur during 2015 in roughly the same area, using the same airgun array, vessel, and sonars.

Another seismic survey by the *Langseth* was conducted along North Carolina during September and October 2014. This seismic survey utilized a 3,300 in³, 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.

5.16 Vessel traffic

Vessel noise could affect marine animals in the study area. Shipping noise generally dominates ambient noise at frequencies from 20 to 300 Hz (Andrew et al. 2002; Hildebrand 2009; Richardson et al. 1995c). Background noise has increased significantly in the past 50 years as a result of increasing vessel traffic, and particularly shipping, with increases of as much as 12 dB in low frequency ranges; background noise may be 20 dB higher now versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995a). Over the past 50 years, the number of commercial vessels has tripled, carrying an estimated six times as much cargo (requiring larger, more powerful 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. Masking of acoustic information can result (Simard et al. 2013); an important issue for marine mammals that rely primarily on sound as a sense. Dunlop et al. (2010) 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 due to increased sea state. Other coping mechanisms include shifting the frequency or amplitude of calls, increasing the redundancy or length of calls, or waiting for a quieter period in which to vocalize (Boness et al. 2013; Holt et al. 2013; Parks et al. 2013). Increases in vessel traffic and marine industrial construction is associated with decreases in the presence of minke whales and gray seals, presumably due to increased noise in the area (Anderwald et al. 2013). Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009).

5.17 U.S. Navy training and testing activities

Table 12 indicates the number of different listed species likely to be "taken" annually as a result of their exposure to U.S. Navy training activities (excluding active sonar) on East Coast Training Ranges from June 2012 through June 2014.

Table 12. Anticipated incidental take of ESA species within U.S. Navy East Coast Training Range Complexes.

Whale or sea turtle species	Operating area							
	Northeast		Virginia Capes		Cherry Point		Jacksonville	
	Harass	Harm	Harass	Harm	Harass	Harm	Harass	Harm
Blue	0	0	0	0	0	0	0	0
Fin	0	0	2	0	0	0	0	0
Humpback	0	0	2	0	0	0	0	0
North Atlantic right	0	0	0	0	0	0	0	0
Sei	0	0	0	0	0	0	0	0
Sperm	0	0	2	0	0	0	0	0
Hardshell sea turtles	0	0	300	2	0	0	11	1
Kemp's ridley	0	0	555	5	0	0	2	0
Leatherback	0	0	9	0	0	0	11	1
Northwest Atlantic loggerhead	0	0	466	8	0	0	19	1

Anticipated effects from harassment include changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent disruptions of the normal behavioral patterns of the animals that have been exposed. Behavioral responses that result from stressors associated with these training activities are expected to be temporary and would not affect the reproduction, survival, or recovery of these species. Instances of harm identified generally represent animals that would have been exposed to underwater detonations at 205 dB re $\mu\text{Pa}^2\text{-s}$ or 13 psi, which corresponds to an exposure in which 50% of exposed individuals would be expected to experience rupture of their tympanic membrane, an injury that correlates with measures of permanent hearing impairment (Ketten 1998c).

U.S. Navy aerial bombing training in the ocean off the southeast U.S. involving live ordnance (500 and 1,000-lb bombs) has been estimated to have injured or killed 84 loggerhead, 12 leatherback, and 12 green or Kemp's ridley sea turtles (NMFS 1997). From 2009- 2012, NMFS issued a series of biological opinions to the U.S. Navy for training activities occurring within their Northeast, Virginia Capes, Cherry Point and Jacksonville Range Complexes that anticipated annual levels of take of listed species incidental to those training activities through 2014. During the proposed activities 2 fin whales, 2 humpback whales, 2 sperm whales, 344 hardshell sea turtles (any combination of green hawksbill, Kemp's ridley or Northwest Atlantic loggerhead sea

turtles), 644 Kemp's ridley sea turtles, 21 leatherback sea turtles and 530 Northwestern Atlantic loggerhead sea turtles per year are expected to be harassed as a result of their behavioral responses to mid- and high frequency active sonar transmissions. Another six Kemp's ridley and five Northwestern Atlantic loggerhead turtles per year are expected to be injured during exposure to underwater detonations.

5.18 U.S. Marine Corps training in the Cherry Point Range Complex

Table 13 identifies the likely take associated with Marine Corps activities in the Cherry Point Range Complex off North Carolina. Individual ESA-listed whales and sea turtles that could occur in the action area would possibly travel through the Cherry Point Range Complex, thus exposing these species to the training activities.

Table 13. Incidental take associated with U.S. Marine Corps training in the Cherry Point Range Complex that is currently authorized.

Species	MCAS Cherry Point water ranges						
	Boat maneuvers (BT-9 & BT-11)		Ordnance/munitions delivery (BT-9 & BT-11)		Underwater explosions (BT-9 only)		
	Harass	Harm (injury, mortality) from vessel strike	Harass	Harm (injury, mortality) from direct strike	Harass (temporary threshold shift and other behavioral impacts)	Harm	
						Injury	Mortality
Green sea turtle	10 of any species per year	1 of any species over a 10-year period	10 of any species per year	2 of any species over a 10-year period	23 per year	1 per year (permanent threshold shift)	1 over a 10-year period
Kemp's ridley sea turtle							
Leatherback sea turtle							
Northwest Atlantic DPS Loggerhead sea turtle							

5.19 Entrapment and entanglement in fishing gear

Fisheries interactions are a significant problem for several marine mammal species and particularly so for humpback whales, as well as sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). In excess of 97% of entanglement is caused by derelict fishing gear (Baulch and Perry 2014). Aside from the potential of entrapment and entanglement, there is also concern that many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to accurately determine the frequency of mortalities. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by

restricting agility and swimming speed. Like fin whales, 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 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005c; Nelson et al. 2007c). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Waring et al. (2007) reported four fin whales in the western North Atlantic having died or were seriously injured in fishing gear

Of the current threats to North Atlantic right whales, entanglement in commercial fishing gear poses one of the greatest threats (**Figure 7**). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 46 confirmed reports of North Atlantic right whales entangled in fishing gear between 1990 and 2007 (Cole et al. 2005a; Nelson et al. 2007a; Waring et al. 2009). Of the 39 reports that NMFS could confirm, North Atlantic right whales were injured in five of the entanglements and killed in four entanglements. Three of the 24 entangled whales between 2004 and 2008 died and one other resulted in serious injury (Glass et al. 2009). Recent efforts to disentangle right whales have met with success (Anonymous. 2009).

Nine instances of entanglement were recorded between 2006 and 2010, two of which were disentangled (Waring et al. 2013). From 1970-2010, 74 instances of entanglement have been documented (Waring et al. 2013). Scars examined between 1980 and 2002 revealed that 75% of 447 individuals examined showed scarring from fishing gear (Waring et al. 2013). It is also estimated that 14 and 51% of right whales are entangled on an annual basis (Knowlton et al. 2005). Another study assessing photographs of right whales from 1980-2009 found 626 individuals having 1,032 entanglement scars (Knowlton et al. 2012). This included 83% having at least one scar and 59% having multiple scars, with juveniles being entangled at higher rates than adults and the sexes entangling equally (Knowlton et al. 2012). Scars also became more abundant over the study period, suggesting entanglement rates are increasing (Knowlton et al. 2012). In August 1993, a dead sperm whale, with longline gear wound tightly around the jaw, was found floating about 32 km off Maine.



Figure 7. A North Atlantic right whale entangled in fisheries gear off Florida, with Georgia Department of Natural Resources and Coastwise Consulting staff attempting to cut rope off (Credit: EcoHealth Alliance and Georgia Department of Natural Resources, ESA permit number 932-1905).

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. Wallace et al. (2010) estimated that worldwide, 447,000 turtles are killed each year from bycatch in commercial fisheries. NMFS (2002a) estimated that 62,000 loggerhead sea turtles have been killed as a result of incidental capture and drowning in shrimp trawl gear. Although turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch to sea turtles and other marine species in U.S. waters, mortality still occurs. The fisheries that have the most significant demographic effect on sea turtles are the Gulf of Mexico shrimp trawl fisheries. The estimated annual number of interactions and mortalities between sea turtles and shrimp trawls in the Gulf shrimp fisheries (state and federal) are believed to have declined versus prior regulations (Epperly et al. 2002; Nance et al. 2008) (**Table 14**). Although participants in this and other fisheries are required to use Turtle Exclusion Devices, which are estimated to reduce the number of sea turtles trawlers capture by as much as 97%, each year these fisheries are expected to capture about 185,000 sea turtles annually and kill about 5,000 of them. Loggerhead sea turtles account for most of this these: capturing about 163,000 loggerhead sea turtles, killing almost 4,000 of them. However, more recent estimates suggest interactions and mortality has decreased from pre-regulatory periods, with a conservative estimate of 26,500 loggerheads captured annually in U.S. Atlantic fisheries causing mortality to 1,400 individuals per year (Finkbeiner et al. 2011). These are followed by green sea turtles: about 18,700 green sea

turtles are expected to be captured each year with more than 500 of them dying as a result of their capture (NMFS 2002b). Each year, various fisheries capture about 2,000 loggerhead sea turtles in Pamlico Sound, of which almost 700 die (Finkbeiner et al. 2011). The action area and its surrounding region appears to be a location of moderate sea turtle longline bycatch relative to long-term global levels (Lewison et al. 2014).

Table 14. Estimated annual interactions between sea turtles and shrimp trawls in the Gulf of Mexico shrimp fisheries associated estimated mortalities based on 2007 Gulf effort data taken from Nance et al. (2008).

Species	Estimated interactions	Estimated mortalities
Leatherback	520	15
Loggerhead	23,336	647
Kemp's ridley	98,184	2,716
Green	11,311	319

Mortality of leatherbacks in the U.S. shrimp fishery is now estimated at 54 turtles per year. Data collected by the Northeast Fisheries Science Center Fisheries Observer Program from 1994 through 1998 (excluding 1997) indicate that a total of 37 leatherbacks were incidentally captured (16 lethally) in drift gillnets set in offshore waters from Maine to Florida during this period. Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000.

Portions of the Atlantic pelagic fisheries for swordfish, tuna, shark, and billfish also operate in the action area and capture and kill the second highest number of sea turtles along the Atlantic coast. These fisheries include purse seine fisheries for tuna, harpoon fisheries for tuna and swordfish, commercial and recreational rod and reel fisheries, gillnet fisheries for shark, driftnet fisheries, pelagic longline fisheries, and bottom longline fisheries. Lewison et al. (2004) estimated that 30,000-60,000 leatherbacks were taken in all Atlantic longline fisheries in 2000 (including the U.S. Atlantic tuna and swordfish longline fisheries, as well as others). Between 1986 and 1995, this fishery captured and killed one North Atlantic right whale, two humpback whales, and two sperm whales. Between 1992 and 1998, the longline components of these fisheries are estimated to have captured more than 10,000 sea turtles (4,585 leatherback sea turtles and 5,280 loggerhead sea turtles), killing 168 of these, disincluding sea turtles that might have died after being released (Johnson et al. 1999; Yeung 1999). Since then, all components of these fisheries are estimated to capture about 1,350 sea turtles each year, killing 345. Finkbeiner et al. (2011) estimated that annual bycatch interactions total 1,400 leatherbacks annually for U.S. Atlantic fisheries (resulting in roughly 40 mortalities).

On 4 July 2004, NMFS published a final rule to implement management measures to reduce bycatch and bycatch mortality of Atlantic sea turtles in the Atlantic pelagic longline fishery (6979 FR 40734). The management measures include mandatory circle hook and bait

requirements and mandatory possession and use of sea turtle release equipment to reduce bycatch mortality. This is expected to significantly reduce sea turtle mortality from pelagic longlines.

In 2008, Southeast Fisheries Science Center observer programs and subsequent analyses indicated that the overall amount and extent of incidental take for sea turtles specified in the incidental take statement of the 2005 opinion on the reef fish fishery had been severely exceeded by the bottom longline component of the fishery (approximately 974 captures and at least 325 mortalities estimated for the period July 2006-2007). The Gulf of Mexico Fishery Management Council developed a long-term management strategy via a new amendment (Amendment 31 to the Reef Fish FMP). The amendment included a prohibition on the use of bottom longline gear in the Gulf of Mexico reef fish fishery, shoreward of a line approximating the 35-fathom contour east of Cape San Blas, Florida, from June through August; a reduction in the number of bottom longline vessels operating in the fishery via an endorsement program and a restriction on the total number of hooks that may be possessed onboard each Gulf of Mexico reef fish bottom longline vessel to 1,000, only 750 of which may be rigged for fishing. These changes are expected to greatly reduce the mortality of loggerhead sea turtles resulting from the operation of this fishery.

Observation of the directed highly migratory shark fisheries has been ongoing since 1994, but a mandatory program was not implemented until 2002. Neritic juvenile and adult loggerhead sea turtles are the primary species taken, but leatherback sea turtles have also been observed caught. From 1994-2002, observers covered 1.6% of all hooks, observing bycatch of 31 loggerhead, 4 leatherback, and 8 unidentified sea turtles with estimated annual average take levels of 30, 222, and 56, respectively (NMFS 2003).

In addition to commercial bycatch, recreational hook-and-line interaction also occurs. Cannon and Flanagan (1996) reported that from 1993 to 1995, at least 170 Kemp's ridley sea turtles were hooked or tangled by recreational hook-and-line gear in the northern Gulf of Mexico. Of these, 18 were dead stranded turtles, 51 were rehabilitated turtles, five died during rehabilitation, and 96 were reported as released by fishermen.

5.20 Invasive species

Invasive species have been referred to as one of the top four threats to the world's oceans consistently ranked behind habitat degradation and alteration (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). In most cases, habitat is directly affected by human alterations, such as hydromodification, mining, dredging, drilling, and construction. However, invasive species, facilitated by human commerce, have the ability to directly alter ecosystems upon which listed species rely.

Invasive species are a major threat to many ESA-listed species. For species listed by the United States Fish and Wildlife Service (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 listed species are at risk of becoming endangered or extinct completely or in part due to 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 due to 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 U.S. as a whole.

5.21 Diseases

The impacts of introduced pathogens in the aquatic environment has been poorly explored and we likely know very little about the true frequency and significance of pathogen invasions (Drake et al. 2001). Pathogens are known to have adverse effects to invertebrate communities. Molluscs such as black and white abalone seem to be particularly sensitive to pathogens. Various species of the genus *Vibrio*, known to cause cholera in humans, white pox and white plague type II diseases in corals, and mortality in abalone of the same genus as black and white abalone, have been identified in ports and ballast water of vessels (Aguirremacedo et al. 2008; Anguiano-Beltrán et al. 1998; Ben-Haim and Rosenberg 2002). Oyster species have sustained several outbreaks from invasive pathogens, including *Haplosporidium nelsoni* (the cause of MSX disease, which Chesapeake Bay eastern oysters have shown 75-92% mortality to) and *Perkinsus marinus* (the cause of Dermo disease) in California, eastern North America, and Europe (Andrews 1984; Burreson and Ford 2004; Burreson et al. 2000; Ford and Haskin 1982; Renault et al. 2000), *Bonamia ostreae* in Europe (Ciguarria and Elston 1997; Van Banning 1987), and in the northeastern U.S., respectively (Ford 1996). Although specific instances of sea turtle pathogen transference via invasive species are not documented, their spread into new areas are easily possible, particularly given environmental perturbations and naïve individuals in receiving habitats.

5.22 Wind energy

Efforts to develop wind energy facilities offshore of the U.S. east coast have increased over the past several years. The Bureau of Ocean Energy Management assumed that the entire area of each Mid-Atlantic Wind Energy Area would be leased based on the expressions of commercial wind energy interest received. Leases could be issued and site characterization and assessment activities started as early as 2012. Site characterization and assessment activities would occur over a period of about 5.5 years per lease (BOEM 2012). The most advanced in development of these is the Cape Wind Energy project (Cape Cod, Massachusetts) calls for 130 wind turbine generators. The Bureau of Ocean Energy Management approved a construction and operations plan for the project in 2011 (USDOJ 2011). Another six-turbine system is proposed off New Jersey, for which state permits were issued in 2011 (Fisherman's Energy of New Jersey LLC 2011). Several leases have been issued that would allow for testing and investigation of wind resources at various sites (BOEM 2012). Significant ocean noise and vessel activity is associated with construction of facilities such as these, which numerous studies have shown to displace marine mammals from the area, but who generally return post-construction. It is not known whether migratory species deflect to avoid facilities such as these once constructed.

5.23 Entrainment in power plants

Sea turtles entering coastal or inshore areas have been affected by entrainment in the cooling-water systems of electrical generating plants. A comprehensive biological opinion that covers all power plant cooling water intakes was issued by the Services in May 2014, but does not identify

amount or extent of listed species expected to be taken. This will be undertaken on a case-by-case basis for each power plant.

5.24 Ship-strikes

Ship-strike is a significant concern for the recovery of listed whales and, to a lesser degree, sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U.S. Atlantic coast and Canada's Maritime Provinces (Cole et al. 2005c; Nelson et al. 2007c). Two of these ship strikes were reported as having resulted in death. An update (unpublished data 1995–2011) ship strike inventory for the eastern seaboard indicates the following percentage of strikes by species: North Atlantic right whale (19%), humpback whale (28%), sei whale (6%), fin whale (17%), sperm whale (2%), and unknown species (16%). Based on the records available, large whales have been struck by ships off almost every coastal state in the U. S., although ship strikes are most common along the Atlantic Coast. More than half (56%) of the recorded ship strikes from 1975-2002 occurred off the coasts of the northeastern U.S. and Canada, while the mid-Atlantic and southeastern areas each accounted for 22% (Jensen and Silber 2003). According to Waring et al. (2007), five fin whales were killed or injured as a result of ship strikes between January 2000 and December 2004. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U.S. and Canadian Atlantic coasts (Cole et al. 2005a; Nelson et al. 2007a). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist et al. 2001).

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 are expected to reduce the chance of humpback whales being hit by ships by 9%, fin whales by 42%, right whales by 62%, and sei whales by 17%; the same rule applies from November through April from Brunswick, Georgia to Jacksonville, Florida, where North Atlantic right whales go for calving and breeding. Speed rules also apply to medium and large ports along the eastern seaboard during this time frame when right whales migrate to and from northern feeding and southern breeding areas. Nearly a dozen shipping lanes transect through coastal waters of the southeastern U.S. from the North-South Carolina to Cape Canaveral, Florida. Modeling efforts suggest voluntary changes in "areas to be avoided" suggested by the International Maritime Organization will reduce right whale strikes over the Scotian Shelf from one lethal strike every 0.78-2.07 years to one every 41 years (Hoop et al. 2012). Part of the susceptibility of North Atlantic right whales to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011b).

We believe the vast majority of ship-strike mortalities go unnoticed, and that actual mortality is higher than currently documented; Kraus et al. (2005) estimated that 17% of ship strikes are actually detected. The magnitude of the risks commercial ship traffic pose to large whales in the proposed action areas has been difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the U.S. EEZ and have virtually no information on interactions between ships and commercial vessels outside of U.S.

waters. With the information available, we know those interactions occur but we cannot estimate their significance to whale species.

Ship strikes are the largest single contributor to North Atlantic right whale deaths, accounting for approximately 35% of all known mortalities, even though right whales should be able to hear the sound produced by vessels (Ketten 1998a; Knowlton and Kraus 2001a; Laist et al. 2001; Richardson et al. 1995a). Some information suggests right whales respond only within very close proximity to ships (Nowacek et al. 2004a). Various types and sizes of vessels have been involved in ship strikes with large whales, including container/cargo ships/freighters, tankers, steamships, U.S. Coast Guard vessels, Navy vessels, cruise ships, ferries, recreational vessels, fishing vessels, whale-watching vessels, and other vessels (Jensen and Silber 2004). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. There have been 18 reports of North Atlantic right whales being struck by vessels between 1999 and 2005 (Cole et al. 2005b; Nelson et al. 2007b). Of the 17 reports that NMFS could confirm, right whales were injured in two of the ship strikes and killed in nine. Recent records show that from 2004-2008, there were 17 confirmed reports of North Atlantic right whales being struck with eight whales dying of their wounds and two additional right whales sustaining serious injuries (Glass et al. 2009). Deaths of females are especially deleterious to the ability of the North Atlantic right whale population to recover. For instance, in 2005, mortalities included six adult females, three of which were carrying near-term fetuses and four of which were just starting to bear calves, thereby representing a lost reproductive potential of as many as 21 individuals over the short term (Kraus et al. 2005). Between 1999 and 2006, ships are confirmed to have struck 22 North Atlantic right whales, killing 13 of these whales (Jensen and Silber 2003; Knowlton and Kraus 2001b; NMFS 2005c). From 1999 to 2003, an average of 2.6 right whales were killed per year from various types of anthropogenic factors, but mostly from ship-strike (Waring et al. 2010). From 2000 to 2004, this increased to 2.8 annually and increased again from 2001 to 2005 to an average of 3.2 right whales (Waring et al. 2010). The most recent estimate of anthropogenic mortality and serious injury available showed a rate of 3.8 right whales per year from 2002 to 2006. Of these, 2.4 were attributed to ship strikes (Glass et al. 2008). Based on records collected between 1970 and 1999, about 60% of the right whales struck by ships along the Atlantic Coast of the U. S., 20% occurred in waters off the northeast states and 20% occurred in waters off the mid-Atlantic or southeast states (Knowlton and Kraus 2001b). Over the same time interval (1970 to 1999), these authors identified 25 (45%) unconfirmed serious injuries and mortalities from ship strikes. Of these, 16 were fatal interactions; two possibly fatal; and seven nonfatal. Based on these confirmed mortalities, ships are responsible for more than one-third (16 out of 45, or 36%) of all confirmed right whale mortalities (a confirmed mortality is one observed under specific conditions defined by NMFS).⁵ Part of the susceptibility of this species to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011b).

⁵ There are four main criteria used to determine whether serious injury or mortality resulted from ship strikes: (1) propeller cut(s) or gashes that are more than approximately 8 cm in depth; (2) evidence of bone breakage determined to have occurred premortem; (3) evidence of hematoma or hemorrhaging; and (4) the appearance of poor health in the ship-struck animal

Knowlton, A. R., and S. D. Kraus. 2001b. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management Special Issue 2*:193-208..

Another study conducted over a similar period – 1970 to 2002 – examined 30 (18 adults and juveniles, and 12 calves) out of 54 reported right whale mortalities from Florida to Canada (Moore et al. 2005). Human interaction (ship strike or gear entanglement) was evident in 14 of the 18 adults examined, and trauma, presumably from vessel collision, was apparent in 10 out of the 14 cases. Trauma was also present in four of the 12 calves examined, although the cause of death was more difficult to determine in these cases. In 14 cases, the assumed cause of death was vessel collision; an additional four deaths were attributed to entanglement. In the remaining 12 cases, the cause of death was undetermined (Moore et al. 2005).

Sea turtle ship strikes are a poorly-studied threat to sea turtles, but has the potential to be highly-significant (Work et al. 2010). All sea turtles must surface to breath and several species are known to bask at the surface for long periods, including loggerhead sea turtles. Although sea turtles can move rapidly, sea turtles apparently are not well able to move out of the way of vessels moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). This, combined with the massive level of vessel traffic in the Gulf of Mexico and coastal Atlantic, has the potential to result in frequent injury and mortality to sea turtles in the region (MMS 2007). Hazel et al. (2007) suggested that green sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases. Overall, ship strike is likely highly underestimated as a source of injury or mortality to sea turtles in the action area.

5.25 Commercial whaling

Large whale population numbers in the action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Between 1969-1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979).

5.26 Scientific and research activities

Scientific research permits issued by the NMFS currently authorize studies of listed species in the North Atlantic Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breath sampling. These research activities were not expected to jeopardize the survival or recovery of ESA-listed species and were largely anticipated to have short-term behavioral or stress effects to impacted individuals.

Authorized research on ESA-listed sea turtles includes capture, handling, and restraint, satellite, sonic, and passive integrated transponder tagging, blood and tissue collection, lavage, ultrasound, captive experiments, laparoscopy, and imaging. Research activities involve “takes” by harassment, with some resulting mortality. There have been numerous permits⁶ issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles. The consultations which took place on the issuance of these ESA

6. See <https://apps.nmfs.noaa.gov/index.cfm> for additional details.

scientific research permits each found that the authorized activities would have no more than short-term effects and would not result in jeopardy to the species or adverse modification of designated critical habitat.

Additional “take” is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of “takes” authorized in a given year, monitoring and reporting indicate that the actual number of “takes” rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these “takes” will occur since they have been authorized. It is also noteworthy that these “takes” are distributed across the Atlantic Ocean, mostly from Florida to Maine, and in the eastern Gulf of Mexico. Although whales and sea turtles are generally wide-ranging, we do not expect many of the authorized “takes” to involve individuals who would also be “taken” under the proposed research.

Tables 15-24 describe the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 15. Blue whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	655	25	90	45	0	2
2010	720	25	90	45	0	0
2011	620	25	90	45	0	0
2012	730	25	90	45	0	0
2013	6,300	630	1,255	540	80	0
2014	5,765	640	1,165	515	80	0
2015	5,765	640	1,165	515	80	0
2016	2,250	190	715	65	80	0
Total	22,805	2,200	4,660	1,815	320	2

Permit numbers: 633-1778, 775-1875, 1036-1744, 1058-1733, 10014, 14451, 14856, 15575, 16109, 16239, 16325, 16388, and 17355.

Table 16. Fin whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	1,671	170	75	0	0	2
2010	1,876	170	45	0	0	0
2011	1,776	170	45	0	0	0
2012	2,846	170	45	0	0	0
2013	9,551	1,215	1,315	495	340	0
2014	9,282	1,180	1,290	535	340	0
2015	9,282	1,180	1,290	535	340	0
2016	5,477	730	840	85	340	0
Total	41,761	4,985	4,945	1,650	1,360	2

Permit numbers: 10014, 605-1904, 775-1875, 948-1692, 981-1707, 1036-1744, 1058-1733, 14118, 14451, 14586, 14856, 15575, 16109, 16239, 16325, 16388, 16473, and 17355.

Table 17. Humpback whale takes in the North Atlantic and Mediterranean.

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.

Table 18. North Atlantic right whale takes.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling
2009	1,860	60	130	45	0
2010	6,875	110	230	45	80
2011	7,455	120	230	45	80
2012	7,640	170	230	45	80
2013	15,183	410	820	90	80
2014	14,118	330	690	65	80
2015	13,918	330	690	65	80
2016	8,903	300	590	65	0
Total	75,952	1,830	3,610	465	480

Permit numbers: 605-1904, 633-1778, 775-1875, 1058-1733, 10014, 14118, 14451, 14856, 15575, 16109, 16239, 16325, 16388, 16473, and 17355.

Table 19. Sei whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	1,604	50	158	45	0	2
2010	1,604	50	158	45	0	0
2011	1,504	50	158	45	0	0
2012	1,824	110	158	45	160	0
2013	8,227	1,735	773	390	160	0
2014	6,978	1,750	640	365	160	0
2015	6,978	1,750	640	365	160	0
2016	4,628	450	340	65	160	0
Total	33,347	5,945	3,025	1,365	800	2

Permit numbers: 605-1904, 633-1778, 775-1875, 1058-1733, 10014, 14118, 14451, 14856, 15575, 16109, 16239, 16325, 16388, 16473, and 17355.

Table 20. Sperm whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	5,560	375	820	0	0	920
2010	4,110	400	520	0	0	120
2011	4,010	425	520	0	0	120
2012	2,030	155	10	0	80	0
2013	8,789	990	720	450	80	0
2014	12,919	1,440	760	530	80	50
2015	12,919	1,440	760	530	80	50
2016	8,964	990	310	80	80	50
Total	59,301	6,215	4,420	1,590	240	1,310

Permit numbers: 633-1778, 775-1875, 909-1719, 948-1692, 981-1707, 1036-1744, 1121-1900, 10014, 14451, 14586, 14856, 15575, 16109, 16239, 16325, 16473, 17312, and 17355.

Table 21. Green sea turtle takes in the Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	3,093	3,093	3,009	1,860	555	66	74	72	6
2010	3,753	3,753	3,669	2,480	555	66	74	72	6
2011	4,255	4,255	3,505	2,990	564	66	74	72	20
2012	3,354	3,354	2,622	2,210	704	66	74	72	18.2
2013	5,001	5,001	4,325	3,654	1,903	91	398	396	4.2
2014	4,336	3,686	3,660	3,044	1,408	65	324	324	4.2
2015	4,280	3,630	3,610	3,044	1,408	65	324	324	4.2
2016	2,960	2,960	2,940	1,734	1,408	65	324	324	4.2
Total	31,032	29,732	27,340	21,016	8,505	550	1,666	1,656	67

Permit numbers: 1450, 1462, 1501, 1506, 1507, 1518, 1522, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 10014, 10022, 13306, 13307, 13543, 13544, 13573, 14506, 14508, 14622, 14655, 14726, 14949, 15112, 15135, 15552, 15556, 15575, 15606, 15802, 16134, 16146, 16174, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, 17506, and 18069.

Table 22. Kemp's ridley sea turtle takes in the Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	1,394	1,394	1,195	425	371	56	53	53	5
2010	1,402	1,402	1,203	426	371	56	53	53	5
2011	2,210	2,210	1,368	976	400	56	53	53	9
2012	2,229	2,219	1,561	972	450	56	53	53	7.2
2013	2,836	2,852	2,190	1,627	990	116	213	218	3.2
2014	2,010	2,026	1,964	706	619	60	160	165	3.2
2015	1,833	1,849	1,819	706	619	60	160	165	3.2
2016	1,420	1,436	1,406	300	264	40	125	125	3.2
Total	15,334	15,388	12,706	6,138	4,084	500	870	885	39

Permit numbers: 1462, 1501, 1506, 1507, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 10014, 10022, 13306, 13543, 13544, 14508, 14726, 14506, 14622, 14655, 14726, 15112, 15135, 15552, 15566, 15575, 15606, 15802, 16134, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, 17506, and 18069.

Table 23. Leatherback sea turtle takes in the North Atlantic Ocean.

Year	Capture/handling/restraint	Satellite, sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Imaging	Laparoscopy	Mortality
2009	1,357	1,357	1,331	197	188	0	0	2
2010	1,421	1,421	1,394	197	188	0	0	1
2011	1,709	1,709	1,682	197	189	0	0	3.4
2012	736	736	709	187	189	0	0	2.6
2013	842	835	808	312	254	65	65	1.6
2014	653	646	620	135	66	65	65	1.6
2015	647	640	620	135	66	65	65	1.6
2016	634	627	617	125	66	65	65	1.6
Total	7,999	7,971	7,781	1,485	1,206	260	260	15.4

Permit numbers: 1506, 1527, 1540, 1544, 1551, 1552, 1557, 1570, 1571, 1576, 10014, 13543, 14506, 14586, 14655, 14726, 15112, 15552, 15556, 15575, 15672, 15802, 16109, 16194, 16253, 16556, 16733, 17355, and 17506.

Table 24. Loggerhead sea turtle takes in the North Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	5,462	5,462	5,044	1,165	1,322	200	109	123	111
2010	5,464	5,464	5,046	1,205	1,322	200	109	116	111
2011	7,165	7,165	6,097	1,420	1,667	200	148	114	122.2
2012	4,791	4,791	3,741	1,370	1,429	200	161	114	29.8
2013	5,909	5,909	4,859	2,609	2,519	305	401	354	24.8
2014	4,052	3,912	3,862	1,460	1,543	105	292	240	24.8
2015	3,935	3,795	3,795	1,470	1,543	105	292	240	7.8
2016	3,510	3,510	3,510	1,255	1,543	105	292	240	7.8
Total	40,288	40,008	35,954	11,954	12,888	1,420	1,804	1,541	439.2

Permit numbers: 1450, 1462, 1501, 1506, 1507, 1522, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 1599, 10014, 10022, 13306, 13307, 13543, 13544, 14249, 14622, 14506, 14508, 14622, 14655, 14726, 15112, 15552, 15566, 15575, 15606, 15802, 16134, 16146, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, 17506, and 18069.

5.27 Physical and oceanographic features

The presence of key habitat features, such as shelter or foraging opportunities, are the primary reasons why listed individuals occur where they do. In the marine environment, this is fundamentally built upon local physical and oceanographic features that influence the marine environment. As such, we describe the physical and oceanographic environment here to establish a rationale for why listed species occur in the action area at the levels we observe or expect. This does not represent a stressor, but is instead an underlying principle for establishing why effects are what we expect them to be.

The continental shelf through the action area is a nearly uniform, smooth seafloor with an evenly-carved continental shelf edge (Backus 1987). The continental shelf slopes gently and is relatively shallow. The continental shelf break is marked by an abrupt increase in the seafloor gradient and ranges in water depth from 100 to 150 m. The average width of the continental slope from Georges Bank to Cape Hatteras is approximately 30 km but varies in size from 10 to 50 km (Tucholke 1987). The only submarine canyon in the area is the Hudson Canyon and is the best developed canyon on the U.S. Atlantic continental margin. Submarine canyons are considered to be highly modified areas of the continental slope containing a much richer biodiversity; the abundance of nutrients introduced by the strong down flowing currents are factors leading to the biological richness found in canyons (Cooper et al. 1987). No seamounts exist within the action area.

The Gulf Stream Current is a powerful surface current, carrying warm water into the cooler North Atlantic just south of the action area (Pickard and Emery 1990; Verity et al. 1993). Surface velocities range from 2-5 nautical miles per hour and the temperature is generally 25° to 28° C (Mann and Lazier 1991). The Gulf Stream is usually sharply defined on its west and north side but much less so on its east or south sides (Pickard and Emery 1990).

In general, the Gulf Stream flows parallel to shore from the Florida Straits to Cape Hatteras, where it flows northeastward past the Grand Banks away from land. While stratification of the water column and other factors may play a role, climactic factors such as the North Atlantic Oscillation (NAO) likely cause its variation in position (Pershing et al. 2001; Schmeits and Dijkstra 2000). Wave-like meandering begins to occur at Cape Hatteras and increases as the current progresses offshore. North of Cape Hatteras, small gyres form that separate from the Gulf Stream as either warm- or cold-core rings (Mann and Lazier 1991). Between three and eleven warm-core rings are formed per year, each about 100 km across (García-Moliner and Yoder 1994), 1,000 m in height (Mann and Lazier 1991), and lasting 11-399 days (García-Moliner and Yoder 1994; Pickard and Emery 1990). Warm-core rings bring warm water and associated plankton to colder inshore areas. Cold-core rings form when a cyclonic loop pinches off from the Gulf Stream, resulting in a counterclockwise rotating ring of cool slope water in the warm Sargasso Sea (Pickard and Emery 1990). Twice as many cold-core rings are formed as warm-core rings every year (Pickard and Emery 1990). They are larger (100-300 km across) and longer lasting (months to years) than warm-core rings (Pickard and Emery 1990).

A persistent front exists from the Mid-Atlantic Bight into New England waters due to the intersection of the continental shelf and slope. This surface manifestation of a thermohaline front extends year round from the surface downward, where it intersects the seafloor just shoreward of the shelf break (Halliwell Jr. and Mooers 1979). Phytoplankton production is enhanced at this frontal boundary, often with twice the concentration of phytoplankton found in adjacent waters

(Ryan et al. 1999b).

An annual phenomenon in the Mid-Atlantic Bight is the formation of the “cold pool”. This mass of cooler water occurs over the continental shelf in summer and stretches from the Gulf of Maine to Cape Hatteras and is detectable from spring through fall (Linder et al. 2004). The cold pool usually exists near the seafloor between the 40 m and 100 m isobaths and extends up into the water column for about 35 m. Minimum temperatures for the cold pool occur in early spring and summer and range from 1.1° to 4.7° C.

The NAO affects sea surface temperatures, wind conditions, and ocean circulation throughout the North Atlantic Ocean (Stenseth et al. 2002b). The NAO is an intensity alteration of the atmospheric pressure between the semi-permanent high pressure center over the Azores Islands and the subpolar low-pressure center over Iceland (Curry and McCartney 2001; Stenseth et al. 2002b). Sea-level atmospheric pressure in the two regions tends to vary inversely, creating “positive” and “negative” phases. However, these phases are stable for years to decades. The NAO was generally positive from 1900 to 1950, mainly negative in the 1960s and 1970s, and mainly positive since 1970 (Hurrell et al. 2001).

The NAO also influences the latitude of the Gulf Stream Current and is largely responsible for its variable location. During positive NAO years, the Gulf Stream is farther east (Taylor and Stephens 1998). The flow rate of the Gulf Stream is also affected; during negative NAO years, the Gulf Stream System is not only shifted southward but weakened by up to 25-33% (Curry and McCartney 2001). The upper slope-water system off the U.S. east coast is affected by the NAO (Pershing et al. 2001). During low NAO periods, the Labrador Current intensifies, leading to the advance of cold slope water along the continental shelf as far south as the Mid-Atlantic Bight (Pershing et al. 2001). Intensity variability in another regionally important current, the Labrador Current, is linked to the effects of winter temperatures in Greenland and its surrounding waterways, sea-ice formation, and the relative balance between the formation of deep and intermediate water masses and surface currents. Although the NAO influences the northern North Atlantic most, its effects remain significant south through the Outer Banks (Hurrell et al. 2001).

The NAO strongly affects trophic groups in North Atlantic marine ecosystems (Drinkwater et al. 2003; Fromentin and Planque 1996). *Calanus* copepod temporal and spatial patterns are linked to the phases of the NAO (Fromentin and Planque 1996; Stenseth et al. 2002b); positive NAO indices are associated with increased *Calanus* copepod abundance in the Gulf of Maine and the corollary in negative NAO index years (Conversi et al. 2001a; Greene et al. 2003b). This has secondary effects, such as prey availability for North Atlantic right whales, which feeds principally on *Calanus finmarchicus*. High *Calanus finmarchicus* abundance is linked to increased North Atlantic right whale calving rates (Greene et al. 2003b). Negative NAO indices are associated with abundances of cod, herring, and sardines: species that are important to other listed mysticetes (Drinkwater et al. 2003).

Phytoplankton are single-celled organisms that form the base of marine food chains and whose occurrence and abundance are strongly driven by light, temperature, and nutrient conditions. As nutrients from river outflows near shore generally provide more nutrients than are present offshore, phytoplankton are generally more abundant nearshore. Although the North Atlantic is generally well mixed (nutrients are generally available), light levels tend to be low for phytoplankton, limiting their growth (Ryan et al. 1999a). However, spring time is a period with

reduced mixing and increasing light levels, meaning that phytoplankton tend to stay at the surface and are better able to photosynthesize, grow, and reproduce at exponential rates (Mann and Lazier 1991; Parsons et al. 1984; Ryan et al. 1999a). However, nutrients are eventually exhausted in surface waters by May and seasonal progression into winter returns the region to a light-limiting condition. During spring and summer, nectophytoplankton are dominant but are replaced by nanophytoplankton during limiting conditions (Ryan et al. 1999b).

Not only the water conditions, but intersections between water bodies (frontal boundaries) are important factors in biological productivity. This is the case year-round between the shelf and slope waters of the mid-Atlantic, but particularly during winter and spring (Ryan et al. 1999a; Ryan et al. 1999b).

Zooplankton, the next higher level in the marine food chain from phytoplankton and the prey of several listed whales and sea turtles, are generally higher in slope water versus other locations (Wiebe et al. 1987). Spring is a time of higher abundance temporally, particularly within the upper 200 m of the water column (Wiebe et al. 1987). However, zooplankton biomass abundance can increase when shelf water intrudes over slope water, creating a stratified water column. High nutrients and a shallow mixed layer set conditions for enhanced phytoplankton production, which subsequently aids zooplankton biomass increases. Copepods are the primary zooplankters dominate in New England shelf waters, and whose abundance is highest in spring on the outer shelf but highest in summer on the inner shelf (Flagg et al. 1984). *Calanus finmarchicus* and *Pseudocalanus* sp. are the predominant copepods over the outer shelf while the inner shelf has *Centropages typicus* and *Temora longicornis* predominating. The relatively large size of *Calanus* species and its annual cycle in New England waters makes it a major driver of New England marine ecosystem during spring (Flagg et al. 1984).

5.28 Impacts of the Environmental Baseline on Listed 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 or continue to occur in the action area. Federal projects in the action area 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 threatened and endangered species remains largely unknown. To the best of our ability, we summarize the effects we can determine based upon the information available to us in this section.

Cetaceans

Climate change has wide-ranging impacts, some of which can be experienced by ESA-listed whales in the action area. Climate change has been demonstrated to alter major current regimes and may alter those in the action area as they are studied further (Johnson et al. 2011; Poloczanska et al. 2009). Considering the sensitivity that North Atlantic right whales have to warm water temperatures during their southbound migration, warming water temperatures may delay their migratory movements. The availability and quality of prey outside the action area in northern feeding areas can also influence the body condition of individuals in the action area, and potentially reduce the number of individuals that undertake migration through the action area. Changes in the timing of North Atlantic right whales have been observed and may be partly or largely due to these climactic factors.

Effects from anthropogenic acoustic sources, whether they are vessel noise, seismic sound, military activities, oil and gas activities, construction, or wind energy, could also have biologically significant impacts to ESA-listed whales in the action area. These activities increase the level of background noise 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 gather information about their environment primarily through sound. At closer ranges to some of 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 exposure is a small fraction of the total exposure individuals receive, it is believed expected to occur in rare instances.

High levels of morbidity and mortality occur as a result of shipstrike (particularly for North Atlantic right whales and humpback whales) and entanglement in fishing gear (right whales). Ship-strike and entanglement occur broadly along the U.S. East Coast, including (in all likelihood) in the action area itself. These two factors are the greatest known source of mortality and impairment to recovery for North Atlantic right whales and represent known mortality sources for all other ESA-listed whales in the action area. Reductions in speed through portions of the action area as well as seasonal or brief closings of areas to fishing are underway to reduce these impacts, but data are not yet available to demonstrate the long-term effectiveness of these strategies. However, these measures are likely reducing the severity and frequency of these interactions.

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 (2004) concluded that 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 would suggest that the cumulative effects of the various human activities in the action area would be greater than the effects of the individual activity. Several investigators reported behavioral responses to close approaches that suggest that individual whales might experience stress responses. Baker et al. (1983) described two responses of whales to vessels, including: (1) “horizontal avoidance” of vessels 2,000 to 4,000 meters away characterized by faster swimming and fewer long dives; and (2) “vertical avoidance” of vessels from 0 to 2,000 meters away during which whales swam more slowly, but spent more time submerged. Watkins et al. (1981) found that both fin and humpback whales appeared to react to vessel approach by increasing swim speed, exhibiting a startled reaction, and moving away from the vessel with strong fluke motions. Other researchers have noted changes in respiration, diving, swimming speed, social exchanges, and other behavior correlated with the number, speed, direction, and proximity of vessels. Results were different depending on the social status of the whales being observed (single males when compared with cows and calves), but humpback whales generally tried to avoid vessels when the vessels were 0.5 to 1.0 kilometer from the whale. Smaller pods of whales and pods

with calves seemed more responsive to approaching vessels (Bauer 1986; Bauer and Herman 1986). These stimuli are probably stressful to the humpback whales in the Action Area, but the consequences of this stress on the individual whales remains unknown (Baker and Herman 1987; Baker et al. 1983). Studies of other baleen whales, specifically bowhead and gray whales, document similar patterns of behavioral disturbance in response to a variety of actual and simulated vessel activity and noise (Malme et al. 1983; Richardson et al. 1985). For example, studies of bowhead whales revealed that these whales oriented themselves in relation to a vessel when the engine was on, and exhibited significant avoidance responses when the vessel's engine was turned on even at a distance of about 900 m (3,000 ft). Jahoda et al. (2003) studied the response of 25 fin whales in feeding areas in the Ligurian Sea to close approaches by inflatable vessels and to biopsy samples. They concluded that close vessel approaches caused these whales to stop feeding and swim away from the approaching vessel. The whales also tended to reduce the time they spent at surface and increase their blow rates, suggesting an increase in metabolic rates that might indicate a stress response to the approach. In their study, whales that had been disturbed while feeding remained disturbed for hours after the exposure ended. They recommended keeping vessels more than 200 meters from whales and having approaching vessels move at low speeds to reduce visible reactions in these whales. Although these responses are generally ephemeral and behavioral in nature, populations within the action area can be exposed to several thousand instances of these activities per year, with some species having so many authorized activities that if they were all conducted, every individual in the population would experience multiple events. This can collectively alter the habitat use of individuals, or make what would normally be rare, unexpected effects (such as severe behavioral responses or infection from satellite or biopsy work) occur on a regular basis.

Sea turtles

Several of the activities described in this *Environmental Baseline* have significant and adverse consequences for nesting sea turtle aggregations whose individuals occur in the Action Area. In particular, the commercial fisheries annually capture substantial numbers of green, Kemp's ridley, leatherback, and Northwest Atlantic loggerhead sea turtles.

Climate change has and will continue to impact sea turtles throughout the action area as well as throughout the range of the populations. Sex ratios of several species are showing a bias, sometimes very strongly, towards females due to higher incubation temperatures in nests. We expect this trend will continue and possibly may be exacerbated to the point that nests may become entirely feminized, resulting in severe demographic issues for affected populations in the future. Hurricanes may become more intense and/or frequent, impacting the nesting beaches of sea turtles and resulting in increased loss of nests over wide areas. Disease and prey distributions may well shift in response to changing ocean temperatures or current patterns, altering the morbidity and mortality regime faced by sea turtles and the availability of prey.

Although only small percentages of these sea turtles are estimated to have died as a result of their capture during research or incidental to fisheries, the actual number could be substantial if considered over the past 5 to 10 years. When we add the percentage of sea turtles that have suffered injuries or handling stress sufficient to have caused them to delay the age at which they reach maturity or the frequency at which they return to nesting beaches, the consequences of these fisheries on nesting aggregations of sea turtles would be greater than we have estimated.

Even with turtle excluder device measures in place, in 2002, NMFS (2002) expected these

fisheries to capture about 323,600 sea turtles each year and kill about 5,600 (~1.7%) of the turtles captured. Loggerhead sea turtles account for most of this total: 163,000 captured, killing almost 4,000 (~2.5%) of them. Kemp's ridleys account for the second-most interactions: 155,503 captures with 4,200 (~2.7%) deaths. These are followed by green sea turtles: about 18,700 captured with more than 500 (~2.7%) dying as a result of capture. Leatherback sea turtle interactions were estimated at 3,090 captures with 80 (~2.6%) deaths as a result (NMFS 2002b). Since 2002, however, effort in the Atlantic shrimp fisheries has declined from a high of 25,320 trips in 2002 to approximately 13,464 trips in 2009, roughly 47% less effort. Since sea turtle takes are directly linked to fishery effort, these takes are expected to decrease proportionately. However, hundreds to a possible few thousand sea turtle interactions are expected annually, with hundreds of deaths (NMFS 2012).

Recent data regarding the three largest subpopulations that comprise the Northwest Atlantic loggerhead DPS indicated either that these subpopulations do not show a nesting decline significantly different from zero (Peninsular Florida and The Greater Caribbean subpopulation) or are showing possible signs of stability in nest numbers (Northern subpopulation). These trends were recently declining. Additional mortalities each year along with other impacts remain a threat to the survival and recovery of this species and could slow recovery green, Kemp's ridley, leatherback, and Northwest Atlantic loggerhead sea turtles.

6 EFFECTS OF THE PROPOSED ACTIONS

Pursuant to section 7(a)(2) of the ESA, Federal agencies must insure, in consultation with NMFS, that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed use of the *Langseth* and issuance of the IHA for “takes” of marine mammals during the seismic studies would expose listed species to seismic airgun pulses, as well as sound emitted from a multi-beam bathymetric echosounder and sub-bottom profiler and other stressors. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed actions, the probability of individual ESA-listed species being exposed to these stressors, and the probable responses of those individuals (given probable exposures) based on the best scientific and commercial evidence available. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual’s fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment and, ultimately, of the Opinion is to determine if it is reasonable to expect the proposed action to have effects on listed species that would reasonably be expected to appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned with behavioral and physiological disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The proposed IHA action would authorize non-lethal “takes” by harassment as defined by the MMPA of listed species during seismic survey activities. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. The MMPA of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, “...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering”) is similar to language in the USFWS’s regulatory definition of “harass”⁷ pursuant to the ESA. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal’s life history or its contribution to the population the animal represents.

As described in the *Approach to the Assessment*, the universe of likely responses is considered in evaluating whether those responses lead to fitness consequences for the individual and (if appropriate), the affected population and species as a whole to determine the likelihood of

7 An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

jeopardy.

6.1 Potential Stressors

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

1. pollution by oil or fuel leakage;
2. acoustic interference from engine noise;
3. ship-strikes;
4. entanglement in towed hydrophone;
5. sound fields produced by airguns; and
6. sound fields produced by sub-bottom profiler or multibeam echosounder

Based on a review of available information, we determined which of these possible stressors would be likely to occur and which would be discountable or insignificant.

6.1.1 Pollution by Oil or Fuel Leakage

The potential for fuel or oil leakages is unlikely. Leaks would likely pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately, to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the *Langseth* or its smaller counterparts is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessel) that would impact listed species directly or pose hazards to their food sources. Because the potential for fuel or oil leakage is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that pollution by oil or fuel leakage is not likely to adversely affect ESA-listed marine mammals or sea turtles.

6.1.2 Disturbance from Engine Noise

The propulsion system of the *Langseth* and the chase vessel are designed to be very quiet compared to other vessels to reduce interference with seismic activities. Although noise originating from vessel propulsion will propagate into the marine environment, this amount of noise generated by the *Langseth* would be highly improbable. The *Langseth*'s passage past a whale or sea turtle would be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of whales to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006). The chase vessel would also not generate sufficient noise to significantly disturb ESA-listed marine mammals or sea turtles. Because the potential acoustic interference from engine noise would be undetectable or so minor that it could not be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise is not likely to adversely affect ESA-listed marine mammals or sea turtles.

6.1.3 Ship Strike

The *Langseth* and the chase vessel will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship-strike (Kite-

Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of ship strike is discountably small due to the hundreds of thousands of kilometers the *Langseth* has traveled without a ship strike, general expected movement of marine mammals away or parallel to the *Langseth*, as well as the generally slow movement of the *Langseth* during most of its travels (Hauser and Holst 2009; Holst 2009; Holst 2010; Holst and Smultea 2008a). The same can be said for the chase vessel to be utilized. All factors considered, we have concluded the potential for ship strike from the research vessel or the chase vessel is highly improbable. Because the potential for ship strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that ship strike is not likely to adversely affect ESA-listed marine mammals or sea turtles.

6.1.4 Entanglement

ESA-listed species could interact directly with the towed hydrophone streamers and these interactions have been documented in the past. For example, a seismic survey in the eastern tropical Pacific during 2011 recovered a dead olive ridley sea turtle in the foil of towed seismic gear; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the streamer design as well as observations of sea turtles investigating the streamer and not becoming entangled or operating in regions of high turtle density and entanglements not occurring (Hauser et al. 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). Although the towed hydrophone streamers could come in direct contact with a listed species, entanglements are highly unlikely and considered improbable based upon investigation into the use of these devices during the activities of other oceanographic activities. . Given this, we expect that the risk of entanglement in towed hydrophone cable or other oceanographic equipment so low as to be discountable. Therefore, it is not likely to adversely affected ESA-listed species and will not be considered further in this Opinion.

Accordingly, this consultation focused on the following stressors likely to occur from the proposed seismic activities that may adversely affect ESA-listed species: 1) acoustic energy introduced into the marine environment by the airgun array and 2) acoustic energy introduced by the sub-bottom profiler and multibeam echosounder sonars.

6.2 Exposure Analysis

Exposure analyses identify the physical, chemical, and biotic stressors produced by a proposed action that co-occur in space and time with ESA-listed species within the action area. The stressors identified for this proposed action that warrant further analysis are sound fields produced by airguns, and sound field produced by sub-bottom profiler or multibeam echosounder .

The *Exposure analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent.

NMFS applies certain acoustic thresholds to help determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are considered "harassed," under the MMPA. These thresholds are used to develop exclusion radii around a source and the

necessary power-down or shut-down criteria to limit marine mammals and sea turtles' exposure to harmful levels of sound. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieuwkerk et al. 2004).

The NSF provided an estimate of the number of marine mammals that would be exposed to levels of sound in which they would be considered "taken" during the proposed survey. Additionally, the Permits and Conservation Division conducted an independent exposure analysis that was informed by comments received during the public comment period that was required on the proposed IHA and draft environmental assessment prepared pursuant to NEPA. In this section we describe both of those analytical methods and our own analytical process to estimate the number of ESA-listed species that might be exposed to the sound field and considered "taken" as required under the ESA.

6.2.1 NSF Exposure Estimates

The NSF applied acoustic thresholds to determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are "harassed," based on definitions provided in the MMPA (65 FR 16374). The NSF concluded that ESA-listed whales would be exposed to the seismic activities. These thresholds were also used to develop exclusion radii around the acoustic source to determine appropriate power-down and shut-down procedures. The acoustic thresholds are described in Table 25. The NSF did not provide estimates of sea turtle exposure.

The exposure analysis estimates the number of ESA-listed whales and sea turtles likely to be exposed to received levels greater than 160 dB re $1 \mu\text{Pa}_{\text{rms}}$ and 166 dB re $1 \mu\text{Pa}_{\text{rms}}$ for whales and sea turtles, respectively. These sound levels are the best estimates of sound exposure criteria above which we would expect an adverse response by listed whales and sea turtles. The NSF provided the predicted distances to which sound levels ≥ 180 and 160 dB re $1 \mu\text{Pa}_{\text{rms}}$ would be received (Level A and Level B harassment under the MMPA) (Table 25).

Table 25. Predicted distances for received sound levels. Distances are for water depths <100m. Adapted from NSF Environmental Assessment 2014.

Source	Tow Depth (m)	Predicted RMS Radii (m)		
		180 dB	166 dB	160 dB
4-airgun subarray (700 in ³)	4.5	378	2,229	5,240
4-airgun subarray (700 in ³)	6	439	2,599	6,100
single bolt airgun (40 in ³)	6	73	424	995

In several decision points of the propagation modeling, an ideal path was not available or a “best” option was unclear. When faced with these decisions, assumptions were made that generally overestimate the distance sound will propagate or increase the likelihood of biologically-meaningful sound exposure to ESA-listed individuals. We agree with the NSF’s assumption that individuals will move away if they experience sound levels high enough to cause significant stress or functional impairment (see *Response Analysis*). Isoleth modeling tends to overestimate the distance to which various isopleths will propagate. In addition, most exposures of listed species will likely occur at depths shallower than 2,000 m for the airguns used in the proposed survey, where received sound levels should be lower than at greater depths (see Figures 2 through 4). A recent study shows that in shallow water, measured power levels and signal length can vary based on bathymetric features (Crone 2014). As we are unable to know where individuals will be in the water column at the time of exposure, we accept that there is variance in the degree to which sound will reach the distances in Table 25, and we are unable to know for certain how local natural features will affect how the sound propagates. In addition, the 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ radius will not always reach the distances described in Table 25, as shorter radii will occur during the use of smaller numbers of airguns (e.g., the use of a single airgun during turns or power-down procedures). A received level of 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$, which would extend horizontally to 2.599 km for the four-airgun array at 6-m tow, is considered here to be the threshold for harassment for sea turtle response based upon the scant information available (McCauley et al. 2000a; McCauley et al. 2000b) (see sea turtle section below).

A major mitigation factor proposed by the NSF is visual monitoring along with power down and shut down, especially for marine mammals, which should reduce exposure of listed whales and sea turtles. However, visual monitoring has several limitations. Although areas ensonified by 160, 166, and 180 dB re 1 $\mu\text{Pa}_{\text{rms}}$ propagation distances are within the visual range of the *Langseth* and its observers, it is unlikely that all listed species are at the surface and visible at these distances. Vessel platforms are subject to some limitations such as that even under good sighting conditions, observers have limited ability to identify protected species during their brief time at the surface. On their own, power-down and shut-down procedures are unlikely to be completely effective at eliminating the co-occurrence of listed individuals within the sound field ≥ 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Other measures such as vessel turns and minimizing airgun source levels, seek to further minimize the exposure ESA-listed species will experience. Ramp-up was effective in reducing hearing-related effects in sonar systems (Von Benda-Beckmann et al. 2014) and we expect reduced or less intense exposure with application of airgun ramp-up.

When combined with the other proposed mitigation and monitoring measures, we conclude that the probability of ESA-listed individuals being exposed to the sound field ≥ 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ is reduced by the use of ramp-ups and shut-downs. PAM will only detect the presence of marine mammals if they vocalize. Further ability to identify bearing, distance, and abundance is limited.

6.2.2 NMFS Exposure Calculations

During consultation, we discussed the approach for estimating exposure with the NSF and the Permits and Conservation Division. Different methods for calculating take estimates for ESA-listed whales were developed by NSF and the Permits and Conservation Division; both were considered during the consultation and are summarized in the record for this consultation. In order to fully account for all the factors we considered important in the exposure analysis, we developed our own methodology to calculate exposure.

--SERDP SDSS Density Estimates

The take estimates provided in the NSF and L-DEO draft EA were reviewed by NMFS. Those estimates were revised by NMFS using more recent species density data from the SERDP SDSS Duke Habitat Model⁸. Both the NMFS Interagency Cooperation Division and the Permits and Conservation Division believe that these more recent density estimates constitute the best available information. Review of the local survey data as well as knowledge of listed species life history and local oceanographic conditions supports these estimates as the best available information. We used mean density estimates obtained from SRDEP SDSS for each ESA-listed whale species during summer months (June through August—the months in which the proposed survey will occur) to calculate the number of individuals per 1,000 km² in the survey area.

NMFS Permits and Conservation Division Methodology

The NMFS Permits and Conservation Division developed a daily ensonified area to apply to the species density estimates. Assuming that the *Langseth* was traveling at its fastest speed (4.5 kts) and a sea state at Beaufort 3 or less, the maximum amount of line kilometers that could be traveled in 24 hours is 200 km. They selected the first grouping of consecutive tracklines that had a total length of 200 km to represent the daily area that could be ensonified during seismic activities. An exclusion zone representing the predicted RMS distances (6.1 km) was then applied to this area; this buffer distance was provided by L-DEO. The Permits and Conservation Division estimated the daily ensonified area to be 1,226 km²; this estimate does not account for overlap of ensonified areas. To account for additional contingency effort (25%), the Permits and Conservation Division included a 25% increase in the number of days (increasing from 30 to 38).

Exposure for each species for a single day was calculated by multiplying the SERDP SDSS species density by the daily ensonified area, and then the sum of those exposures over 38 days resulted in the final Permits and Conservation Division estimated take numbers. This calculation assumes 100% turnover of individuals within the ensonified area on a daily basis—that is, each individual exposed to the seismic activities is a unique individual. For species where the instance of exposure was less than one (blue, fin, humpback, North Atlantic right, and sei whales), the number of individuals exposed was increased to the mean group size based upon CETAP and AMAPPS survey data. For sei and sperm whales, the Permits and Conservation Division adjusted the number of instances of exposure (35 and 796, respectively) to the mean group size for each species, calculated from AMAPPS survey data. The results of the Permits and Conservation Division's calculations and their proposed take numbers is in Table 26.

NMFS Interagency Cooperation Division Methodology

We estimated the daily ensonified area by dividing the total ensonified area (with overlap and plus 25% contingency) by 38 days to get 1,904 km².

To obtain a total number of exposures for a given ESA-listed marine mammal, we multiplied the SERDP SDSS summer density estimate for a given species by the amount of ensonified area, including contingency area and overlap (72,348 km²).

We recognize a high degree of overlapping ensonified area from one trackline to former and

8 (http://seamap.env.duke.edu/serdp/serdp_map.php)

subsequent ones. The L-DEO and NSF provided a comparison of the area of overlap to the area of no overlap, which we used to determine the ensonified area that reflected repeated sound field exposure. The area including overlap is 35.5 (rounded up to 36) times the area with no overlap, and represents the average number of times a single point within the ensonified area could be “hit” during seismic activities. If a whale remained stationary at such a point (due to motivating factors such as forage or breeding opportunity), an individual could be ensonified to the 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ level up to 36 times.

Although we recognize that individuals do move in their environment and we have accounted for this based upon a 20% turnover rate for sperm whales and a 60% turnover rate for ESA-listed baleen whales, there are still individuals who may not move out of the study area. We expect that some individuals will not be displaced more than a few hundred meters to a few kilometers because of previous seismic survey exposure and therefore would be available to be re-exposed on subsequent passes of the airgun array as it progresses along closely-spaced parallel tracklines. We therefore divided the number of exposures (adjusted for natural turnover rate; 20% or 60% for sperm and baleen whales, respectively) by 36 to identify the number of individuals we expect would be exposed to at least 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$.

Based on review of observed effects of seismic sound exposure to marine mammals (see *response section*), some individuals will move a distance of several hundred meters to tens of kilometers away due to individual or situational sensitivity or other rationale for why whales move (ex. feeding or breeding opportunities unrelated to effects of the proposed action). As such, it is reasonable to expect that some individuals will receive a single exposure and vacate the action area. Other individuals may move, but move to locations where re-exposure could occur, either due to the direction or short distance of travel. Thus, it is possible that some individuals may be exposed up to the maximum number of transect lines that would be surveyed. This is unlikely unless the exposure does not represent a significant one, motivating the individual to vacate the area at least temporarily. Another possibility is that the motivation for an individual to stay in a specific area is high. This possibility is particularly significant given that marine mammals tend to return to specific areas for foraging and breeding, or use particular migratory corridors.

In our calculations, we also recognized that fin, humpback, North Atlantic right, and sei whales tend to travel in groups or cow/calf pairs during summer foraging periods. Therefore, if we can reasonably expect a single individual to be exposed, it is also reasonable to expect a group of individuals to be exposed. For North Atlantic right, humpback, fin and blue whales, the calculations provided an estimate of zero, and so the exposure estimates were increased based on probable group size.

To obtain group size estimates, we used regional abundance surveys conducted under CETAP and the AMAPPS summer surveys for the years 2010, 2011, and 2013. For North Atlantic right whales, we used Palka (2012) and Whitt et al. (2013). The Whitt et al. study focused specifically on North Atlantic right whales in the nearshore waters of New Jersey, so we consider this to be especially relevant to the action. These group size estimates were used as the number of exposed individuals. This number represents the proposed take estimates (**Table 26**). We still expect that each of these individuals could be exposed up to 36 times if they remained stationary or moved short distances in random directions.

Table 26. Comparisons of the proposed take estimates calculated by the NMFS Permits and Conservation Division, and the NMFS Interagency Cooperation Division for ESA-listed whales.

Whale species	NMFS Permits and Conservation Division	NMFS Interagency Cooperation Division
North Atlantic Right	3	3
Humpback	3	3
Sei	5	3
Fin	3	3
Blue	1	1
Sperm	31	27

We consider it important to account for areas of overlap in the survey area because during seismic activities, areas can be ensonified more than once by the airgun array because of the closely-spaced seismic survey tracklines. We believe that including the full area of overlap more accurately represents the action and/or individuals exposed to the action's acoustic stressors.

Sources of Variability

While there were differences in the approaches for calculating exposure for ESA-listed whales, the resulting exposure numbers either were the same or fell within bounds of variability and uncertainty inherent in both approaches. There are two primary sources of variability; 1) numeric variability from each input and 2) biological variability depending on natural behaviors of individuals.

Numeric Variability

Each input point of the exposure estimate calculations has a degree of numeric uncertainty. The two parameters common to both our calculations and the Permits and Conservation Division were the SERDP SDSS density estimates and the daily ensonified area. The differences in each of our respective daily ensonified area calculations represent a decision to consider the action area differently (and thus use a different number in the calculation)—that is, a conceptual difference. Numeric uncertainty is introduced through the SERDP SDSS density estimates. The AMAPPS surveys collected the sightings data, which in turn supported the SERDP SDSS density estimates. Each of these components had assumptions associated with the sighting methodology and the modelling, along with coefficient of variances and other information that we do not have access to, and thus cannot know. Even though we cannot quantify these mathematical components, we believe that they contributed to numeric variability, which influenced the resulting exposure estimates when we used the density estimates in our calculations.

Biological Variability

There are a few behaviors and natural conditions that we can expect to occur, and thus introduce

variability in calculating exposure estimates for sperm and sei whales. These include variability in group size and natural movement of whales.

Based on what we know about the behavior of the sperm and sei whales, we expect there to be variation in how many whales we can expect to be present in a group at any one time, and thus how many are potentially exposed to the seismic activities.

Sperm whale groups are generally comprised of females and immature whales, with a global mean group size of 25 (Whitehead 2003). Data taken from the AMAPPS and CETAP surveys (i.e., from an area more specific to the action area), show that sperm whale group size varies from 1-3. It should also be noted that there was a degree of interannual variability in sperm whale sightings during the AMAPPS surveys. For instance, in 2010, 6 individual sperm whales were sighted, then 2 in 2011, and then in 2012 sightings increased to 112, and 154 in 2013. Sperm whales are especially challenging to count during surveys because they can dive for long periods of time and groups can be spread over large distances (e.g., several kilometers) (Whitehead 2003). Sei whale group size also varied from 1-3, according to the CETAP and AMAPPS surveys. The mean group size was 2.62 (rounded up to 3). Individual sei whale sightings also displayed interannual variability.

There is some uncertainty associated with this factor making it difficult to more finely account for the probability of movement (particularly horizontal movement in terms of latitudinal and longitudinal location). In addition, the regional abundance surveys conducted under CETAP and the AMAPPS (which the SERDP SDSS density estimates are based on) do not explicitly capture factors like physical oceanographic features, habitat, trophic-level data or prey distribution. These natural phenomenon are complex and variable, and represent significant drivers in species behavior and likelihood of being present in an area.

Summary

In conclusion, although our exposure estimate methodology was different, and we arrived at a different estimate for sperm and sei whales than the Permits and Conservation Division, we believe that the estimates fall within the bounds of biological and mathematical variability that we can reasonably expect from either approach.

Marine Mammals

Exposure of Listed Mammals to Airguns. Exposure estimates stem from the best available information on whale densities and a planned ensonified area of approximately 72,348 km² along survey track lines, including areas of repeated exposure and contingency estimates.

Our exposure estimates (**Table 27**) were calculated as described above to obtain the total number of exposures (rounded to the next whole number).

Table 27. Estimated exposure of ESA-listed whales to sound levels ≥ 160 dB re $1 \mu\text{Pa}_{\text{rms}}$ during the proposed seismic activities, based on a daily ensonified area of $1,904 \text{ km}^2$.

Whale density per $1,000 \text{ km}^2$	# of exposures to listed whales	# of whales exposed to proposed activities	Population size	% of population exposed	Population/location
Blue: 0	1	Up to 1	440	Up to 0.23%	Northwest Atlantic ¹
Fin: 0.014	3	Up to 3	3,985	Up to 0.08%	Northwest Atlantic ¹
Sei: 0.74	3	Up to 3	386	Up to 1.04%	Nova Scotia stock ¹
Humpback: 0	3	Up to 3	11,600	Up to 0.03%	Northwestern Atlantic ²
North Atlantic right: 0	3	Up to 3	444	Up to 0.68%	North Atlantic ¹
Sperm: 17.07	27	Up to 27	13,190	Up to 0.20%	Northeast Atlantic, Faroe Islands, Iceland, and northeastern U.S. coast ³
Total	40	--	--	--	--

¹ Waring et al. (2013)² IWC (2014)³ Whitehead (2002)

Whales of all age classes are likely to be exposed. Listed whales are expected to be feeding, traveling, or migrating in the area and some females of all ESA-listed whale species would have young-of-the-year accompanying them. We would normally assume that sex distribution is even for whales and sexes are exposed at a relatively equal level. However, sperm whales in the area likely consist of groups of adult females and their offspring and generally consist of more females than males in the group. Therefore, we expect a female bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be lower than to other age and sex class combinations.

Exposure of listed whales to multibeam echosounder and sub-bottom profiler.

Three additional acoustic systems will operate during the proposed *Langseth* cruise, as well as from the chase vessel: the multibeam echosounder and the sub-bottom profiler. These systems have the potential to expose listed species to sound above the $160 \text{ dB re } 1 \mu\text{Pa}_{\text{rms}}$ threshold. All

systems operate at generally higher frequencies than airgun operations (10.5-13 kHz for the multibeam echosounder, and 3.5 kHz for the sub-bottom profiler). As such, their frequencies will attenuate more rapidly than those from airgun sources. Listed individuals would experience higher levels of airgun noise well before either multibeam echosounder or sub-bottom profiler noise of equal amplitude would reach them.

As with the *Langseth*, the chase vessel is expected to avoid close whale approaches, which reduces the chance of exposure to sonars as well. While airguns are not operational, marine mammal observers will remain on duty to collect sighting data. If listed whales closely approached the vessel, the *Langseth* would take evasive actions to avoid a ship-strike and simultaneously avoid exposure to very high source levels. Ship strike has already been ruled out as a discountable effect, and we also rule out high-level ensonification of listed whales (multibeam echosounder source level = 242 dB re 1 $\mu\text{Pa}_{\text{rms}}$; sub-bottom profiler source level = 204 dB re 1 $\mu\text{Pa}_{\text{rms}}$). Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multibeam echosounders and sub-bottom profilers similar to those to be used during the proposed activities presented a low risk for auditory damage or any other injury. An individual would require exposure to 250–1,000 consecutive pulses from a sub-bottom profiler to be at risk for a temporary threshold shift (TTS). To be susceptible to TTS, a whale would have to pass at very close range and match the vessel's speed; we expect a very small probability of this during the proposed study. An individual would have to be well within 100 m of the vessel to experience a single multibeam echosounder pulse that could result in TTS (LGL Ltd. 2008). The same result could only occur at even closer ranges for sub-bottom profiler signals, because the signals are weaker. Furthermore, we expect both multibeam echosounder and sub-bottom profiler systems to operate continuously with duty cycles of 1-20 s. It is possible, however, that some small number of listed whales (fewer than those exposed to airguns) could experience low-level multibeam echosounder and/or sub-bottom profiler sound exposure. We are unable to quantify the level of exposure, but do not expect any exposure at levels sufficient to cause more than behavioral responses in some species capable of hearing frequencies produced by these systems.

Sea Turtles

Exposure of listed turtles to airguns. NSF did not provide estimates of the expected number of ESA-listed turtles exposed to received levels ≥ 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Exposure estimates stem from the best available information on turtle densities and a planned ensonified area of approximately 2.599 km² along survey track lines, including areas of repeated exposure from adjacent track lines and turning legs. Exposures were developed by multiplying the ensonified area by the expected density. Based upon information presented in the *Response analysis*, we expect all exposures at the 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$ level and above to constitute “take”.

Loggerhead, Kemp's ridley, and leatherback sea turtle densities during summer in the action area were taken from the SERDP SDSS Marine Animal Model Mapper⁹. This online mapping program is designed to deliver density estimates based on a user-provided area. We used this program to enter a polygon representing the ensonified area (i.e., the action area). The SERDP

⁹ <http://seamap.env.duke.edu/search/?app=serdp>

SDSS provided an output containing the mean density (individuals per km²) of turtle species for the action area. These densities were adjusted to represent density per 1,000 km².

The SERDP SDSS Marine Animal Model Mapper does not have density estimates available for green sea turtles. To obtain the number of green sea turtles exposed to the proposed action, we relied upon NOAA Fisheries survey data from the Atlantic Marine Assessment Program for Protected Species (AMAPPS). The NMFS Northeast and Southeast Fisheries Science Centers conduct the AMAPPS survey. The AMAPPS survey began in 2010 and results are available through 2013. The AMAPPS survey in 2012 took place in spring and fall; since the proposed action will take place in summer, the 2012 AMAPPS survey results were not included in this analysis. The AMAPPS summer surveys varied in their timing and duration, but generally lasted a month to seven weeks, and took place from June to late September. We used the results of the northern legs of each survey; the northern study area covered from the Gulf of St. Lawrence, Canada to Cape May, NJ. In 2010 and 2011, the southern leg of the AMAPPS aerial surveys covered the New Jersey coast, and the sea turtle sightings were also included in **Table 28**. The results of the Cetacean and Turtle Assessment Program conducted by the University of Rhode Island (CETAP 1982) were also incorporated. The CETAP survey took place year round throughout November 1978-January 1982.

Table 28. Number of sea turtles sighted during summer AMAPPS aerial and vessel surveys (2010-2013) and CETAP (1978-1982) surveys.

Turtle species (Number of individuals)	AMAPPS Summer Surveys						CETAP Survey	Total
	Aerial				Vessel			
	2010 North Leg	2010 South Leg	2011 North Leg	2011 South Leg	2011 North Leg	2013 North Leg	1978-1982	
Green	6	112	5	60	0	0	3	186
Kemp's Ridley	5	20	0	4	0	0	1	30
Leatherback	20	97	41	30	4	3	142	337
Loggerhead	30	742	34	228	10	34	2926	4,004
Unidentified Hardshell	8	531	6	154	7	29	0	735

In addition to the CETAP and AMAPPS survey data, we examined fisheries observer data collected from 2000-2014 in the statistical areas in and around the seismic survey area (612, 614, and 615). Similar to the AMAPPS and CETAP data, loggerheads were the most commonly encountered sea turtle, followed by leatherbacks. Only one Kemp's ridley was observed in fisheries bycatch. Two green turtles were observed in September (one in 2012, and one in 2014), captured in bottom trawls, and two were sighted swimming at the surface in August 2005. No hawksbill sea turtles were observed. The data shown in **Table 29** shows sea turtles, which were incidentally captured during fishing operations ("fisheries bycatch"), and sea turtles which were sighted in the water by the observer from the fishing vessel ("sighting").

Table 29: Observer data for sea turtles in statistical areas 612, 614, and 615 (2000-2014).

Species	Fisheries Bycatch	Sighting	Total
Green	2	2	4
Kemps Ridley	1	0	1
Loggerhead	41	10	51
Leatherback	1	4	5
Unknown/Hardshell	16	17	33

Based on the AMAPPS and CETAP survey results, and fisheries observer data, it is possible that a maximum of 190 green sea turtles could be present along the Atlantic coast when the seismic activities are taking place. However, this total is not a likely representation of the number of green turtles that we expect to be exposed to the seismic activities in the action area. These survey sightings of green turtles occurred over a much larger area than for the proposed seismic activities. The highest instances of green turtle sightings came from the southern legs of the 2010 and 2011 aerial AMAPPS surveys (112 and 60, respectively). These surveys focused on more southerly areas (from Cape Canaveral, Florida, to New Jersey). Due to their life history, we would expect more green turtles to be present in these areas. Data from a more discrete location (i.e., the fisheries observer data in the statistical areas surrounding the action area) indicate that it is more likely that fewer green turtles (>112 or 60) will be exposed to the seismic activities. In addition, the spread of green turtle sightings during the southern legs of the AMAPPS surveys is over the entire survey area, with concentrations near Cape Canaveral, Florida, Cape Hatteras, North Carolina, the Delmarva peninsula, and the coast of New Jersey. For the northern legs of the AMAPPS surveys (New Jersey to Nova Scotia), however, green turtle sightings occurred near New Jersey and Long Island, New York—that is, the southern portion of the survey area, and not further north. We are unable to parse out sightings of green turtles by specific location from the AMAPPS reports.

Taking the AMAPPS, CETAP, and observer data as the best information available to us, with the understanding of the broad spatial area that these surveys covered, we chose to take the average number of green turtle sightings as the likely number of individuals exposed. The average

number of green turtles sighted during all surveys and observer activity is 27. This amount falls within what we would expect based on the relative proportion of all sea turtle species, and the areas we would expect green turtles to be (compared to other sea turtle species; see discussion below). Therefore, we expect that up to 27 green sea turtles may be exposed to the seismic activities.

The relatively large number of unknown hardshell turtles reflects the inherent difficulty in positively identifying sea turtles during surveys while being sighted from a vessel or airplane. During the 2014 seismic activities, PSOs aboard the *Langseth* sighted 3 unidentified sea turtles in addition to identifying 19 loggerheads. We have no reliable method to account for parsing out the species within these unidentified turtle sightings. However, these unidentified turtles will likely be one of the species known to be in the action area. A major mitigation factor proposed by the NSF is visual monitoring which should reduce exposure of sea turtles. Regions ensonified to 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$ are within the visual range of the *Langseth* and its observers, and would allow other mitigation measures like power-down and shut-down procedures to occur if a sea turtle (identifiable or not) is sighted. On their own, power-down and shut-down procedures are unlikely to be completely effective at eliminating the co-occurrence of listed individuals within the sound field ≥ 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Other measures such as vessel turns and minimizing airgun source levels, seek to further minimize the exposure protected species will experience.

The mitigation measures in place would reduce the number of exposures (e.g., shut-down) before the sea turtle could be exposed or identified. Taking all this into account, we believe that the exposure estimates for each sea turtle species are sufficiently expansive to account for the unidentified turtles.

Our exposure estimates for loggerhead, Kemp's ridley and leatherback sea turtles (

Table 30) were calculated by using density estimates from the SERDP-SDSS multiplied by the daily ensonified area with overlap to obtain the total number of exposures (rounded to the next whole number). We expect that the potential amount of re-exposure (up to 35.5; rounded to 36) applies to sea turtles as described above for ESA-listed whales. The same justification described above for marine mammal exposure and "take" applies to sea turtles.

We believe that sea turtle species are likely to be mostly migratory in the action area, and that movements would be largely captured within the SERDP-SDSS density estimates (Wood 2012).

Based on abundance surveys conducted by the AMAPPS and CETAP during summer months (June-September), we expect that loggerheads would be the most commonly encountered sea turtle species. Loggerheads were the most frequently sighted species during the vessel and aerial surveys from 2010-2013. Nineteen loggerheads (along with 3 other unidentified sea turtles) were also sighted by protected species observers during the *Langseth's* survey in July 2014. Neritic zones (i.e., <200m deep, and depths where the action will take place) represent important foraging habitat for juvenile and adult loggerheads (Conant et al. 2009). Therefore, we recognize that movement in and out of the action area is a possibility, but we are unable to quantify it.

Table 30. Estimated exposure of ESA-listed sea turtles to sound levels ≥ 166 dB re 1 $\mu\text{Pa}_{\text{rms}}$ during the proposed seismic activities.

Sea turtle density per 1,000 km ² SERDP-SDSS	# of exposures to listed turtles	# of turtles exposed to proposed activities	Population size	% of population exposed	Population/location
Green*	27	Up to 27	Unknown	Unknown	North Atlantic
Kemp's ridley 12.4	26	Up to 26	>189,000	0.01%	North Atlantic ¹
Leatherback 10.9	23	Up to 23	34,000	0.07 %	North Atlantic ²
Loggerhead 80.11	164	Up to 164	>32,000	0.51%	Northwestern Atlantic ³
Total	240	--	--	--	--

*SERDP SDSS density estimates were not available for green turtles; see text for explanation.

¹Gallaway et al. (2013)

²TEWG (2007a)

³(NMFS 2001b; TEWG 1998a)

Leatherback sea turtles spend the majority of their time in oceanic waters (see *Status of the Species*), and telemetry data indicate that while foraging, leatherbacks are in a “pattern of near continuous travel” (Hays et al. 2006). It should be noted that the action will take place closer to shore than leatherbacks are typically found (i.e., offshore); the SRDEP density estimate calculated for leatherbacks was the lowest of the turtle species. It is unlikely that leatherbacks would be found foraging in the action area, but should they be encountered during the proposed action, it is likely that they are moving through the area. Leatherbacks were the second-most frequently sighted sea turtle during the AMAPPS and CETAP surveys (after loggerheads).

Kemp's ridley and green sea turtles were sighted infrequently during the AMAPPS and CETAP surveys, and accounted for a lower proportion of the total sea turtle sightings. Green sea turtles are typically found inshore and nearshore, and are not expected to be a prominent species in the action area. However, even these relatively fewer sightings found in the surveys and fisheries observer data indicates that green (and Kemp's Ridley) sea turtles could be present in the action

area.

As discussed in the *Status of listed resources* section, hawksbill sea turtles are circumtropical, and are not typically found in the action area. There is telemetry evidence demonstrating that hawksbill sea turtles migrate long distances (368-2,425km) between foraging and nesting sites (Miller et al. 1998), and hawksbills tagged in Costa Rica traveled to foraging grounds in Nicaragua and Honduras (Troëng et al. 2005). For the purposes of this action, we examined records closer to the proposed action area. Hawksbill sea turtles were not sighted during the AMAPPS or CETAP surveys. Density estimates were not calculated for the SERDP or the NMSDD. After examining fisheries observer data for records of hawksbill sea turtles found in and around the action area (Stat Areas 614, 615, and 612) during summer months, we found no records of hawksbills in the proposed action area. There are limited reports of hawksbills stranding in the mid-Atlantic (two in Virginia from 2001-2013, one in spring, and one in fall) (Barco 2014). Overall, we do not expect it is likely that hawksbill sea turtles will be exposed to the proposed action and this species will not be considered further.

We do not expect sound generated by the proposed action to expose eggs or hatchlings because we do not expect these life stages to be present in the action area. However the *Status of listed resources* section identifies the oceanic environment of the North Atlantic as an important developmental habitat for juveniles and subadults of all sea turtle species and we expect these to occur in the action area. In addition, adult life stages of all species are expected to be exposed to sound. For sea turtle species that have been studied, a skewed sex distribution biased towards females versus males exists. As such, we expect more female sea turtles of all species to be exposed than males.

Exposure of ESA-listed turtles to multibeam echosounder and sub-bottom profiler. Sea turtles hear in the low frequency range. The multibeam echosounder and the SBP operate at 10.5-13 kHz, which emit sounds outside the hearing frequency of sea turtles. Thus, sea turtles are not expected to respond to sounds emitted by multibeam echosounder or sub-bottom profiler.

6.3 Response Analysis

As discussed in the *Approach to the assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after exposure to a stressor created by the action in the action area. Our response analysis attempts to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reducing the fitness of listed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences. Our primary concerns in this consultation revolve around exposure of listed individuals to anthropogenic sound sources, which can have a variety of effects that can have fitness consequences (Francis and Barber 2013; Nowacek and Tyack 2013).

6.3.1 Potential Response of Marine Mammals to Acoustic Sources

Response of marine mammals to airguns. A pulse of seismic airgun sound displaces water around the airgun and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as listed whales and sea turtles considered in this Opinion. Possible responses considered in this analysis consist of:

- hearing threshold shifts,

- auditory interference (masking),
- behavioral responses, and
- non-auditory physical or physiological effects

The *Response analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and sea turtles in the action area.

Marine mammals and threshold shifts. Exposure of marine mammals to very strong sound pulses can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. Threshold shift depends upon the duration, frequency, sound pressure, and rise time of the sound. A temporary threshold shift (TTS) results in a temporary hearing change (Finneran and Schlundt 2013). TTSs can last minutes to days. Full recovery is expected. However, a recent mouse study has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, permanent threshold shift (PTS) can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. TTS and PTS are generally specific to the frequencies over which exposure occurs, but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action) (Kastak et al. 2005; Ketten 2012; Schlundt et al. 2000).

Few data are available to precisely define each listed species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency would need to be ~186 dB SEL or ~196-201 dB re 1 $\mu\text{Pa}_{\text{rms}}$ in order to produce a low-level TTS from a single pulse (Southall et al. 2007b). PTS is expected at levels ~6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007b). In terms of exposure to the *Langseth's* airgun array, an individual would need to be within a few meters of the largest airgun to experience a single pulse >230 dB re 1 μPa peak (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of ~190 dB re 1 $\mu\text{Pa}_{\text{rms}}$, PTS could occur. A marine mammal would have to be within 100 m of the *Langseth's* airgun array to be within the 190 dB re 1 $\mu\text{Pa}_{\text{rms}}$ isopleth and risk a TTS. Estimates that are conservative for species impact evaluation are 230 dB re 1 μPa (peak) for a single pulse, or multiple exposures to ~198 dB re 1 $\mu\text{Pa}^2\text{s}$.

Overall, we do not expect TTS or PTS to occur to any listed whale as a result of airgun exposure for several reasons. We expect that individuals will move away from the airgun array as it approaches. We further believe that as sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the sound source and thus avoid exposures that would induce TTS. Ramp-ups would also reduce the probability of TTS-inducing exposure at the start of seismic surveys. Furthermore, mitigation measures would be in place to initiate a power-down if individuals enter or are about to enter the

180 dB isopleth or within 585 m during full airgun operations, which is below the levels believed to be necessary for potential TTS. As stated in the *Exposure analysis*, each individual is expected to be potentially be exposed dozens of times to 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ levels. We do not expect this to produce a cumulative TTS, PTS, or other injury for several reasons. We expect that individuals will recover between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals to generally move away to at least a short distance as received sound levels increase, reducing the degree significance of any given exposure that is biologically meaningful.

Marine mammals and auditory interference (masking). Interference, or masking, generally occurs when the interfering noise is of a similar frequency and similar to or louder than the auditory signal received by an animal processing echolocation signals or listening for acoustic information from other individuals (Francis and Barber 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues. Generally, noise will only mask a signal if it is sufficiently close to the signal in frequency. This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

There is frequency overlap between airgun noise and vocalizations of listed whales, particularly baleen whales but also sperm whales. Any masking that might occur would likely be temporary because seismic sources are discontinuous and the seismic vessel would continue to transit. The proposed seismic surveys could mask whale calls at some of the lower frequencies. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, and though the findings by Madsen et al. (2006) suggest frequencies of seismic pulses can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (0-188 Hz for the *Langseth* airguns). Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls would be expected to pose a somewhat greater risk of masking. The *Langseth's* airguns will emit a 0.1 s pulse when fired every 5 sec. Therefore, pulses will not "cover up" the vocalizations of listed whales to a significant extent (Madsen et al. 2002). We address the response of listed whales stopping vocalizations as a result of airgun sound in the *Marine mammals and behavioral responses* section below.

Although seismic sound pulses begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as shallow water environments, seismic sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

Marine mammals and behavioral responses. We expect the greatest response to airgun sounds in terms of number of responses and overall impact to be in the form of changes in behavior.

Listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case the effects can equate to take but are unlikely to be significant at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis and Barber 2013). Although some studies are available which address responses of listed whales considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-listed or species outside the action area are also considered here. Individual differences in responding to stressful stimuli also appear to exist and appear to have at least a partial genetic basis in trout (Laursen et al. 2011). Animals generally respond to anthropogenic perturbations as they would predators, increasing vigilance and altering habitat selection (Reep et al. 2011). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sound. Whales continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002; McDonald et al. 1993; McDonald et al. 1995a; Nieukirk et al. 2004; Richardson et al. 1986; Smultea et al. 2004; Tyack et al. 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al. 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995a). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012). A blue whale discontinued calls in response to received airgun sound of 143 dB re 1 μ Pa for one hour before resuming (McDonald et al. 1995a). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 μ Pa_{p-p} (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Langseth's* airguns. If individuals ceased calling in response to the *Langseth's* airguns during the course of the proposed survey, the effect would likely be temporary.

There are numerous studies of the responses of some baleen whale to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of ~160 dB re 1 μ Pa_{rms} as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). Activity of individuals seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother/calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984; Miller et al.

1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999). Surface duration decreased markedly during seismic sound exposure, especially while individuals were engaged in traveling or non-calf social interactions (Robertson et al. 2013). Migrating bowhead whales show strong avoidance reactions to received 120–130 dB re 1 $\mu\text{Pa}_{\text{rms}}$ exposures at distances of 20–30 km, but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152–178 dB re 1 $\mu\text{Pa}_{\text{rms}}$) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999; Richardson et al. 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at received levels of 116–129 dB re 1 μPa (possibly but not knowingly due to whale movement away from the airguns), but did not change at received levels of 99–108 dB re 1 μPa (Blackwell et al. 2013). Despite the above information and exposure to repeated seismic surveys, bowheads continue to return to summer feeding areas and when displaced, appear to reoccupy areas within a day (Richardson et al. 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether individuals that tolerate repeat exposures may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 $\mu\text{Pa}_{\text{rms}}$ (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984; Malme et al. 1986; Malme et al. 1988; Würsig et al. 1999; Yazvenko et al. 2007a; Yazvenko et al. 2007b). Migrating gray whales began to show changes in swimming patterns at \sim 160 dB re 1 μPa and slight behavioral changes at 140–160 dB re 1 $\mu\text{Pa}_{\text{rms}}$ (Malme and Miles 1985; Malme et al. 1984). As with bowheads, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984). Johnson et al. (2007b) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002–2005.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1 $\mu\text{Pa}_{\text{rms}}$ when females with calves were present, or 8–12 km from the seismic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Closest approaches were generally limited to 3–4 km, although some individuals (mainly males) approached to within 100 m on occasion where sound levels were 179 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Changes in course and speed generally occurred at estimated received level of 157–164 dB re 1 $\mu\text{Pa}_{\text{rms}}$.

Natural sources of sound also influence humpback behavior. Migrating humpbacks showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise ((Dunlop et al. 2014a)). Since natural sources of noise alone can influence whale behavior, additional anthropogenic sources could also add to these effects.

Multiple factors may contribute to the degree of response exhibited by migrating humpbacks. In a preliminary study examining the responses by migrating humpbacks of exposure to a 20in³ air gun, researchers found that the whales' behavior seemed to be influenced by social effects;

“whale groups decreased dive time slightly and decreased speed towards the source, but there were similar responses to the control” (i.e., a towed air gun, not in operation) (Dunlop et al. 2014b). Whales in groups may pick up on responses by other individuals in the group and react. The results of this continued study are still pending, and will examine the effects of a full size commercial air gun array on humpback behavior (Dunlop et al. 2014b).

Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150–169 dB re 1 μ Pa and no clear evidence of avoidance was apparent at received levels up to 172 re 1 μ Pa_{rms} (Malme et al. 1984; Malme et al. 1985). Potter et al. (2007) found that humpbacks on feeding grounds in the Atlantic did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al. 2006a; Moulton et al. 2006b; Moulton and Miller 2005). When spotted at the average sighting distance, individuals would have likely been exposed to ~169 dB re 1 μ Pa_{rms} (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found Atlantic sperm whales to show little or no response (Davis et al. 2000b; Madsen et al. 2006; Miller et al. 2009; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). Detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from <130-162 dB re 1 μ Pa_{p-p}, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2003; Jochens and Biggs 2004; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re 1 μ Pa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a nonrandom distribution of satellite-tagged sperm whales at and beyond five kilometers from seismic airgun arrays, suggesting individuals were not displaced or move away from the array at and beyond these distances in the Gulf of Mexico (Winsor and Mate 2013). However, no tagged whales within five kilometers were available to assess potential displacement within five kilometers (Winsor and Mate 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally <188 Hz) pulses produced by seismic airguns (Richardson et al. 1995c). Sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold and Fish 1998), so even though this species

generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were ~30 dB re 1 μ Pa lower at 1 kHz and 60 dB re 1 μ Pa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions to impulse noise likely vary depending on the activity at time of exposure – e.g., in the presence of abundant food or during breeding encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2006b).

For whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that whales would be displaced from that is essential for breeding if whales depart an area as a consequence of the *Langseth's* presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

Marine mammals and physical or physiological effects. Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history.

Stress is an adaptive response and does not normally place an animal at risk. 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 (Busch and Hayward 2009; Gregory and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003; Dickens et al. 2010; Dierauf and Gulland 2001b; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancina et al. 2008; Noda et al. 2007; Thomson and Geraci 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). 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; Herraiez 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 2001a). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). Stress is lower in immature right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud noises generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re 1 $\mu\text{Pa} \cdot \text{m}_{\text{p-p}}$) and single pure tones (up to 201 dB re 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S.; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012b). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities would be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006g; NRC 2003). As we do not expect individuals to experience TTS or PTS, (see *Marine mammals and threshold shifts*), we also do not expect any listed individual to experience a stress response at high levels. We assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, the stressor (sounds associated with the airgun, multibeam echosounder, or sub-bottom profiler) will dissipate in a short period as the vessel (and stressors) transects away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. In fish eggs and embryos exposed to sound levels only 15 dB greater than background, increased mortality was found and surviving fry had slower growth rates (a similar effect was observed in shrimp), although the opposite trends have also been found in sea bream. Dogs exposed to loud music took longer to digest food. The small intestine of rats leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). Exposure to 12 hours of loud noise can alter elements of cardiac tissue. In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight and Swaddle 2011). It is noteworthy that although various exposures to loud noise appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa; the impacts of even loud sound are complex and not universally negative (Kight and Swaddle 2011).

It is possible that an animal's prior exposure to seismic sounds influences its future response. We have little information available to us as to what response individuals would have to future exposures to seismic sources compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response would likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre and Jurado 1997; André et al. 1997; Gordon et al. 2006). We do not believe sensitization would occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to seismic sounds that would be expected to produce a more intense, frequent, and/or earlier response to

subsequent exposures (see *Response Analysis*).

Marine mammals and strandings. There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys.

Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico. The *R/V Ewing* had been operating a 20-airgun, 8,490-in³ airgun array 22 km offshore the general area at the time that strandings occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002) as some vacationing marine mammal researchers who happened upon the stranding were ill-equipped to perform an adequate necropsy. Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between seismic sound sources and beaked whale strandings (Cox et al., 2006). At present, the factors of seismic airguns that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed to for use will cause marine mammal strandings. We do not expect listed whales to strand as a result of the proposed seismic survey.

Responses of marine mammal prey. Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for listed whales. Unfortunately, species-specific information on the prey of listed whales is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of listed whales to react in manners similar to those fish and invertebrates described herein.

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, and this is limited to close-range exposure to high-amplitudes (Bjarti 2002; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996a; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect fish to be capable of moving away from the airgun array if it causes them discomfort.

More evidence exists for sub-lethal effects. Several species at various life stages have been exposed to high-intensity sound sources (220-242 dB re 1 μ Pa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). TTS was not found in whitefish at received levels of \sim 175 dB re 1 μ Pa²·s, but pike did show 10-15 dB of hearing loss with recovery within 1 day (Popper et al. 2005). Caged pink snapper have experienced PTS when exposed over 600 times to received seismic sound levels of 165-209 dB re 1 μ Pa_{p-p}. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish and capelin eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne et al. 2009). Salmonid swim bladders were reportedly damaged by received sound levels of \sim 230 dB re 1 μ Pa (Falk and Lawrence 1973).

By far the most common response by fishes is a startle or distributional response, where fish

react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged *Pelates* spp., pink snapper, and trevally generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (McCauley and Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (McCauley and Fewtrell 2013a). Startle responses were observed in rockfish at received airgun levels of 200 dB re 1 μPa_{0-p} and alarm responses at >177 dB re 1 μPa_{0-p} (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20-60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186–191 re 1 μPa_{0-p} . Caged European sea bass showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days (Skalski et al. 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 km away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity. Whiting exhibited a downward distributional shift upon exposure to 178 dB re 1 μPa_{0-p} airgun sound, but habituated to the sound after one hour and returned to normal depth (sound environments of 185-192 dB re 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from airgun sound (Dalen and Knutsen 1986). Hake may redistribute downward (La Bella et al. 1996a). Lesser sandeels exhibited initial startle responses and upward vertical movements before fleeing from the survey area upon approach of an active seismic vessel (Hassel et al. 2003; Hassel et al. 2004). McCauley et al. (2000; 2000a) found smaller fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156–161 dB re 1 $\mu\text{Pa}_{\text{rms}}$, but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock did not respond to airgun sounds received at 195–218 dB re 1 μPa_{0-p} , but did exhibit continual startle responses and fled from the seismic source when visible (Wardle et al. 2001). Blue whiting and mesopelagic fishes were found to redistribute 20–50 m deeper in response to airgun ensonification and a shift away from the survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142–186 dB re 1 μPa_{p-p} sound levels from an airgun (Thomsen 2002). Cod and haddock likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160–180 dB re 1 μPa_{0-p} (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). Increased swimming activity in response to airgun exposure, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163–191 dB re 1 μPa_{0-p} (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a 4-5 month seismic survey (Pickett et al. 1994). La Bella et al. (1996b) found no differences in trawl catch data before and after seismic operations and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching airguns.

Squid responses to airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re 1 $\mu\text{Pa}_{\text{rms}}$ by first ejecting ink and then moving rapidly away from the

area (McCauley and Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156–161 dB re 1 $\mu\text{Pa}_{\text{rms}}$. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the surveys in time and space, as well as pathological information from the carcasses. Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Payne et al. 2013). However, feeding did increase in exposed individuals (Payne et al. 2013).

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We do not expect krill (the primary prey of most listed baleen whales) to experience effects from airgun sound. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed survey. Based upon the best available information, fishes and squids ensonified by the ~ 160 dB isopleths could vacate the area and/or dive to greater depths, and be more alert for predators. We do not expect indirect effects from airgun activities through reduced feeding opportunities for listed whales to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both sperm whales and their prey would re-distribute back into the area once survey activities have passed.

Marine mammal response to multibeam echosounder and sub-bottom profiler. We expect listed whales to experience ensonification from not only airguns, but also seafloor and ocean current mapping systems. Multibeam echosounder and sub-bottom profiler frequencies are much higher than frequencies used by all listed whales except blue, humpback, North Atlantic right and sperm whales. We expect that these systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng et al. 2014). However, we do not expect these sub-harmonic frequencies in these systems to be audible to these species. Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80-90 dB re 1 μPa range, it is difficult to determine the significance of this because the source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5-4.0 kHz mid-frequency sonar at received levels below 90 dB re 1 μPa . Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen et al. 2013). Hearing is poorly understood for listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multibeam echosounder and sub-bottom profiler systems (Ketten 1997; Richardson et al. 1995c). Thus, if fin or sei, whales are exposed, they are unlikely to hear these frequencies well (if at all) and a response is not expected.

Assumptions for blue, humpback, and sperm whale hearing are much different than for other listed whales. Humpback and sperm whales vocalize between 3.5-12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000a; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993;

Weilgart and Whitehead 1997; Weir et al. 2007; Winn et al. 1970). The response of a blue whale to 3.5 kHz sonar supports this species ability to hear this signal as well (Goldbogen et al. 2013). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1-3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel. Sperm whales have stopped vocalizing in response to 6-13 kHz pingers, but did not respond to 12 kHz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but not while traveling (Andre and Jurado 1997; André et al. 1997).

Investigations stemming from a 2008 stranding event in Madagascar suggest a 12 kHz multibeam echosounder, similar in operating characteristics as that proposed for use aboard the *Langseth*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (Southall et al. 2013). Although pathological data to suggest a direct physical affect are lacking and the authors acknowledge that although the use of this type of sonar is widespread and common place globally without noted incidents like the Madagascar stranding, all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multibeam echosounder (Southall et al. 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth*'s multibeam echosounder and that of the chase vessel. Although effects such as this have not been documented for ESA-listed species, the combination of exposure to this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis and Barber 2013).

Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by L-DEO differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multibeam echosounder and sub-bottom profiler. The sound energy received by any individuals exposed to the multibeam echosounder and sub-bottom profiler sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multibeam echosounder and sub-bottom profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have been correlated to use of these sonars. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, sperm, or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multibeam echosounder was less than 3% that of ship strike.

6.3.2 Potential Responses of Sea Turtles to Acoustic Sources

Sea turtle response to airguns. As with marine mammals, sea turtles may experience

- hearing threshold shifts
- behavioral responses
- non-auditory physical or physiological effects

Sea turtles and threshold shifts. Although leatherback sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel et al. 2005). Few data are available to assess sea turtle hearing, let alone the effects seismic equipment may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead experienced TTS upon multiple airgun exposures in a shallow water enclosure, but recovered within one day.

As with marine mammals, we assume that sea turtles will not move towards a source of stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sources (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003). For this reason, mitigation measures are also in place to limit sea turtle exposure. Although data on the precise levels that can result in TTS or PTS are lacking, we do not expect either of these to occur to any sea turtle as a result of the proposed action.

Sea turtles and behavioral responses. As with listed whales, it is likely that sea turtles will experience behavioral responses in the form of avoidance. O'Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175–176 dB re 1 $\mu\text{Pa}_{\text{rms}}$ (or slightly less) in a shallow canal. Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 μPa and 175 dB re 1 μPa , respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 μPa , with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994b; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter and Larbi Doukara 2012). Responses decreased with increasing distance of closest approach by the seismic array (DeRuiter and Larbi Doukara 2012). The authors developed a response curve based upon observed responses and predicted received exposure level. Recent monitoring studies show that some sea turtles move away from approaching airguns, although sea turtles may approach active seismic arrays within 10 m (Holst et al. 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 166 dB re 1 μPa . This corresponds with previous reports of sea turtle hearing thresholds being generally higher than for marine mammals (DFO 2004). At 166 dB re 1 μPa . We anticipate some change in swimming patterns and a stress response of exposed individuals. Some turtles may approach the active seismic array to closer proximity, but we expect them to eventually turn away. We expect temporary displacement of exposed individuals from some

portions of the action area while the *Langseth* transects through.

Sea turtles and stress. Direct evidence of seismic sound causing stress is lacking in sea turtles. However, we expect sea turtles to generally avoid high-intensity exposure to airguns in a fashion similar to predator avoidance. As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles experience a stress response to airguns when they exhibit behavioral avoidance or when they are exposed to sound levels apparently sufficient to initiate an avoidance response (~166 dB re 1 μ Pa). We expect breeding adult females may experience a lower stress response, as female loggerhead and green sea turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than ~166 dB re 1 μ Pa, but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea turtle response to multibeam echosounder and sub bottom profiler. Sea turtles do not possess a hearing range that includes frequencies emitted by these systems. Therefore, listed sea turtles will not hear these sounds even if they are exposed and are not expected to respond to them.

7 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area considered by this Opinion. 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.

We expect that those aspects described in the *Environmental Baseline* will continue to impact listed resources into the foreseeable future. We expect climate change, habitat degradation, dredging, seismic surveys, military activities, entrapment and entanglement, invasive species impacts, wind energy projects, entrainment in power plants, ship-strikes, pollution, scientific research, and harvests to continue into the future. Movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring throughout the Atlantic Ocean, which may aid in abating the downward trajectory of sea turtle populations.

8 INTEGRATION AND SYNTHESIS OF EFFECTS

As explained in the *Approach to the Assessment* section, risks to listed individuals are analyzed using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, as well as lifetime reproductive success. When ESA-listed 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 animals are not likely to experience reductions in their fitness, we conclude our assessment. If 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.

ESA-Listed whales. The NSF proposes to allow the use of its vessel, the *Langseth*, to conduct a seismic survey by L-DEO that could incidentally harass several ESA-listed marine mammal species; and PR1 proposes to authorize the incidental take of marine mammals. These species include: blue whales, fin whales, humpback whales, North Atlantic right whales, sei whales, and sperm whales, all of which are endangered throughout their ranges.

The *Status of Listed Resources* section identified commercial whaling as the primary reason for reduced populations, many of whom are a small fraction of their former abundance (Tables 3-7). Although large-scale commercial harvests no longer occur for these species, some harvests from subsistence and scientific research in regional and worldwide populations still occur. Other worldwide threats to the survival and recovery of ESA-listed whale species include: altered prey base and habitat quality as a result of global warming, ship strike, entanglement in fishing gear, toxic chemical burden and biotoxins, ship noise, competition with commercial fisheries, and killer whale predation. Populations of whales inhabiting the North Atlantic face area-specific threats identified in the *Environmental Baseline*.

Despite these pressures, available trend information indicates most local populations of ESA-listed whales are stable or increasing. As previously mentioned, the *Cumulative Effects* section identifies actions in the *Environmental Baseline* we expect to generally continue for the foreseeable future.

The *Effects Analysis* supports the conclusion of harassment to listed whales by proposed seismic activities. As discussed in the exposure analysis, we expect up to 1 blue, 3 fin, 5 sei, 3 humpback, 3 North Atlantic right, and 31 sperm whales could be exposed to airgun sounds which will elicit a behavioral response of temporarily moving out of the area. We expect a low-level, transitory stress response to accompany this behavior. The number of individuals exposed is a small fraction of the populations, with some individual re-exposure and reactions. These exposures should not limit the fitness of any single individual. The other actions we considered in the Opinion, the operation of multibeam echosounder and sub-bottom profiler systems, are not expected to be audible to fin or sei whales and consequently are not expected to have any direct effects on these species. However, blue, humpback, North Atlantic right and sperm whales could hear sounds produced by these systems. Responses could include cessation of vocalization by sperm whales and/or movement out of the survey area by these species. Behavioral harassment caused by exposure to sound sources associated with the proposed seismic survey are expected to cause some individuals to cease these activities temporarily and possibly move out of the immediate area. However, we expect that individuals will either resume foraging in a secondary location or reoccupy the habitat from which they were displaced within a period of days (or less). We do not expect these effects to have fitness consequences for any individual. The *Effects Analysis* also found that, although sperm whales may experience temporarily reduced feeding opportunities; this indirect effect would be transient and not reduce individual fitness of any whale. Based upon these findings, the risk of fitness consequences to any single individual is not expected to translate to population or species-level consequences. Overall, we do not expect a fitness reduction to any individual whale from the survey or IHA. As such, we do not expect fitness consequences to populations or listed whale species as a whole.

ESA-Listed turtles. ESA-Listed turtles that are expected to occur within the action area include

green sea turtles, leatherback sea turtles, loggerhead sea turtles, and Kemp's ridley sea turtles, which are either threatened or endangered. The *Status of Listed Resources* section found that most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and turtles, as well as severe bycatch pressure in worldwide fishing industries. As previously mentioned, the *Cumulative Effects* section identified actions in the *Environmental Baseline* to generally continue for the foreseeable future.

From the *Effects Analysis*, we expect that 27 green, 26 Kemp's ridley, 23 leatherback, and 164 loggerhead sea turtles could experience exposure to airgun sounds and be harassed by these sounds. These sounds may induce a temporary increase stress levels, swimming patterns, and movement out of the action area. Population size is not available to calculate the subset of all population affected. However, those that are available suggest a very small proportion of each population would be affected. We expect transient responses that do not affect the fitness of any one individual. We do not expect impairment of local nesting by the proposed survey. As we do not expect any sea turtle to be capable of hearing signals produced by the multibeam echosounder and sub-bottom profiler systems, we do not expect direct effects from these systems on sea turtle fitness. We do not anticipate any indirect effects from the proposed actions to influence sea turtles. Overall, we do not expect any individual sea turtle to undergo a fitness consequence. Based upon these findings, the risk of fitness consequences to any single individual is not expected to translate to population or species-level consequences. Because we do not expect individual sea turtles to experience fitness reductions, we also do not expect reductions in the viability of the populations these individuals belong or the viability of the species those populations comprise.

9 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed actions and cumulative effects, it is NMFS' biological opinion that the proposed seismic survey off the New Jersey coast and NMFS' Permits and Conservation Division's issuance of an IHA is not likely to jeopardize the continued existence of blue, fin, sei, humpback, North Atlantic right, and sperm whales as well as green, leatherback, loggerhead, and Kemp's ridley sea turtles. The proposed action would have no effect on critical habitat.

10 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the “take” of endangered and threatened species, respectively, without 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 the NMFS as an act which actually kills or injures wildlife, which may include significant habitat modification or degradation which actually kills or injures fish or wildlife 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. Under the terms of sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 CFR § 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take or “the extent of land or marine area that may be affected by an action” may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953).

Section 7(b)(4)(C) of the ESA specifies that in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under section 101(a)(5) of the MMPA. One of the federal actions considered in this Opinion is the Permits and Conservation Division’s proposed authorization of the incidental taking of fin, blue, sei, humpback, North Atlantic right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA. The final authorization would be issued and its mitigation and monitoring measures incorporated in this Incidental Take Statement as Terms and Conditions. With this authorization, the incidental take of listed whales would be exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA as long as such take occurs consistent with this statement.

The NMFS anticipates the proposed seismic survey along offshore New Jersey is likely to result in the incidental take of ESA-listed species by harassment. The proposed action is expected to take by harassment 1 blue, 3 fin, 5 sei, 3 humpback, 3 North Atlantic right, and 31 sperm whales as well as 27 green, 26 Kemp’s ridley, 23 leatherback, and 164 loggerhead sea turtles by exposing individuals to received seismic sound levels greater than 160 dB re 1 μ Pa by harassment (166 dB re 1 μ Pa for sea turtles) (**Table 31**). For sei and sperm whales, we are adopting the numbers presented by the Permits and Conservation Division in their IHA as the number of sei and sperm whales takes authorized in the incidental take statement. For the reasons discussed above in the *Exposure analysis* section, we believe that this amount of take is as reasonably likely to occur to sei and sperm whales despite the differences in analytical methods.

These estimates are based on the best available information of densities in the area to be ensonified above 160 dB re 1 μ Pa for whales during the proposed activities and 166 dB re 1 μ Pa for sea turtles. This incidental take would result primarily from exposure to acoustic energy during seismic operations and would be in the form of harassment, and is not expected to result in the death or injury of any individuals that are exposed.

Table 31. Number of individual ESA-listed whales and sea turtles authorized for incidental take.

Species	Number of Individuals Authorized for Incidental Take
Blue whale	1
Fin whale	3
Sei whale	5
Humpback whale	3
North Atlantic right whale	3
Sperm whale	31
Green sea turtle	27
Kemp's ridley sea turtle	26
Leatherback sea turtle	23
Loggerhead sea turtle	164

Harassment of blue, fin, humpback, North Atlantic right, sei, and sperm whales exposed to seismic studies at levels less than 160 dB re 1 μ Pa, or of leatherback, loggerhead, green, and Kemp's ridley sea turtles at levels less than 166 dB re 1 μ Pa, is not expected. During airgun operation, if overt adverse reactions (for example, startle responses, dive reactions, or rapid departures from the area) by ESA-listed whales or sea turtles are observed at less intense levels than 160 dB or 166 dB re 1 μ Pa, respectively, incidental take may be exceeded. The NSF and NMFS' Permits and Conservation Division must contact the ESA Interagency Cooperation Division to determine whether reinitiation of consultation is required because of such responses.

Any incidental take of blue, fin, humpback, North Atlantic right, sei, and sperm whales or leatherback, loggerhead, green, and Kemp's ridley sea turtles is restricted to the permitted action as proposed. If the actual incidental take exceeds the predicted level or type, the NSF and NMFS' Permits and Conservation Division must reinitiate consultation. All anticipated takes would be "takes by harassment", as described previously, involving temporary changes in behavior.

10.2 Effect of the Take

In the accompanying Opinion, NMFS has determined that the amount of incidental take, coupled with other effects of the proposed actions, is not likely to jeopardize the continued existence of any listed species.

10.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the NSF and the Permits Division so that they become binding conditions for L-DEO for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS believes the reasonable and prudent measure described below is necessary and appropriate to minimize the amount of incidental take of listed whales and sea turtles resulting from the proposed actions. This measure is non-discretionary and must be a binding condition of the NSF and NMFS' authorization for the exemption in section 7(o)(2) to apply. If the NSF or NMFS fail to ensure compliance with this term and conditions and its implementing terms and conditions, the protective coverage of section 7(o)(2) may lapse.

- The Permits and Conservation Division and the NSF must ensure that the L-DEO implements and monitors the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue, fin, sei, humpback, North Atlantic right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for green, Kemp's ridley, leatherback, and loggerhead sea turtles. In addition, the Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and to inform the ESA Interagency Cooperation Division if take is exceeded.

10.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the NSF, L-DEO, and Permits and Conservation Division must comply with the following terms and conditions, which implement the reasonable and prudent measure described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR 402.14(i)). These terms and conditions are non-discretionary. If NSF, L-DEO, and/or the Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the Reasonable and Prudent Measures, the L-DEO and the NMFS' Permits and Conservation Division shall ensure that:

Mitigation and Monitoring Requirements

- A. Establish a safety radius corresponding to the anticipated 180-dB isopleth for full (700 in³) and single (40 in³) airgun operations.
- B. Use two, NMFS-approved, vessel-based PSVOs to watch for and monitor marine mammal or sea turtle species near the seismic source vessel during daytime airgun operations, start-ups of airguns at night, and while the seismic array and streamers are being deployed and retrieved. Vessel crew will also assist in detecting marine mammals or sea turtles, when

practical. Observers will have access to reticle binoculars (7 X 50 Fujinon), big-eye binoculars (25 X 150), optical range finders, and night vision devices. PSVOs shifts will last no longer than 4 hours at a time. PSVOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.

- C. Record the following information when a marine mammal or sea turtle is sighted:
- i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace.
 - ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare.
 - iii. The data listed under ii. would also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.
- D. Visually observe the entire extent of the safety radius using PSVOs, for at least 30 min prior to starting the airgun (day or night). If PSVOs find a marine mammal or sea turtle within the safety zone, L-DEO must delay the seismic survey until the marine mammal or sea turtle has left the area. If the PSVO sees a marine mammal or sea turtle that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the PSVO sees no marine mammals or sea turtles during that time, they should assume that the animal has moved beyond the safety zone. If for any reason the entire radius cannot be seen for the entire 30 min (e.g., rough seas, fog, darkness), or if marine mammals or sea turtles are near, approaching or in the safety radius, the airguns may not be started up. If one airgun is already running at a source level of at least 180 dB, L-DEO may start subsequent guns without observing the entire safety radius for 30 min prior, provided no marine mammals or sea turtles are known to be near the safety radius. In the event a North Atlantic right whale is visually sighted, the airgun array will be shut-down regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 min after the last documented whale visual sighting. If concentrations (six or more individuals) of blue, fin, humpback, sei, or sperm whales are observed, then the array will be powered down and the group avoided if possible if they do not appear to be traveling.
- E. Use the passive acoustic monitoring system (PAM) to detect marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO and/or bioacoustician will monitor the PAM at all times in shifts of up to six hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.
- F. Record the following when an animal is detected by the PAM:
- i. Contact the PSVO immediately (and initiate power or shut-down, if required);
 - ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional

information was recorded, position and water depth when first detected, bearing if determinable, species or species group, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

G. Apply a “ramp-up” procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs will monitor the safety radius, and if marine mammals or sea turtles are sighted, a course/speed alteration, power-down, or shut-down will occur as though the full array were operational.

H. Alter speed or course during seismic operations if a marine mammal or sea turtle, based on its position and relative motion, appears likely to enter the safety zone. If speed or course alteration is not safe or practical, or if after alteration the marine mammal or sea turtle still appears likely to enter the safety zone, further mitigation measures, such as power-down or shut-down, will be taken.

I. Shut-down or power-down the airguns upon marine mammal or sea turtle detection within, approaching, or entering the safety radius. A power-down means shutting down one or more airguns and reducing the safety radius to the degree that the animal is outside of it. Following a power-down, if the marine mammal or sea turtle approaches the smaller designated safety radius, the airguns must completely shut down. Airgun activity will not resume until the marine mammal or sea turtle has cleared the safety radius, which means it was visually observed to have left the safety radius, or has not been seen within the radius for 15 min (small odontocetes) or 30 min (sea turtle, mysticetes, and large odontocetes). The array will not resume firing until 30 min after the last documented whale visual sighting. The *Langseth* may operate a small-volume airgun (i.e., mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

J. To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours. Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored. No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSVO(s) on duty.

Reporting Requirements

A. NSF is required to submit a report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days after the expiration of the IHA. NSF shall provide this report to the ESA Interagency Cooperation Division. This report must contain and summarize the following information:

- i. Dates, times, locations, heading, speed, weather, and associated activities during all seismic operations.
- ii. Species, number, location, distance from the vessel, and behavior of any marine

mammals or sea turtles, as well as associated seismic activity (number of power-downs and shutdowns), observed throughout all monitoring activities.

iii. An estimate of the number (by species) of marine mammals or sea turtles that:

- a. Are known to have been exposed to the seismic activity (visual observation) at received levels greater than or equal to 160 dB re 1 microPa (rms) (marine mammals), 166 dB re 1 microPa (rms) (sea turtles), and/or 180 dB re 1 microPa (rms) for cetaceans with a discussion of any specific behaviors those individuals exhibited.
- b. May have been exposed (modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 microPa (rms) (marine mammals), 166 dB re 1 microPa (rms) (sea turtles), and/or 180 dB re 1 microPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

iv. A description of the implementation and effectiveness of the:

- a. Terms and conditions of the Opinion's Incidental Take Statement.
- b. Mitigation measures of the IHA. For the Opinion, the report will confirm the implementation of each term and condition and describe the effectiveness, as well as any conservation measures, for minimizing the adverse effects of the action on listed whales and sea turtles.

B. In the unanticipated event that any taking of an ESA-listed marine mammal or sea turtle in a manner not considered in this biological opinion, such as an injury, serious injury or mortality, and is judged to result from these activities, L-DEO will immediately cease operating all authorized sound sources and report the incident to Cathy Tortorici, ESA Interagency Cooperation Division Chief, at Cathy.Tortorici@noaa.gov as well as the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 (Mendy.Garron@noaa.gov) immediately. L-DEO will postpone the research activities until NMFS is able to review the circumstances of the take. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate and necessary, and notify L-DEO that they may resume the seismic survey operations.

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound sources used in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and

- Photographs or video footage of the animal(s) (if equipment is available).

C. In the unanticipated event that any cases of marine mammal or sea turtle injury or mortality are judged to result from these activities (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO will cease operating seismic airguns and report the incident to Cathy Tortorici ESA Interagency Cooperation Division Chief at Cathy.Tortorici@noaa.gov as well as the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 (Mendy.Garron@noaa.gov) immediately. Airgun operation will then be postponed until NMFS is able to review the circumstances and work with L-DEO to determine whether modifications in the activities are appropriate and necessary. If the lead observer judged that the injury or mortality is not a result of the authorized activities, operations may continue.

1 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 endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

We recommend the following conservation recommendations, which would provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect endangered large whales as well as endangered or threatened sea turtles and fishes:

1. *Effects of seismic noise on sea turtles.* The NSF should promote and fund research examining the potential effects of seismic surveys on listed sea turtle species.
2. The NSF should develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun sources.

In order for the ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting ESA-listed species or their habitats, NMFS' Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

2 REINITIATION NOTICE

This concludes formal consultation on the proposed seismic source survey to be funded by the NSF and conducted by the L-DEO on board the *R/V Langseth* in the Atlantic Ocean off the New Jersey coast, and NMFS Permits and Conservation Division's issuance of an incidental harassment authorization for the proposed studies pursuant to section 101(a)(5)(D) of the MMPA. As provided in 50 CFR §402.16, reinitiation of consultation will be required where discretionary Federal involvement or control over the action has been retained or is authorized by law, and: (1) if the amount or extent of incidental take is exceeded; (2) if new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) if the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this

opinion; or (4) if a new species is listed or critical habitat designated that may be affected by the action.

B LITERATURE CITED

- Aburto, A. D., J. Rountry, and J. L. Danzer. 1997. Behavioral response of blue whales to active signals. Naval Command, Control, and Ocean Surveillance Center, RDT&E Division, San Diego, CA.
- 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.
- Ackerman, R. A. 1997. The nest environment, and the embryonic development of sea turtles. Pages 83-106 in P. L. Lutz, and J. A. Musick, editors. *The Biology of Sea Turtles*. CRC Press, Boca Raton, Florida.
- Addison, D. S. 1997. Sea turtle nesting on Cay Sal, Bahamas, recorded June 2-4, 1996. *Bahamas Journal of Science* 5:34-35.
- Addison, D. S., and B. Morford. 1996. Sea turtle nesting activity on the Cay Sal Bank, Bahamas. *Bahamas Journal of Science* 3:31-36.
- Agler, B. A., R. L. Schooley, S. E. Frohock, S. K. Katona, and I. E. Seipt. 1993. Reproduction of photographically identified fin whales, *Balaenoptera physalus*, from the Gulf of Maine. *Journal of Mammalogy* 74(3):577-587.
- Aguayo, A. L. 1974. Baleen whales off continental Chile. Pp.209-217 In: *The Whale Problem: A Status Report*. W.E. Schevill (Ed), Harvard University Press, Cambridge, Massachusetts.
- Aguilar, A. 1983. Organochlorine pollution in sperm whales, *Physeter macrocephalus*, from the temperate waters of the eastern North Atlantic. *Marine Pollution Bulletin* 14(9):349-352.
- Aguilar, A., and A. Borrell. 1988. Age- and sex-related changes in organochlorine compound levels in fin whales (*Balaenoptera physalus*) from the eastern North Atlantic. *Marine Environmental Research* 25:195-211.
- Aguilar, A., and C. H. Lockyer. 1987. Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. *Canadian Journal of Zoology* 65:253-264.
- Aguirre, A. A., G. H. Balazs, B. Zimmerman, and F. D. Galey. 1994. Organic contaminants and trace metals in the tissues of green turtles (*Chelonia mydas*) afflicted with fibropapillomas in the Hawaiian Islands. *Marine Pollution Bulletin* 28(2):109-114.
- Aguirremacedo, M., and coauthors. 2008. Ballast water as a vector of coral pathogens in the Gulf of Mexico: The case of the Cayo Arcas coral reef. *Marine Pollution Bulletin* 56(9):1570-1577.
- Al-Bahry, S., and coauthors. 2009. Bacterial flora and antibiotic resistance from eggs of green turtles *Chelonia mydas*: An indication of polluted effluents. *Marine Pollution Bulletin* 58(5):720-725.
- Alava, J. J., and coauthors. 2006. Loggerhead sea turtle (*Caretta caretta*) egg yolk concentrations of persistent organic pollutants and lipid increase during the last stage of embryonic development. *Science of the Total Environment* 367(1):170-181.
- Anan, Y., T. Kunito, I. Watanabe, H. Sakai, and S. Tanabe. 2001. Trace element accumulation in hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) from Yaeyama Islands, Japan. *Environmental Toxicology and Chemistry* 20(12):2802-2814.

- Anderson, J. J. 2000. A vitality-based model relating stressors and environmental properties to organism survival. *Ecological Monographs* 70(3):445-470.
- Anderson, R. C., T. A. Branch, A. Alagiyawadu, R. Baldwin, and F. Marsac. 2012. Seasonal distribution, movements and taxonomic status of blue whales (*Balaenoptera musculus*) in the northern Indian Ocean. *Journal of Cetacean Research and Management* 12(2):203-218.
- Anderwald, P., and coauthors. 2013. Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. *Endangered Species Research* 21(3):231-240.
- Andre, M., and L. F. L. Jurado. 1997. Sperm whale (*Physeter macrocephalus*) behavioural response after the playback of artificial sounds. Pages 92 in Tenth Annual Conference of the European Cetacean Society, Lisbon, Portugal.
- André, M., M. Terada, and Y. Watanabe. 1997. Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. Report of the International Whaling Commission 47:499-504.
- 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, J. D. 1984. Epizootiology of diseases of oysters (*Crassostrea virginica*), and parasites of associated organisms in eastern North America. *Helgoland Marine Research* 37(1-4):149-166.
- Andrews, R. C. 1916. The sei whale (*Balaenoptera borealis* Lesson). *Memoirs of the American Museum of Natural History, New Series* 1(6):291-388.
- Angliss, R. P., and K. L. Lodge. 2004. Alaska Marine Mammal Stock Assessments - 2003. NOAA Technical Memorandum NMFS-AFSC-144:U.S. Department of Commerce, 230p.
- Anguiano-Beltrán, C., R. Searcy-Bernal, and M. L. Lizárraga-Partida. 1998. Pathogenic effects of *Vibrio alginolyticus* on larvae and postlarvae of the red abalone *Haliotis rufescens*. *Diseases of Aquatic Organisms* 33:119-122.
- Anil, A. C., and coauthors. 2013. North Atlantic blue and fin whales suspend their spring migration to forage in middle latitudes: Building up energy reserves for the journey? *PLoS ONE* 8(10):e76507.
- Anonmyous. 2009. Right whale sedation enables disentanglement effort. *Marine Pollution Bulletin* 58(5):640-641.
- 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.
- Arcangeli, A., and coauthors. 2013a. Seasonal sightings of *Balaenoptera physalus* in the Bonifacio Strait (Pelagos Sanctuary). *Biol. Mar. Mediterr.* 20(1):252-253.
- Arcangeli, A., A. Orasi, S. P. Carcassi, and R. Crosti. 2013b. Exploring thermal and trophic preference of *Balaenoptera physalus* in the central Tyrrhenian Sea: A new summer feeding ground? *Marine Biology*.
- Arnbom, T., V. Papastavrou, L. S. Weilgart, and H. Whitehead. 1987. Sperm whales react to an attack by killer whales. *Journal of Mammalogy* 68(2):450-453.

- Arthur, K., and coauthors. 2008. The exposure of green turtles (*Chelonia mydas*) to tumour promoting compounds produced by the cyanobacterium *Lyngbya majuscula* and their potential role in the aetiology of fibropapillomatosis. *Harmful Algae* 7(1):114-125.
- 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.
- Attard, C. R. M., and coauthors. 2012. Hybridization of Southern Hemisphere blue whale subspecies and a sympatric area off Antarctica: Impacts of whaling or climate change? *Molecular Ecology* 21(23):5715-5727.
- Au, W. W. L. 2000a. Hearing in whales and dolphins: an overview. Pages 1-42 in W. W. L. Au, A. N. Popper, and R. R. Fay, editors. *Hearing by Whales and Dolphins*. Springer-Verlag, New York.
- Au, W. W. L. 2000b. Hearing in whales and dolphins: an overview. Chapter 1 In: Au, W.W.L., A.N. Popper, and R.R. Fay (eds), *Hearing by Whales and Dolphins*. Springer-Verlag New York, Inc. pp.1-42.
- Au, W. W. L., and coauthors. 2006. Acoustic properties of humpback whale songs. *Journal of the Acoustical Society of America* 120(2):1103-1110.
- Avens, L., and L. R. Goshe. 2007. Skeletochronological analysis of age and growth for leatherback sea turtles in the western North Atlantic. Pages 223 in M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. *27th Annual Symposium on Sea Turtle Biology and Conservation*, Myrtle Beach, South Carolina.
- Avens, L., and L. R. Goshe. 2008. Skeletochronological analysis of age and growth for leatherback sea turtles in the western North Atlantic. Pages 223 in M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. *Twenty-Seventh Annual Symposium on Sea Turtle Biology and Conservation*, Myrtle Beach, South Carolina.
- Avens, L., and coauthors. 2013. Complementary skeletochronology and stable isotope analyses offer new insight into juvenile loggerhead sea turtle oceanic stage duration and growth dynamics. *Marine Ecology Progress Series* 491:235-251.
- Avens, L., J. C. Taylor, L. R. Goshe, T. T. Jones, and M. Hastings. 2009. Use of skeletochronological analysis to estimate the age of leatherback sea turtles *Dermochelys coriacea* in the western North Atlantic. *Endangered Species Research* 8(3):165-177.
- Backus, R. H. 1987. Geology. Pages 22-24 in R. H. Backus, editor. *George's Bank*. MIT Press, Cambridge, Massachusetts.
- Backus, R. H., and W. E. Schevill. 1966. Physeter clicks. Pages 510-528 in K. S. Norris, editor. *Whales, dolphins, and porpoises*. University of California Press, Berkeley, California.
- Bacon, C., M. A. Smultea, B. Würsig, K. Lomac-MacNair, and J. Black. 2011. Comparison of blue and fin whale behavior, headings and group characteristics in the southern California Bight during summer and fall 2008-2010. Pages 23 in *19th Biennial Conference on the Biology of Marine Mammals*, Tampa, Florida.
- Bailey, H., and coauthors. 2009. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. *Endangered Species Research* 10:93-106.
- Bain, D. E., and R. Williams. 2006. Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. *International Whaling Commission Working Paper SC/58/E35*.

- Baker, C. S., and L. M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. *Canadian Journal of Zoology* 65(11):2818-2821.
- Baker, C. S., L. M. Herman, B. G. Bays, and G. B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory.
- Baker, C. S., and coauthors. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. *Marine Ecology Progress Series* 494:291-306.
- Baker, J. D., C. L. Littnan, and D. W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. *Endangered Species Research* 4:1-10.
- Balazs, G. H. 1982. Growth rates of immature green turtles in the Hawaiian Archipelago. Pages 117-125 in K. A. Bjorndal, editor. *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington, D. C.
- Balazs, G. H. 1983. Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands. U.S. Department of Commerce, NOAA-TM-NMFS-SWFC-36.
- Balazs, G. H., and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. *Biological Conservation* 117(5):491-498.
- 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.
- Baldwin, R. M. 1992. Nesting turtles on Masirah Island: Management issues, options, and research requirements. Ministry of Regional Municipalities and Environment, Oman.
- 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.
- Barbieri, E. 2009. Concentration of heavy metals in tissues of green turtles (*Chelonia mydas*) sampled in the Cananea Estuary, Brazil. *Brazilian Journal of Oceanography* 57(3):243-248.
- Barco, S. a. W. M. S. 2014. Sea turtle species in the Coastal Waters of Virginia: Analysis of stranding and survey data. Virginia Aquarium and Marine Science Center Foundation.
- Barendse, J., P. B. Best, I. Carvalho, and C. Pomilla. 2013. Mother knows best: Occurrence and associations of resighted humpback whales suggest maternally derived fidelity to a Southern Hemisphere coastal feeding ground. *PLoS ONE* 8(12):e81238.
- Barlow, J. 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.
- Bartol, S. M., J. A. Musick, and M. Lenhardt. 1999. Evoked potentials of the loggerhead sea turtle (*Caretta caretta*). *Copeia* 1999(3):836-840.
- Barton, B. T., and J. D. Roth. 2008. Implications of intraguild predation for sea turtle nest protection. *Biological Conservation* 181(8):2139-2145.

- Bass, A. L., S. P. Epperly, J. Braun, D. W. Owens, and R. M. Patterson. 1998. Natal origin and sex ratios of foraging sea turtles in the Pamlico-Albemarle Estuarine Complex. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, NMFS-SEFSC-415, Miami, Florida.
- Bauer, G. B. 1986. The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions. University of Hawaii.
- Bauer, G. B., and L. M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Honolulu, Hawaii.
- Baulch, S., and C. Perry. 2014. Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin* 80(1-2):210-221.
- Baumgartner, M. F., T. V. N. Cole, P. J. Clapham, and B. R. Mate. 2003. North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. *Marine Ecology Progress Series* 264:137-154.
- Beale, C. M., and P. Monaghan. 2004. Behavioural responses to human disturbance: A matter of choice? *Animal Behaviour* 68(5):1065-1069.
- Beamish, P., and E. Mitchell. 1971. Ultrasonic sounds recorded in the presence of a blue whale *Balaenoptera musculus*. *Deep Sea Research and Oceanographic Abstracts* 18(8):803-809, +2pls.
- Beardsley, R. C., and coauthors. 1996. Spatial variability in zooplankton abundance near feeding right whales in the Great South Channel. *Deep-Sea Research* 43:1601-1625.
- Bell, L. A. J., U. Fa'anunu, and T. Koloa. 1994. Fisheries resources profiles: Kingdom of Tonga, Honiara, Solomon Islands.
- Bellido, J. J., and coauthors. 2010. Loggerhead strandings and captures along the southern Spanish Coast: Body size-based differences in natural versus anthropogenic injury. *Chelonian Conservation and Biology* 9(2):276-282.
- Ben-Haim, Y., and E. Rosenberg. 2002. A novel *Vibrio* sp. pathogen of the coral *Pocillopora damicornis*. *Marine Biology* 141:47-55.
- Benson, S. R., and coauthors. 2007a. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. *Chelonian Conservation and Biology* 6(1):150-154.
- Benson, S. R., and coauthors. 2011a. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2(7).
- Benson, S. R., and coauthors. 2011b. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2(7):art84.
- Benson, S. R., and coauthors. 2007b. Beach use, internesting movement, and migration of leatherback turtles, *Dermochelys coriacea*, nesting on the north coast of Papua New Guinea. *Chelonian Conservation and Biology* 6(1):7-14.
- Berchok, C. L., D. L. Bradley, and T. B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. *Journal of the Acoustical Society of America* 120(4):2340-2354.
- Bernardo, J., and P. T. Plotkin. 2007. An evolutionary perspective on the arribada phenomenon, and reproductive behavioral polymorphism of olive ridley sea turtles (*Lepidochelys olivacea*). Pages 59-87 in P. T. Plotkin, editor. *Biology and conservation of Ridley sea turtles*. Johns Hopkins University Press, Baltimore, Maryland.

- Bérubé, M., and coauthors. 1998. Population genetic structure of North Atlantic, Mediterranean and Sea of Cortez fin whales, *Balaenoptera physalus* (Linnaeus 1758): analysis of mitochondrial and nuclear loci. *Molecular Ecology* 7:585-599.
- Berube, M., and coauthors. 1999. Genetic analysis of the North Atlantic fin whale: Insights into migration patterns. *European Research on Cetaceans* 12:318.
- Berube, M., U. R. Jorge, A. E. Dizon, R. L. Brownell, and P. J. Palsbøll. 2002. Genetic identification of a small and highly isolated population of fin whales (*Balaenoptera physalus*) in the Sea of Cortez, Mexico. *Conservation Genetics* 3(2):183-190.
- Berzin, A. A. 1971. The sperm whale. *Pacific Sci. Res. Inst. Fisheries Oceanography*. Translation 1972, Israel Program for Scientific Translation No. 600707, Jerusalem: 1-394.
- Berzin, A. A. 1972. The sperm whale. Pacific Scientific Research Institute of Fisheries and Oceanography, Moscow. (Translated from Russian 1971 version by Israel Program for Scientific Translation, Jerusalem).
- Best, P. B., J. Bannister, R. L. Brownell, and G. Donovan. 2001a. Right whales: Worldwide status.
- Best, P. B., A. Branadão, and D. S. Butterworth. 2001b. Demographic parameters of southern right whales off South Africa. *Journal of Cetacean Research and Management (Special Issue 2)*:161-169.
- Best, P. B., P.A.S. Canham, and N. Macleod. 1984. Patterns of reproduction in sperm whales, *Physeter macrocephalus*. Report of the International Whaling Commission Special Issue 8:51-79.
- Biedron, I. S., C. W. Clark, and F. Wenzel. 2005. Counter-calling in North Atlantic right whales (*Eubalaena glacialis*). Pages 35 in Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
- Biggs, D. C., R. R. Leben, and J. G. Ortega-Ortiz. 2000. Ship and satellite studies of mesoscale circulation and sperm whale habitats in the northeast Gulf of Mexico during GulfCet II. *Gulf of Mexico Science* 2000(1):15-22.
- Binckley, C. A., J. R. Spotila, K. S. Wilson, and F. V. Paladino. 1998. Sex determination and sex ratios of Pacific leatherback turtles, *Dermochelys coriacea*. *Copeia* 2(291-300).
- Bjarti, T. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen.
- Bjorndal, K. A. 1982. The consequences of herbivory for the life history pattern of the Caribbean green turtle, *Chelonia mydas*. Pages 111-116 in K. A. Bjorndal, editor. *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington D.C.
- Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. Pages 199-231 in *The Biology of Sea Turtles*. CRC Press, Boca Raton, Florida.
- Bjorndal, K. A., and A. B. Bolten. 2000. Proceedings on a workshop on assessing abundance and trends for in-water sea turtle populations. NOAA.
- Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2000. Green turtle somatic growth model: evidence for density dependence. *Ecological Applications* 10(1):269-282.
- Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2003. Survival probability estimates for immature green turtles *Chelonia mydas* in the Bahamas. *Marine Ecology Progress Series* 252:273-281.

- Bjorndal, K. A., A. B. Bolten, and M. Y. Chaloupka. 2005. Evaluating trends in abundance of immature green turtles, *Chelonia mydas*, in the greater Caribbean. *Ecological Applications* 15(1):304-314.
- Bjorndal, K. A., and coauthors. 2013. Temporal, spatial, and body size effects on growth rates of loggerhead sea turtles (*Caretta caretta*) in the Northwest Atlantic. *Marine Biology* 160(10):2711-2721.
- Blackwell, S. B., and coauthors. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science* 29(4):E342-E365.
- Blanco, G. S., and coauthors. 2012. Post-nesting movements and feeding grounds of a resident East Pacific green turtle *Chelonia mydas* population from Costa Rica. *Endangered Species Research* 18(3):233-245.
- Bleakney, J. S. 1955. Four records of the Atlantic ridley turtle, *Lepidochelys kempi*, from Nova Scotian waters. *Copeia* 1955(2):137.
- Blunden, J., and D. S. Arndt. 2013. State of climate in 2013. *Bulletin of the American Meteorological Society* 95(7):S1-S257.
- Boebel, O., E. Burkhardt, and H. Bornemann. 2006. Risk assessment of Atlas hydrosweep and Parasound scientific echosounders. *EOS, Transactions, American Geophysical Union* 87(36).
- BOEM. 2012. Commercial wind lease issuance and site assessment activities on the Atlantic Outer Continental Shelf offshore New Jersey, Delaware, Maryland, and Virginia. Bureau of Ocean Energy Management.
- Boness, D. J., P. J. Clapham, and S. L. Mesnick. 2013. Effects of noise on acoustic signal production in marine mammals. Pages 251-271 in H. Brumm, editor. *Animal Communication and Noise*. Springer-Verlag, Berlin.
- Booman, C., and coauthors. 1996. Effekter av luftkanonskyting på egg, larver og yngel. *Fisken Og Havet* 1996(3):1-83.
- Borobia, M. P. J. G. Y. S. J. N. G., and P. Béland. 1995. Blubber fatty acids of finback, and humpback whales from the Gulf of St. Lawrence. *Marine Biology* 122:341-353.
- Borrell, A. 1993. PCB and DDTs in blubber of cetaceans from the northeastern North Atlantic. *Marine Pollution Bulletin* 26(3):146.
- Borrell, A., and A. Aguilar. 1987. Variations in DDE percentage correlated with total DDT burden in the blubber of fin and sei whales. *Marine Pollution Bulletin* 18:70-74.
- Bort, J. E., S. Todd, P. Stevick, S. Van Parijs, and E. Summers. 2011. North Atlantic right whale (*Eubalaena glacialis*) acoustic activity on a potential wintering ground in the Central Gulf of Maine. Pages 38 in 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.
- Bouchard, S., and coauthors. 1998. Effects of exposed pilings on sea turtle nesting activity at Melbourne Beach, Florida. *Journal of Coastal Research* 14(4):1343-1347.
- Bourgeois, S., E. Gilot-Fromont, A. Viallefont, F. Boussamba, and S. L. Deem. 2009. Influence of artificial lights, logs and erosion on leatherback sea turtle hatchling orientation at Pongara National Park, Gabon. *Biological Conservation* 142(1):85-93.
- Bowen, B. W., and coauthors. 2004. Natal homing in juvenile loggerhead turtles (*Caretta caretta*). *Molecular Ecology* 13:3797-3808.
- Bowen, B. W., A. L. Bass, L. Soares, and R. J. Toonen. 2005. Conservation implications of complex population structure lessons from the loggerhead turtle (*Caretta caretta*). *Molecular Ecology* 14:2389-2402.

- Bowlby, C. E., G. A. Green, and M. L. Bonnell. 1994. Observations of leatherback turtles offshore of Washington and Oregon. *Northwestern Naturalist* 75:33-35.
- Bowles, A. E., M. Smultea, B. Würsig, D. P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustic Society of America* 96(4):2469–2484.
- Boyd, I. L. 2002. Antarctic marine mammals. Pages 30-36 in W. F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. *Encyclopedia of Marine Mammals*. Academic Press, San Diego, California.
- Boyd, I. L., C. Lockyer, and H. D. Marsh. 1999. Reproduction in marine mammals. J. E. Reynolds III, and S. A. Rommel, editors. *Biology of Marine Mammals*. Smithsonian Institution Press, Washington, D.C.
- 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.
- Braham, H. W. 1991. *Endangered Whales: A Status Update*. A report on the 5-year status of stocks review under the 1978 amendments to the U.S. Endangered Species Act.:National Marine Mammal Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service. Seattle, Washington. 56p.
- Branch, T. A., and Y. A. Mikhalev. 2008. Regional differences in length at sexual maturity for female blue whales based on recovered Soviet whaling data. *Marine Mammal Science* 24(3):690-703.
- 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.
- Bräutigam, A., and K. L. Eckert. 2006. *Turning the tide: Exploitation, trade, and management of marine turtles in the Lesser Antilles, Central America, Colombia, and Venezuela*. TRAFFIC International, Cambridge, United Kingdom.
- Breitzke, M., O. Boebel, S. El Nagggar, W. Jokat, and B. Werner. 2008. Broad-band calibration of marine seismic sources used by R/V *Polarstern* for academic research in polar regions. *Geophysical Journal International* 174:505-524.
- Brito, C., N. Vleira, E. Sa, and I. Carvalho. 2009. Cetaceans' occurrence off the west central Portugal coast: A compilation of data from whaling, observations of opportunity and boat-based surveys. *Journal of Marine Animals and Their Ecology* 2(1):10-13.
- Brito, J. L. 1998. The marine turtle situation in Chile. Pages 12-15 in S. P. Epperly, and J. Braun, editors. *Seventeenth Annual Symposium on Sea Turtle Biology and Conservation*. .
- Brock, K. A., J. S. Reece, and L. M. Ehrhart. 2009. The effects of artificial beach nourishment on marine turtles: Differences between loggerhead and green turtles. *Restoration Ecology* 17(2):297-307.
- Broderick, A., and coauthors. 2006. Are green turtles globally endangered? *Global Ecology and Biogeography* 15:21-26.
- 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., and coauthors. 2001. Sighting heterogeneity of right whales in the western North Atlantic: 1980-1992. *Journal of Cetacean Research and Management (Special Issue)* 2:245-250.
- Browning, C. L., R. M. Rolland, and S. D. Kraus. 2009. Estimated calf and perinatal mortality in western North Atlantic right whales (*Eubalaena glacialis*). *Marine Mammal Science* 26(3):648-662.
- Buchanan, R. A., J. R. Christian, S. Dufault, and V. D. Moulton. 2004. Impacts of underwater noise on threatened or endangered species in United States waters. American Petroleum Institute, LGL Report SA791, Washington, D.C.
- Buckland, S. T., K. L. Cattanach, and S. Lens. 1992. Fin whale abundance in the eastern North Atlantic, estimated from Spanish NASS-89 data. Report of the International Whaling Commission 42:457-460.
- Bugoni, L., L. Krause, and M. V. Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. *Marine Pollution Bulletin* 42(12):1330-1334.
- Burchfield, P. M. 2010. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamualipas, Mexico. 2009. Gladys Porter Zoo.
- Burke, V. J., E. A. Standora, and S. J. Morreale. 1991. Factors affecting strandings of cold-stunned juvenile Kemp's ridley and loggerhead sea turtles in Long Island, New York. *Copeia* 1991(4):1136-1138.
- Burkhardt, E., O. Boebel, H. Bornemann, and C. Ruholl. 2013. Risk assessment of scientific sonars. *Bioacoustics* 17:235-237.
- Burreson, E. M., and S. E. Ford. 2004. A review of recent information on the Haplosporidia, with special reference to *Haplosporidium nelsoni* (MSX disease). *Aquatic Living Resources* 17(4):499-517.
- Burreson, E. M., N. A. Stokes, and C. S. Friedman. 2000. Increased Virulence in an Introduced Pathogen: *Haplosporidium nelsoni* (MSX) in the Eastern Oyster *Crassostrea virginica*. *Journal of Aquatic Animal Health* 12(1):1-8.
- Burtenshaw, J. C., and coauthors. 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep-Sea Research II* 51:967-986.
- 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(12):2844-2853.
- Byles, R. A. 1988. The behavior and ecology of sea turtles, *Caretta caretta* and *Lepidochelys kempi*, in the Chesapeake Bay. College of William and Mary, Williamsburg, Virginia.
- Byles, R. A. 1989a. Distribution, and abundance of Kemp's ridley sea turtle, *Lepidochelys kempii*, in Chesapeake Bay and nearby coastal waters. Pages 145 in C. W. Caillouet Jr., and A. M. Landry Jr., editors. First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management.
- Byles, R. A. 1989b. Satellite telemetry of Kemp's ridley sea turtle *Lepidochelys kempii* in the Gulf of Mexico. Pages 25-26 in S. A. Eckert, K. L. Eckert, and T. H. Richardson, editors. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.
- Byles, R. A., and P. T. Plotkin. 1994. Comparison of the migratory behavior of the congeneric sea turtles *Lepidochelys olivacea* and *L. kempii*. Pages 39 in B. A. Schroeder, and B. E.

- Witherington, editors. Thirteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Byrne, R., J. Fish, T. K. Doyle, and J. D. R. Houghton. 2009. Tracking leatherback turtles (*Dermochelys coriacea*) during consecutive inter-nesting intervals: Further support for direct transmitter attachment. *Journal of Experimental Marine Biology and Ecology* 377(2):68-75.
- Caillouet, C. C., T. Fontaine, S. A. Manzella-Tirpak, and T. D. Williams. 1995. Growth of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) following release. *Chelonian Conservation and Biology* 1:231-234.
- Caillouet Jr., C. W., C. T. Fontaine, S. A. Manzella-Tirpak, and T. D. Williams. 1995. Growth of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) following release. *Chelonian Conservation and Biology* 1(3):231-234.
- Caldwell, J., and W. Dragoset. 2000. A brief overview of seismic air-gun arrays. *The Leading Edge* 19(8):898-902.
- Camacho, M., and coauthors. 2012. Comparative study of polycyclic aromatic hydrocarbons (PAHs) in plasma of Eastern Atlantic juvenile and adult nesting loggerhead sea turtles (*Caretta caretta*). *Marine Pollution Bulletin* 64(9):1974-1980.
- Campani, T., and coauthors. 2013. Presence of plastic debris in loggerhead turtle stranded along the Tuscany coasts of the Pelagos Sanctuary for Mediterranean Marine Mammals (Italy). *Marine Pollution Bulletin* 74(1):225-230.
- Campbell, C. L., and C. J. Lagueux. 2005. Survival probability estimates for large juvenile and adult green turtles (*Chelonia mydas*) exposed to an artisanal marine turtle fishery in the western Caribbean. *Herpetologica* 61:91-103.
- Cannon, A. C., and J. P. Flanagan. 1996. Trauma and treatment of Kemp's ridley sea turtles caught on hook-and-line by recreational fisherman. *Sea Turtles Biology and Conservation Workshop*.
- Carder, D. A., and S. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale. *Journal of the Acoustic Society of America* 88(Supplement 1):S4.
- 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.
- Cardona, L., A. Aguilar, and L. Pazos. 2009. Delayed ontogenic dietary shift and high levels of omnivory in green turtles (*Chelonia mydas*) from the NW coast of Africa. *Marine Biology* 156(7):1487-1495.
- Cardona, L., P. Campos, Y. Levy, A. Demetropoulos, and D. Margaritoulis. 2010. Asynchrony between dietary and nutritional shifts during the ontogeny of green turtles (*Chelonia mydas*) in the Mediterranean. *Journal of Experimental Marine Biology and Ecology* in press(in press):in press.
- Carr, A., and D. K. Caldwell. 1956. The ecology, and migrations of sea turtles: 1. Results of field work in Florida, 1955. *American Museum Novitates* 1793:1-23.
- Carr, A., M. H. Carr, and A. B. Meylan. 1978. The ecology and migration of sea turtles, 7. the west Caribbean turtle colony. *Bulletin of the American Museum of Natural History, New York* 162(1):1-46.
- Carr, A. F. 1986. RIPS, FADS, and little loggerheads. *BioScience* 36(2):92-100.

- Carretta, J. V., and K. A. Forney. 1993. Report of the two aerial surveys for marine mammals in California coastal waters utilizing a NOAA DeHavilland twin otter aircraft: March 9-April 7, 1991 and February 8-April 6, 1992. NMFS, SWFSC.
- Carretta, J. V., and coauthors. 2005. U.S. Pacific Marine Mammal Stock Assessments - 2004. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-375, 322p.
- Casale, P., P. P. D'Astore, and R. Argano. 2009a. Age at size and growth rates of early juvenile loggerhead sea turtles (*Caretta caretta*) in the Mediterranean based on length frequency analysis. *Herpetological Journal* 19(1):29-33.
- Casale, P., A. D. Mazaris, D. Freggi, C. Vallini, and R. Argano. 2009b. Growth rates and age at adult size of loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea, estimated through capture-mark-recapture records. *Scientia Marina* 73(3):589-595.
- Castellote, M., C. W. Clark, and M. O. Lammers. 2010. Population identity and migration movements of fin whales (*Balaenoptera physalus*) in the Mediterranean Sea and Strait of Gibraltar. IWC Scientific Committee, Agadir, Morocco.
- Castellote, M., C. W. Clark, and M. O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation*.
- Caswell, H., M. Fujiwara, and S. Brault. 1999. Declining survival probability threatens the North Atlantic right whales. *Proceedings of the National Academy of Sciences of the United States of America*. 96:3308-3313.
- Cattanach, K. L., J. Sigurjónsson, S. T. Buckland, and T. Gunnlaugsson. 1993. Sei whale abundance in the North Atlantic estimated from NASS-87 and NASS-89 data. Report of the International Whaling Commission 43:315-321.
- Cattet, M. R. L., K. Christison, N. A. Caulkett, and G. B. Stenhouse. 2003. Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases* 39(3):649-654.
- Caurant, F., P. Bustamante, M. Bordes, and P. Miramand. 1999. Bioaccumulation of cadmium, copper and zinc in some tissues of three species of marine turtles stranded along the French Atlantic coasts. *Marine Pollution Bulletin* 38(12):1085-1091.
- Caut, S., E. Guirlet, and M. Girondot. 2009a. Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. *Marine Environmental Research* 69(4):254-261.
- Caut, S., E. Guirlet, and M. Girondot. 2009b. Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. *Marine Environmental Research* in press(in press):in press.
- Celik, A., and coauthors. 2006. Heavy metal monitoring around the nesting environment of green sea turtles in Turkey. *Water Air and Soil Pollution* 169(1-4):67-79.
- 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., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. *PLoS ONE* 9(3):e86464.
- CETAP. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Cetacean and Turtle Assessment Program,

- University of Rhode Island. Final Report #AA551-CT8-48 to the Bureau of Land Management, Washington, DC, 538 pp.
- Chacón Chaverri, D. 1999. Anidación de la tortuga *Dermochelys coriacea* (Testudines: Dermochelyidae) en playa Gandoca, Costa Rica (1990 a 1997). *Revista de Biología Tropical* 47(1-2):225-236.
- Chaloupka, M. 2001. Historical trends, seasonality, and spatial synchrony in green sea turtle egg production. *Biological Conservation* 101:263-279.
- Chaloupka, M., and coauthors. 2008a. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. *Global Ecology and Biogeography* 17(2):297-304.
- Chaloupka, M., and C. Limpus. 2005. Estimates of sex- and age-class-specific survival probabilities for a southern Great Barrier Reef green sea turtle population. *Marine Biology* 146:1251-1261.
- Chaloupka, M., C. Limpus, and J. Miller. 2004. Green turtle somatic growth dynamics in a spatially disjunct Great Barrier Reef metapopulation. *Coral Reefs* 23:325-335.
- Chaloupka, M. Y., N. Kamezaki, and C. Limpus. 2008b. Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? *Journal of Experimental Marine Biology and Ecology* 356(1-2):136-143.
- Chaloupka, M. Y., and J. A. Musick. 1997. Age, growth, and population dynamics. Pages 233-273 in P. L. Lutz, and J. A. Musick, editors. *The biology of sea turtles*. CRC Press, Boca Raton, Florida.
- Chapman, C. J., and A. D. Hawkins. 1969. The importance of sound in fish behaviour in relation to capture by trawls. *FAO Fisheries Report* 62(3):717-729.
- Chen, T. L., and coauthors. 2009. Particulate hexavalent chromium is cytotoxic and genotoxic to the North Atlantic right whale (*Eubalaena glacialis*) lung and skin fibroblasts. *Environmental and Molecular Mutagenesis* 50(5):387-393.
- Chen, Z., and G. Yang. 2010. Novel CHR-2 SINE subfamilies and t-SINEs identified in cetaceans using nonradioactive southern blotting. *Genes and Genomics* 32(4):345-352.
- Cheng, I. J., and coauthors. 2009. Ten Years of Monitoring the Nesting Ecology of the Green Turtle, *Chelonia mydas*, on Lanyu (Orchid Island), Taiwan. *Zoological Studies* 48(1):83-94.
- Cherfas, J. 1989a. *The hunting of the whale*. Viking Penguin Inc., N.Y., 248p.
- Cherfas, J. 1989b. *The Hunting of the Whale*. Viking Penguin Inc., New York, New York.
- 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.
- Chiquet, R. A., B. Ma, A. S. Ackleh, N. Pal, and N. Sidorovskaia. 2013. Demographic analysis of sperm whales using matrix population models. *Ecological Modelling* 248:71-79.
- Christal, J., and H. Whitehead. 1997. Aggregations of mature male sperm whales on the Galápagos Islands breeding ground. *Marine Mammal Science* 13(1):59-69.
- Christal, J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: variation and change. *Canadian Journal of Zoology* 76:1431-1440.
- Christensen, I., T. Haug, and N. Øien. 1992a. A review of feeding, and reproduction in large baleen whales (Mysticeti) and sperm whales *Physeter macrocephalus* in Norwegian and adjacent waters. *Fauna Norvegica Series A* 13:39-48.
- Christensen, I., T. Haug, and N. Øien. 1992b. Seasonal distribution, exploitation and present abundance of stocks of large baleen whales (Mysticeti) and sperm whales (*Physeter*

- macrocephalus*) in Norwegian and adjacent waters. ICES Journal of Marine Science 49:341-355.
- Ciguarria, J., and R. Elston. 1997. Independent introduction of *Bonamia ostreae*, a parasite of *Ostrea edulis*, to Spain. Diseases of Aquatic Organisms 29:157-158.
- Clapham, P. J. 1994. Maturation 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. 2002. Are ship-strikes mortalities affecting the recovery of the endangered whale populations off North America? European Cetacean Society Newsletter (special issue) 40:13-15.
- 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 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. 2006. Acoustic communication in the great whales: The medium and the message. 86th Annual Conference of the American Society of Mammalogists.
- Clark, C. W. 1995. Matters arising out of the discussion of blue whales. Annex M1. Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. Report of the International Whaling Commission, Annex M 45:210-212.
- Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: evidence from models and empirical measurements. Pp.564-582 In: J.A. Thomas, C.F. Moss, and M. Vater (Editors), Echolocation in Bats and Dolphins. University of Chicago Press, Chicago, Illinois.
- Clark, C. W., and W. T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Echolocation in Bats and Dolphins. Jeanette A. Thomas, Cynthia F. Moss and Marianne Vater. University of Chicago Press. p.564-582.
- Clark, C. W., and G. C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales.
- Clarke, C. W., and R. A. Charif. 1998a. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997.
- Clarke, C. W., and R. A. Charif. 1998b. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997. JNCC Report No. 281.

- 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.
- Clarke, M. R. 1977. Beaks, nets and numbers. *Symposium of the Zoological Society of London* 38:89-126.
- Clarke, M. R. 1980a. Cephalopods in the diet of sperm whales of the Southern Hemisphere and their bearing on sperm whale biology. *Discovery Reports* 37.
- Clarke, M. R. 1996. Cephalopods as prey. III. Cetaceans. *Philosophical Transactions of the Royal Society of London B* 351:1053-1065.
- Clarke, M. R. 1997. Cephalopods in the stomach of a sperm whale stranded between the islands of Terschelling and Ameland, southern North Sea. *Bulletin de L'Institut Royal des Sciences Naturelles de Belgique, Biologie* 67-Suppl.:53-55.
- Clarke, R. 1956. Sperm whales of the Azores. *Discovery Reports* 28:237-298.
- Clarke, R. 1980b. Catches of sperm whales and whalebone whales in the southeast Pacific between 1908 and 1975. *Report of the International Whaling Commission* 30:285-288.
- Clavero, M., and E. Garcia-Berthou. 2005. Invasive species are a leading cause of animal extinctions. *Trends in Ecology and Evolution* 20(3):110.
- Cohen, A. N., and B. Foster. 2000. The regulation of biological pollution: Preventing exotic species invasions from ballast water discharged into California coastal waters. *Golden Gate University Law Review* 30(4):787-773.
- Cole, A. J., K. M. C. Seng, M. S. Pratchett, and G. P. Jones. 2009. Coral-feeding fishes slow progression of black-band disease. *Coral Reefs* 28:965.
- Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005a. Mortality and serious injury determinations for large whales stocks along the eastern seaboard of the United States, 1999-2003. NOAA Northeast Fisheries Science Center 05-08.
- Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005b. Mortality and serious injury determinations for North Atlantic Ocean large whale stocks 1999-2003. U.S. Department of Commerce, NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, 05-08, Woods Hole, MA.
- Cole, T. V. N., D. L. Hartley, and R. L. Merrick. 2005c. 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.
- Collard, S. B. 1990. Leatherback turtles feeding near a watermass boundary in the eastern Gulf of Mexico. *Marine Turtle Newsletter* 50:12-14.
- Conant, T. A., and coauthors. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- Conversi, A., S. Piontkovski, and S. Hameed. 2001a. 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 II* 48:519-530.
- Conversi, A., S. Piontkovski, and S. Hameed. 2001b. 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.

- Conway, C. A. 2005. Global population structure of blue whales, *Balaenoptera musculus* spp., based on nuclear genetic variation. University of California, Davis.
- Cooper, R. A., P. Valentine, J. R. Uzzmann, and R. A. Slater. 1987. Submarine canyons. Pages 52-63 in R. H. Backus, editor. George's Bank. MIT Press, Cambridge, Massachusetts.
- Corkeron, P., P. Ensor, and K. Matsuoka. 1999. Observations of blue whales feeding in Antarctic waters. *Polar Biology* 22:213-215.
- Corsolini, S., A. Aurigi, and S. Focardi. 2000. Presence of polychlorobiphenyls (PCBs), and coplanar congeners in the tissues of the Mediterranean loggerhead turtle *Caretta caretta*. *Marine Pollution Bulletin* 40(11):952-960.
- COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale *Balaenoptera musculus* (Atlantic population, Pacific population) in Canada. COSEWIC, Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37p. Available at: www.sararegistry.gc.ca/status/status_e.cfm.
- COSEWIC. 2005. COSEWIC assessment and update status report on the fin whale *Balaenoptera physalus* (Pacific population, Atlantic population) in Canada. COSEWIC, Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37p. Available at: www.sararegistry.gc.ca/status/status_e.cfm.
- COSEWIC. 2011. COSEWIC assessment and status report on the humpback whale *Megaptera novaeangliae* North Pacific population in Canada. COSEWIC Committee on the Status of Endangered Wildlife in Canada.
- Cotte, C., C. Guinet, I. Taupier-Letage, B. Mate, and E. Petiau. 2009. Scale-dependent habitat use by a large free-ranging predator, the Mediterranean fin whale. *Deep Sea Research Part I* 56(5):801-811.
- 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.
- Cowan, E., and coauthors. 2002. Influence of filtered roadway lighting on the seaward orientation of hatchling sea turtles. Pages 295-298 in A. Mosier, A. Foley, and B. Brost, editors. Twentieth Annual Symposium on Sea Turtle Biology and Conservation.
- Coyne, M., and A. M. Landry Jr. 2007. Population sex ratios, and its impact on population models. Pages 191-211 in P. T. Plotkin, editor. *Biology and conservation of Ridley sea turtles*. Johns Hopkins University Press, Baltimore, MD.
- Coyne, M., A. M. Landry Jr., D. T. Costa, and B. B. Williams. 1995. Habitat preference, and feeding ecology of the green sea turtle (*Chelonia mydas*) in south Texas waters. Pages 21-24 in J. I. Richardson, and T. H. Richardson, editors. Twelfth Annual Workshop on Sea Turtle Biology and Conservation.
- Cranford, T. W. 1992. Functional morphology of the odontocete forehead: implications for sound generation. University of California at Santa Cruz, Santa Cruz, California.

- Crognale, M. A., S. A. Eckert, D. H. Levenson, and C. A. Harms. 2008. Leatherback sea turtle *Dermochelys coriacea* visual capacities and potential reduction of bycatch by pelagic longline fisheries. *Endangered Species Research* 5:249-256.
- Croll, D. A., and coauthors. 2002. Only male fin whales sing loud songs. *Nature* 417:809.
- Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical report for LFA EIS, 28 February 1999. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz. 437p.
- Crone, T. J., M. Tolstoy, and H. Carton. 2014. Estimating shallow water sound power levels and mitigation radii for the R/V Marcus G. Langseth using an 8 km long MCS streamer. *Geochemistry, Geophysics, Geosystems* 15:3793-3807.
- Crouse, O. T., L. B. Crowder, and H. Caswell. 1987. A site based population model for loggerhead sea turtles and implications for conservation. *Ecology* 68(5):1412-1423.
- Cummings, W. C. 1985. Right whales--*Eubalaena glacialis*, and *Eubalaena australis*. Pages 275-304 in S. H. Ridgway, and R. Harrison, editors. *The Sirenians and Baleen Whales*, volume 3. Academic Press, New York, New York.
- Cummings, W. C., J. F. Fish, and P. O. Thompson. 1972. Sound production and other behaviour of southern right whales, *Eubalaena glacialis*. *Transactions of the San Diego Society of Natural History* 17(1):1-14.
- Cummings, W. C., and P. O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. *Journal of the Acoustical Society of America* 50(4B):1193-1198.
- Cummings, W. C., and P. O. Thompson. 1977. Long 20-Hz sounds from blue whales in the northeast Pacific. Pages 73 in *Second Biennial Conference on the Biology of Marine Mammals*, San Diego, California.
- Cummings, W. C., and P. O. Thompson. 1994. Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. *Journal of the Acoustical Society of America* 95:2853.
- 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.
- Dalen, J., and G. M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Pp.93-102 In: H.M. Merklinger (Ed), *Progress in Underwater Acoustics*. Plenum, New York. 839p.
- 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.
- Davenport, J., and G. H. Balazs. 1991. "Fiery bodies" – are pyrosomas an important component of the diet of leatherback turtles? *The British Herpetological Society Bulletin* 31:33-38.
- Davenport, J., J. Wrench, J. McEvoy, and V. Carnacho-Ibar. 1990. Metal and PCB concentrations in the "Harlech" leatherback. *Marine Turtle Newsletter* 48:1-6.
- Davies, K. T. A., C. T. Taggart, and R. K. Smedbol. 2014. Water mass structure defines the diapausing copepod distribution in a right whale habitat on the Scotian Shelf. *Marine Ecology Progress Series* 497:69-85.
- Davis, R. W., W. E. Evans, and B. Würsig. 2000a. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume I:

- Executive Summary. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-02. 40p.
- Davis, R. W., W. E. Evans, and B. Würsig. 2000b. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume II: Technical Report. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-03. 364p.
- Davis, R. W., W. E. Evans, and B. Würsig. 2000c. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume III: Data Appendix. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-04. 229p.
- Davis, R. W., and coauthors. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. Deep Sea Research, Part 1: Oceanographic Research Papers 49(1):121-142.
- de Stephanis, R., J. Giménez, E. Carpinelli, C. Gutierrez-Exposito, and A. Cañadas. 2013. As main meal for sperm whales: Plastics debris. Marine Pollution Bulletin.
- De Weede, R. E. 1996. The impact of seaweed introductions on biodiversity. Global Biodiversity 6:2-9.
- Deem, S. L., and coauthors. 2007. Artificial lights as a significant cause of morbidity of leatherback sea turtles in Pongara National Park, Gabon. Marine Turtle Newsletter 116:15-17.
- Deem, S. L., and coauthors. 2009. COMPARISON OF BLOOD VALUES IN FORAGING, NESTING, AND STRANDED LOGGERHEAD TURTLES (*CARETTA CARETTA*) ALONG THE COAST OF GEORGIA, USA. journal of wildlife diseases 45(1):41-56.
- Deng, Z. D., and coauthors. 2014. 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. PLoS ONE 9(4):e95315.
- DeRuiter, S. L., and K. Larbi Doukara. 2012. Loggerhead turtles dive in response to airgun sound exposure. Endangered Species Research 16(1):55-63.
- DFO. 2004. Review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. Department of Fisheries and Oceans, Canada. Habitat Status Report 2004/002. 15p.
- Dickens, M. J., D. J. Delehanty, and L. M. Romero. 2010. Stress: An inevitable component of animal translocation. Biological Conservation 143(6):1329-1341.
- Dickerson, D., and coauthors. 2007. Effectiveness of relocation trawling during dredging for reducing incidental take of sea turtles. Pages 509-530 in World Dredging Congress.
- Diebold, J. B., and coauthors. 2010. *R/V Marcus G. Langseth* seismic source: Modeling and calibration. Geochemistry Geophysics Geosystems 10(12):Q12012.
- Dierauf, L., and F. Gulland. 2001a. CRC Handbook of Marine Mammal Medicine. CRC Press, Boca Raton, Florida.
- Dierauf, L. A., and F. M. D. Gulland. 2001b. CRC Handbook of Marine Mammal Medicine, Second Edition edition. CRC Press, Boca Raton, Florida.
- Diez, C. E., and coauthors. 2010. Caribbean leatherbacks: results of nesting seasons from 1984-2008 at Culebra Island, Puerto Rico. Marine Turtle Newsletter 127:22-23.
- DOC. 1983. Draft management plan and environmental impact statement for the proposed Hawaii Humpback Whale National Marine Sanctuary. Prepared by the NOAA Office of

- Ocean and Coastal Resource Management and the State of Hawaii. U.S. Department of Commerce.
- Dodd, C. K. 1988a. Synopsis of the biological data on the loggerhead sea turtle: *Caretta caretta* (Linnaeus 1758). Fish and Wildlife Service Biological Report 88(14):110.
- Dodd, C. K. J. 1988b. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). USFWS Biological Report 88(14):110 pp.
- Dodd Jr., C. K. 1988. Synopsis of the biological data on the loggerhead sea turtle, *Caretta caretta* (Linnaeus 1758).
- Dow, W. E., D. A. Mann, T. T. Jones, S. A. Eckert, and C. A. Harms. 2008. In-water and in-air hearing sensitivity of the green sea turtle (*Chelonia mydas*). 2nd International Conference on Acoustic Communication by Animals, Corvallis, OR.
- Drake, L. A., K.-H. Choi, G. M. Ruiz, and F. C. Dobbs. 2001. Global redistribution of bacterioplankton and virioplankton communities. *Biological Invasions* 3:193-199.
- Drinkwater, K. F., and coauthors. 2003. The Response of marine ecosystems to climate variability associated with the North Atlantic Oscillation. Pages 211-234 in *The North Atlantic Oscillation: Climatic Significance and Environmental Impact*. American Geophysical Union.
- Druon, J.-N., and coauthors. 2012. Potential feeding habitat of fin whales in the western Mediterranean Sea: An environmental niche model. *Marine Ecology Progress Series* 464:289-306.
- Dufault, S., H. Whitehead, and M. Dillon. 1999. An examination of the current knowledge on the stock structure of sperm whales (*Physeter macrocephalus*) worldwide. *Journal of Cetacean Research and Management* 1(1):1-10.
- Dunlop, R., D. H. Cato, M. J. Noad, and D. M. Stokes. 2013. Source levels of social sounds in migrating humpback whales (*Megaptera novaeangliae*). *Journal of the Acoustical Society of America* 134(1):706-714.
- Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). *Marine Mammal Science* 24(3):613-629.
- Dunlop, R. A., D. H. Cato, and M. J. Noad. 2010. 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. 2014a. Evidence of a Lombard response in migrating humpback whales (*Megaptera novaeangliae*). *Journal of the Acoustical Society of America* 136(1):430-437.
- Dunlop, R. A., M. J. Noad, R. McCauley, E. Kruest, and D. H. Cato. 2014b. The behavioural response of humpback whales (*Megaptera novaeangliae*) to a small seismic air gun. Pages 23 in *Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014)*, Amsterdam, The Netherlands.
- Dutton, D. L., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). *Journal of Zoology* 248:397-409.
- Dutton, D. L., P. H. Dutton, M. Chaloupka, and R. H. Boulon. 2005. Increase of a Caribbean leatherback turtle *Dermochelys coriacea* nesting population linked to long-term nest protection. *Biological Conservation* 126(2):186-194.

- Dutton, P. H., and coauthors. 2013. Population stock structure of leatherback turtles (*Dermochelys coriacea*) in the Atlantic revealed using mtDNA and microsatellite markers. *Conservation Genetics* 14:625-636.
- Dwyer, C. M. 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress? *Animal Welfare* 13(3):269-281.
- Eckert, K. L., B. P. Wallace, J. G. Frazier, S. A. Eckert, and P. C. H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). U.S. Fish and Wildlife Service.
- Eckert, S. A. 1998. Perspectives on the use of satellite telemetry and electronic technologies for the study of marine turtles, with reference to the first year long tracking of leatherback sea turtles. Pages 44-46 in S. P. Epperly, and J. Braun, editors. 17th Annual Symposium on Sea Turtle Biology and Conservation.
- Eckert, S. A. 1999. Data acquisition systems for monitoring sea turtle behavior and physiology. Pages 88-93 in K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly, editors. *Research and Management Techniques for the Conservation of Sea Turtles*. UCN/SSC Marine Turtle Specialist Group Publication No. 4.
- Eckert, S. A. 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. *Marine Ecology Progress Series* 230:289-293.
- Eckert, S. A. 2006. High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. *Marine Biology* 149(5):1257-1267.
- Eckert, S. A., D. Bagley, S. Kubis, L. Ehrhart, and C. Johnson. 2006. Internesting and postnesting movements and foraging habitats of leatherback sea turtles (*Dermochelys coriacea*) nesting in Florida. *Chelonian Conservation and Biology* 5(2):239-248.
- Edds-Walton, P. L. 1997a. Acoustic communication signals of mysticete whales. *Bioacoustics: The International Journal of Animal Sound and its Recording* 8:47-60.
- Edds-Walton, P. L. 1997b. Acoustic communication signals of mysticete whales. *Bioacoustics* 8:47-60.
- Edds, P. L. 1982. Vocalizations of the blue whale, *Balaenoptera musculus*, in the St. Lawrence River. *Journal of Mammalogy* 63(2):345-347.
- Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. *Bioacoustics* 1:131-149.
- 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.
- Eguchi, T., P. H. Dutton, S. A. Garner, and J. Alexander-Garner. 2006. Estimating juvenile survival rates and age at first nesting of leatherback turtles at St. Croix, U.S. Virgin Islands. Pages 292-293 in M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. *Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation*. International Sea Turtle Society, Athens, Greece.
- Ehrhart, L. M., D. A. Bagley, and W. E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: Geographic distribution, abundance, and population status. Pages 157-174 in A. B. Bolten, and B. E. Witherington, editors. *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Ehrhart, L. M., W. E. Redfoot, and D. A. Bagley. 2007. Marine turtles of the central region of the Indian River Lagoon System, Florida. *Florida Scientist* 70(4):415-434.

- 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.
- Elftman, M. D., C. C. Norbury, R. H. Bonneau, and M. E. Truckenmiller. 2007. Corticosterone impairs dendritic cell maturation and function. *Immunology* 122(2):279-290.
- Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology* 26(1):21-28.
- Engås, A., S. Løkkeborg, E. Ona, and A. Vold Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53:2238-2249.
- Engås, A., S. Løkkeborg, A. V. Soldal, and E. Ona. 1993. Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. *Journal of Northwest Atlantic Fisheries Science* 19:83-90.
- Epperly, S., and coauthors. 2002. Analysis of sea turtle bycatch in the commercial shrimp fisheries of southeast U.S. waters and the Gulf of Mexico. U.S. Department of Commerce NMFS-SEFSC-490.
- Epperly, S. P., J. Braun, and A. J. Chester. 1995a. Aerial surveys for sea turtles in North Carolina inshore waters. Beaufort Laboratory, Southeast Fisheries Science Center, National Marine Fisheries Service, Beaufort, North Carolina.
- Epperly, S. P., and coauthors. 1995b. Winter distribution of sea turtles in the vicinity of Cape Hatteras and their interactions with the summer flounder trawl fishery. *Bulletin of Marine Science* 56(2):547-568.
- Epperly, S. P., J. Braun, and A. Veishlow. 1995c. Sea turtles in North Carolina waters. *Conservation Biology* 9(2):384-394.
- Erbe, C. 2002a. Hearing abilities of baleen whales. Contractor Report DRDC Atlantic CR 2002-065. Defence R&D Canada, Queensland, Australia. 40p.
- Erbe, C. 2002b. Hearing abilities of baleen whales. Defence R&D Canada – Atlantic report CR 2002-065. Contract Number: W7707-01-0828. 40pp.
- Eriksen, N., and B. Pakkenberg. 2013. Anthropogenic noise and conservation. Pages 409-444 in H. Brumm, editor. *Animal Communication and Noise*. Springer-Verlag, Berlin.
- Evans, K., M. A. Hindell, and G. Hince. 2004. Concentrations of organochlorines in sperm whales (*Physeter macrocephalus*) from Southern Australian waters. *Marine Pollution Bulletin* 48:486-503.
- Evans, P. G. H. 1998. Biology of cetaceans of the North-east Atlantic (in relation to seismic energy). Chapter 5 *In*: Tasker, M.L. and C. Weir (eds), *Proceedings of the Seismic and Marine Mammals Workshop*, London 23-25 June 1998. Sponsored by the Atlantic Margin Joint Industry Group (AMJIG) and endorsed by the UK Department of Trade and Industry and the UK's Joint Nature Conservation Committee (JNCC).
- Falk, M. R., and M. J. Lawrence. 1973. Seismic exploration: Its nature and effects on fish. Department of the Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, Canada.
- Fauquier, D. A., and coauthors. 2013. Brevetoxin in blood, biological fluids, and tissues of sea turtles naturally exposed to *Okarenia brevis* blooms in central west Florida. *Journal of Zoo and Wildlife Medicine* 44(2):364-375.

- Ferraroli, S., J. Y. Georges, P. Gaspar, and Y. L. Maho. 2004. Where leatherback turtles meet fisheries. *Nature* 429:521-522.
- FFWCC. 2007a. Florida statewide nesting beach survey data–2005 season. Florida Fish and Wildlife Conservation Commission.
- FFWCC. 2007b. Long-term monitoring program reveals a continuing loggerhead decline, increases in green turtle and leatherback nesting. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute.
- Fiedler, P., and coauthors. 1998. Blue whale habitat and prey in the Channel Islands. *Deep-Sea Research II* 45:1781-1801.
- 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.
- Finkbeiner, E. M., and coauthors. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. *Biological Conservation*.
- Finneran, J. J., and C. E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 133(3):1819-1826.
- Fisherman's Energy of New Jersey LLC. 2011. Fishermen's energy receives permits from New Jersey Department of Environmental Protection. Fisherman's Energy of New Jersey LLC.
- Fitzsimmons, N. N., A. D. Tucker, and C. J. Limpus. 1995. Long-term breeding histories of male green turtles and fidelity to a breeding ground. *Marine Turtle Newsletter* 68:2-4.
- Flagg, C. N., C. D. Wirick, and S. L. Smith. 1984. The interaction of phytoplankton, zooplankton and currents from 15 months of continuous data in the Mid-Atlantic Bight. *Deep Sea Research Part II: Topical Studies in Oceanography* 41(2-3):411-435.
- Flint, M., and coauthors. 2009. Development and application of biochemical and haematological reference intervals to identify unhealthy green sea turtles (*Chelonia mydas*). *The Veterinary Journal*.
- Florida Power and Light Company St. Lucie Plant. 2002. Annual environmental operating report 2001. Florida Power and Light Company St. Lucie Plant, Juno Beach, Florida.
- Foley, A. M., B. A. Schroeder, A. E. Redlow, K. J. Fick-Child, and W. G. Teas. 2005. Fibropapillomatosis in stranded green turtles (*Chelonia mydas*) from the eastern United States (1980-98): Trends and associations with environmental factors. *Journal of Wildlife Diseases* 41(1):29-41.
- Fonfara, S., U. Siebert, A. Prange, and F. Colijn. 2007. The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). *Journal of the Marine Biological Association of the United Kingdom* 87(1):305-311.
- 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 R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. *Mammal Review* 38(1):50-86.
- Ford, S. E. 1996. Range extension by the oyster parasite *Perkinsus marinus* into the Northeastern United States: Response to climate change? *Journal of Shellfish Research* 15(1):45-56.

- Ford, S. F., and H. H. Haskin. 1982. History and epizootiology of *Haplosporidium nelsoni* (MSX), an oyster pathogen in Delaware Bay, 1957-1980. *Journal of Invertebrate Pathology* 40:118-141.
- Formia, A., M. Tiwari, J. Fretey, and A. Billes. 2003. Sea turtle conservation along the Atlantic Coast of Africa. *Marine Turtle Newsletter* 100:33-37.
- Fortune, S. M. E., and coauthors. 2012. Growth and rapid early development of North Atlantic right whales (*Eubalaena glacialis*). *Journal of Mammalogy* 93(5):1342-1354.
- Fossette, S., and coauthors. 2009a. Thermal and trophic habitats of the leatherback turtle during the nesting season in French Guiana. *Journal of Experimental Marine Biology and Ecology*.
- Fossette, S., and coauthors. 2009b. Spatio-temporal foraging patterns of a giant zooplanktivore, the leatherback turtle. *Journal of Marine Systems* in press(in press):in press.
- Foti, M., and coauthors. 2009. Antibiotic resistance of gram negatives isolates from loggerhead sea turtles (*Caretta caretta*) in the central Mediterranean Sea. *Marine Pollution Bulletin* 58(9):1363-1366.
- Fournillier, K., and K. L. Eckert. 1999. Draft sea turtle recovery action plan for Trinidad and Tobago. Caribbean Environment Programme, Kingston, Jamaica.
- Frair, W. R., G. Ackman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea*: warm turtle from cold water. *Science* 177:791-793.
- Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6):305-313.
- Francour, P., A. Ganteaume, and M. Poulain. 1999. Effects of boat anchoring in *Posidonia oceanica* seagrass beds in the Port-Cros National Park (north-western Mediterranean Sea). *Aquatic Conservation: Marine and Freshwater Ecosystems* 9:391-400.
- 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.
- Frasier, T. R. 2005. Integrating genetic and photo-identification data to assess reproductive success in the North Atlantic right whale (*Eubalaena glacialis*). McMaster University, Hamilton, Ontario.
- Frasier, T. R., P. K. Hamilton, M. W. Brown, S. D. Kraus, and B. N. White. 2010. Reciprocal exchange and subsequent adoption of calves by two North Atlantic right whales (*Eubalaena glacialis*). *Aquatic Mammals* 36(2):115-120.
- Frazer, L. N., and E. Mercado, III. 2000. A sonar model for humpback whales. *IEEE Journal of Oceanic Engineering* 25(1):160-182.
- Frazer, N. B., and L. M. Ehrhart. 1985a. Preliminary Growth Models for Green, *Chelonia mydas*, and Loggerhead, *Caretta caretta*, Turtles in the Wild. *Copeia* 1985(1):73-79.
- Frazer, N. B., and L. M. Ehrhart. 1985b. Preliminary growth models for green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles in the wild. *Copeia* 1985:73-79.
- Frazer, N. B., C. J. Limpus, and J. L. Greene. 1994. Growth and estimated age at maturity of Queensland loggerheads. Pages 42-45 in K. A. C. Bjorndal, A. B. C. Bolten, D. A. C.

- Johnson, and P. J. C. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Department of Commerce, Hilton Head, South Carolina.
- Frazier, J. G. 2001. General natural history of marine turtles. Proceedings: Marine turtle conservation in the Wider Caribbean Region: A dialogue for effective regional management, Santo Domingo, Dominican Republic.
- 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.
- Fritts, T. H. 1982. Plastic Bags in the Intestinal Tracts of Leatherback Marine Turtles. *Herpetological Review* 13(3):72-73.
- Fritts, T. H., and M. A. McGehee. 1981. Effects of petroleum on the development and survival of marine turtles embryos. U.S. Fish and Wildlife Service, Contract No. 14-16-00009-80-946, FWSIOBS-81-3, Washington, D.C.
- Fromentin, J.-M., and B. Planque. 1996. *Calanus* and environment in the eastern North Atlantic. II. Influence of the North Atlantic Oscillation on *C. finmarchicus* and *C. helgolandicus*. *Marine Ecology Progress Series* 134:111-118.
- Fuentes, M., M. Hamann, and C. J. Limpus. 2009a. Past, current and future thermal profiles of green turtle nesting grounds: Implications from climate change. *Journal of Experimental Marine Biology and Ecology* 383(1):56-64.
- Fuentes, M. M. P. B., M. Hamann, and C. J. Limpus. 2009b. Past, current and future thermal profiles of green turtle nesting grounds: Implications from climate change. *Journal of Experimental Marine Biology and Ecology* in press(in press):in press.
- Fuentes, M. M. P. B., C. J. Limpus, and M. Hamann. 2010. Vulnerability of sea turtle nesting grounds to climate change. *Global Change Biology*.
- Fuentes, M. M. P. B., and coauthors. 2009c. Proxy indicators of sand temperature help project impacts of global warming on sea turtles in northern Australia. *Endangered Species Research* 9:33-40.
- Fujihara, J., T. Kunito, R. Kubota, and S. Tanabe. 2003. Arsenic accumulation in livers of pinnipeds, seabirds and sea turtles: Subcellular distribution and interaction between arsenobetaine and glycine betaine. *Comparative Biochemistry and Physiology C-Toxicology & Pharmacology* 136(4):287-296.
- 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.
- Gagnon, C. J., and C. W. Clark. 1993. The use of U.S. Navy IUSS passive sonar to monitor the movement of blue whales. Abstracts of the 10th Biennial Conference on the Biology of Marine Mammals, Galveston, TX. November 1993.
- Gailey, G., B. Würsig, and T. L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, Northeast Sakhalin Island, Russia. *Environmental Monitoring and Assessment*. Available online at [http://www.springerlink.com/content/?mode=boolean&k=ti%3a\(western+gray+whale\)&sortorder=asc](http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc). DOI 10.1007/s10661-007-9812-1. 17p.
- Gallaway, B. J., and coauthors. 2013. Kemps Ridley Stock Assessment Project: Final report. Gulf States Marine Fisheries Commission, Ocean Springs, Mississippi.
- Gambaiani, D. D., P. Mayol, S. J. Isaac, and M. P. Simmonds. 2009. Potential impacts of climate change and greenhouse gas emissions on Mediterranean marine ecosystems and

- cetaceans. *Journal of the Marine Biological Association of the United Kingdom* 89(1):179-201.
- Gambell, R. 1976. World whale stocks. *Mammal Review* 6(1):41-53.
- Gambell, R. 1979. The blue whale. *Biologist* 26(5):209-215.
- Gambell, R. 1985a. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). Pages 171-192 in S. H. Ridgway, and R. Harrison, editors. *Handbook of marine mammals, Volume 3: The sirenians and baleen whales*. Academic Press, London, UK.
- Gambell, R. 1985b. Sei whale *Balaenoptera borealis* (Lesson, 1828). Pages 193-240 in S. H. Ridgway, and R. Harrison, editors. *Handbook of Marine Mammals. Vol. 3: The sirenians and baleen whales*. Academic Press, London, United Kingdom.
- Garcia-Fernandez, A. J., and coauthors. 2009. Heavy metals in tissues from loggerhead turtles (*Caretta caretta*) from the southwestern Mediterranean (Spain). *Ecotoxicology and Environmental Safety* 72(2):557-563.
- García-Moliner, G., and J. A. Yoder. 1994. Variability in pigment concentration in warm-core rings as determined by coastal zone color scanner satellite imagery from the Mid-Atlantic Bight. *Journal of Geophysical Research* 99(C7):14277-14290.
- 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.
- Gardner, S. C., S. L. Fitzgerald, B. A. Vargas, and L. M. Rodriguez. 2006. Heavy metal accumulation in four species of sea turtles from the Baja California Peninsula, Mexico. *Biometals* 19(1):91-99.
- Gardner, S. C., M. D. Pier, R. Wesselman, and J. A. Juarez. 2003. Organochlorine contaminants in sea turtles from the Eastern Pacific. *Marine Pollution Bulletin* 46:1082-1089.
- Garner, J. A. 2012. Reproductive endocrinology of nesting leatherback sea turtles in St. Croix, U.S. Virgin Islands. Texas A&M University.
- Garner, J. A., S. A. Garner, P. Dutton, and T. Eguchi. 2012. Where do we go from here? Thirty seasons of leatherbacks: An update on the status of the St. Croix population. Pages 220 in T. T. Jones, and B. P. Wallace, editors. *Thirty-First Annual Symposium on Sea Turtle Biology and Conservation*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, San Diego, California.
- Garrison, L. P., and L. Stokes. 2010. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2009. NMFS, Southeast Fisheries Science Center.
- Gaskin, D. E. 1972. Whales, dolphins, and seals; with special reference to the New Zealand region. Heinemann, London. 200 pp.
- Gauthier, J. M., C. D. Metcalf, and R. Sears. 1997a. 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.
- Gauthier, J. M., C. D. Metcalfe, and R. Sears. 1997b. 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.
- Gauthier, J. M., C. D. Metcalfe, and R. Sears. 1997c. Validation of the blubber biopsy technique for monitoring of organochlorine contaminants in Balaenopterid whales. *Marine Environmental Research* 43(3):157-179.

- Genov, T., P. Kotnjek, and L. Lipej. 2009. New record of the humpback whale (*Megaptera novaengliae*) in the Adriatic Sea. *Annales* 19(1):25-30.
- Gero, S., D. Engelhaupt, L. Rendell, and H. Whitehead. 2009. Who cares? Between-group variation in alloparental caregiving in sperm whales. *Behavioral Ecology*.
- Gero, S., and coauthors. 2013. Behavior and social structure of the sperm whales of Dominica, West Indies. *Marine Mammal Science*.
- Gill, B. J. 1997. Records of turtles, and sea snakes in New Zealand, 1837-1996. *New Zealand Journal of Marine and Freshwater Research* 31:477-486.
- Gillespie, D., and R. Leaper. 2001. Report of the Workshop on Right Whale Acoustics: Practical Applications in Conservation, Woods Hole, 8-9 March 2001. International Whaling Commission Scientific Committee, London.
- Gilpatrick, J., James W., and W. L. Perryman. 2009. Geographic variation in external morphology of North Pacific and Southern Hemisphere blue whales (*Balaenoptera musculus*). *Journal of Cetacean Research and Management* 10(1):9-21.
- Girard, C., A. D. Tucker, and B. Calmettes. 2009. Post-nesting migrations of loggerhead sea turtles in the Gulf of Mexico: dispersal in highly dynamic conditions. *Marine Biology* 156(9):1827-1839.
- Glass, A. H., T. V. N. Cole, and M. Garron. 2009. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2003-2007 (second edition).
- Glass, A. H., T. V. N. Cole, M. Garron, R. L. Merrick, and R. M. P. III. 2008. Mortality and serious injury determinations for baleen whale stocks along the United States Eastern Seaboard and adjacent Canadian Maritimes, 2002-2006. U.S. Department of Commerce, National Marine Fisheries Service, Northeast Fisheries Science Center, Woods Hole, Massachusetts.
- Gless, J. M., M. Salmon, and J. Wyneken. 2008. Behavioral responses of juvenile leatherbacks *Dermochelys coriacea* to lights used in the longline fishery. *Endangered Species Research* 5:239-247.
- Glockner-Ferrari, D. A., and M. J. Ferrari. 1985. Individual identification, behavior, reproduction, and distribution of humpback whales, *Megaptera novaengliae*, in Hawaii. U.S. Marine Mammal Commission, Washington, D.C.; National Technical Information Service, Springfield, Virginia: 36p.
- Godley, B., and coauthors. 2002. Long-term satellite telemetry of the movements and habitat utilization by green turtles in the Mediterranean. *Ecography* 25:352-362.
- Godley, B. J., D. R. Thompson, and R. W. Furness. 1999. Do heavy metal concentrations pose a threat to marine turtles from the Mediterranean Sea? *Marine Pollution Bulletin* 38:497-502.
- Godley, B. J., D. R. Thompson, S. Waldron, and R. W. Furness. 1998. The trophic status of marine turtles as determined by stable isotope analysis. *Marine Ecology Progress Series* 166:277-284.
- Godley, B. J. E., and coauthors. 2003. Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. *Marine Ecology Progress Series* 253:279-288.
- Goff, G. P., and J. Lien. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. *Canadian Field Naturalist* 102(1):1-5.

- Goldbogen, J. A., and coauthors. 2013. Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society of London Series B Biological Sciences* 280(1765):Article 20130657.
- González Carman, V., and coauthors. 2012. Revisiting the ontogenetic shift paradigm: The case of juvenile green turtles in the SW Atlantic. *Journal of Experimental Marine Biology and Ecology* 429:64-72.
- Goodyear, J. D. 1993. A sonic/radio tag for monitoring dive depths and underwater movements of whales. *Journal of Wildlife Management* 57(3):503-513.
- Goold, J. C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. *Journal of the Marine Biological Association of the U.K.* 79:541-550.
- Goold, J. C., and R. F. W. Coates. 2006. Near source, high frequency air-gun signatures. Paper SC/58/E30, prepared for the International Whaling Commission (IWC) Seismic Workshop, St. Kitts, 24-25 May 2006. 7p.
- Goold, J. C., and P. J. Fish. 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. *Journal of the Acoustical Society of America* 103(4):2177-2184.
- Goold, J. C., H. Whitehead, and R. J. Reid. 2002. North Atlantic Sperm Whale, *Physeter macrocephalus*, strandings on the coastlines of the British Isles and Eastern Canada. *Canadian Field-Naturalist* 116:371-388.
- Goold, J. C., and S. E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98(3):1279-1291.
- Gordon, A. N., A. R. Pople, and J. Ng. 1998. Trace metal concentrations in livers and kidneys of sea turtles from south-eastern Queensland, Australia. *Marine and Freshwater Research* 49(5):409-414.
- Gordon, J., R. Antunes, N. Jaquet, and B. Wursig. 2006. An investigation of sperm whale headings and surface behaviour before, during and after seismic line changes in the Gulf of Mexico. [Pre-meeting]. Unpublished paper to the IWC Scientific Committee. 10 pp. St Kitts and Nevis, West Indies, June (SC/58/E45).
- Gordon, J., and coauthors. 2004. A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal* 37(4):16-34.
- Gosho, M. E., D. W. Rice, and J. M. Breiwick. 1984. The sperm whale, *Physeter macrocephalus*. *Marine Fisheries Review* 46(4):54-64.
- Gotelli, N. J., and A. M. Ellison. 2004. *A Primer of Ecological Statistics*. Sinauer Associates, Inc. Sunderland, Massachusetts. 510p.
- Goujon, M., J. Forcada, and G. Desportes. 1994. Fin whale abundance in the eastern North Atlantic, estimated from the French program MICA-93 data. *European Research on Cetaceans* 8:81-83.
- Grant, G. S., and D. Ferrell. 1993. Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. *Brimleyana* 19:77-81.
- Green, G. A., and coauthors. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.
- Green, G. A., R. A. Grotefendt, M. A. Smultea, C. E. Bowlby, and R. A. Rowlett. 1993. Delphinid aerial surveys in Oregon and Washington offshore waters. Final report.

- National Marine Fisheries Service, National Marine Mammal Laboratory, Seattle, Washington.
- 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. 2003a. Impact of climate variability on the recovery of endangered North Atlantic right whales. *Oceanography* 16(4):98-103.
- Greene, C. H., A. J. Pershing, R. D. Kenney, and J. W. Jossi. 2003b. Impact of climate variability on the recovery of endangered North Atlantic right whales. *Oceanography* 16(4):98-103.
- Greene Jr, C. R., N. S. Altman, and W. J. Richardson. 1999. Bowhead whale calls. *Western Geophysical and NMFS*.
- Greer, A. E., J. D. Lazell Jr., and R. M. Wright. 1973. Anatomical evidence for counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). *Nature* 244:181.
- Greer, A. W., M. Stankiewicz, N. P. Jay, R. W. McAnulty, and A. R. Sykes. 2005. The effect of concurrent corticosteroid induced immuno-suppression and infection with the intestinal parasite *Trichostrongylus colubriformis* on food intake and utilization in both immunologically naive and competent sheep. *Animal Science* 80:89-99.
- Gregory, L. F., and J. R. Schmid. 2001. Stress responses and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the northwestern Gulf of Mexico. *General and Comparative Endocrinology* 124:66-74.
- Griffin, R. B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. *Marine Mammal Science* 15(1):33-51.
- Guerra, A., A. F. Gonzalez, and F. Rocha. 2004. A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. ICES Annual Science Conference, Vigo, Spain.
- Guerra, M., A. M. Thode, S. B. Blackwell, and A. M. Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. *Journal of the Acoustical Society of America* 130(5):3046-3058.
- Guerranti, C., and coauthors. 2013. Perfluorinated compounds in blood of *Caretta caretta* from the Mediterranean Sea. *Marine Pollution Bulletin* 73(1):98-101.
- Gulko, D., and K. L. Eckert. 2003. *Sea Turtles: An Ecological Guide*. Mutual Publishing, Honolulu, Hawaii.
- Gulland, F. M. D., and coauthors. 1999. Adrenal function in wild and rehabilitated Pacific harbor seals (*Phoca vitulina richardii*) and in seals with phocine herpesvirus-associated adrenal necrosis. *Marine Mammal Science* 15(3):810-827.
- Gunnlaugsson, T., and J. Sigurjónsson. 1990. NASS-87: estimation of whale abundance based on observations made onboard Icelandic and Faroese survey vessels. *Report of the International Whaling Commission* 40:571-580.
- Hain, J. H. W., G. R. Carter, S. D. Kraus, C. A. Mayo, and H. E. Winn. 1982. Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. *Fishery Bulletin* 80(2):259-268.
- Hain, J. H. W., and coauthors. 1995. Apparent bottom feeding by humpback whales on Stellwagen Bank. *Marine Mammal Science* 11(4):464-479.
- Hain, J. H. W., W. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the U.S. *Marine Fisheries Review* 47(1):13-17.

- Hain, J. H. W., M. J. Ratnaswamy, R. D. Kenney, and H. E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Report of the International Whaling Commission 42:653-669.
- Halliwell Jr., G. R., and C. N. K. Mooers. 1979. The space-time structure and variability of the shelf water-slope water and Gulf Stream surface temperature fronts and associated warm-core eddies. *Journal of Geophysical Research* 84(C12):7707-7725.
- Hamann, M., C. Limpus, G. Hughes, J. Mortimer, and N. Pilcher. 2006. Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia, including consideration of the impacts of the December 2004 tsunami on turtles and turtle habitats. IOSEA Marine Turtle MoU Secretariat, Bangkok.
- Hamilton, P., and L. A. Cooper. 2010. Changes in North Atlantic right whale (*Eubalaena glacialis*) cow-calf association times and use of the calving ground: 1993-2005. *Marine Mammal Science* 26(4):896-916.
- Hamilton, P. K., R. D. Kenney, and T. V. N. Cole. 2009. Right whale sightings in unusual places. *Right Whale News* 17(1):9-10.
- Hamilton, P. K., A. R. Knowlton, and M. K. Marx. 2007. Right whales tell their own stories: The photo-identification catalog. Pages 75-104 in S. D. Kraus, and R. M. Rolland, editors. *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge.
- Hamilton, P. K., A. R. Knowlton, M. K. Marx, and S. D. Kraus. 1998. Age structure and longevity in North Atlantic right whales *Eubalaena glacialis* and their relationship to reproduction. *Marine Ecology Progress Series* 171:285-292.
- Hansen, L. J., K. D. Mullin, T. A. Jefferson, and G. P. Scott. 1996. Visual surveys aboard ships and aircraft. In: R. W. Davis and G. S. Fargion (eds). *Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final report. Volume II: Technical report:OCS Study MMS 96- 0027*, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans. p.55-132.
- Harris, R. E., T. Elliott, and R. A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006. GX Technology Corporation, Houston, Texas.
- Hart, K. M., and coauthors. 2013a. Ecology of juvenile hawksbills (*Eretmochelys imbricata*) at Buck Island Reef National Monument, US Virgin Islands. *Marine Biology* 160(10):2567-2580.
- Hart, K. M., D. G. Zawada, I. Fujisaki, and B. H. Lidz. 2013b. Habitat-use of breeding green turtles, *Chelonia mydas*, tagged in Dry Tortugas National Park, USA: Making use of local and regional MPAS. Pages 46 in T. Tucker, and coeditors, editors. *Thirty-Third Annual Symposium on Sea Turtle Biology and Conservation*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Baltimore, Maryland.
- Hassel, A., and coauthors. 2003. Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.
- Hassel, A., and coauthors. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). *ICES Journal of Marine Science* 61:1165-1173.
- Hatase, H., Y. Matsuzawa, W. Sakamoto, N. Baba, and I. Miyawaki. 2002. Pelagic habitat use of an adult Japanese male loggerhead turtle *Caretta caretta* examined by the Argos satellite system. *Fisheries Science* 68:945-947.

- Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto. 2006. Individual variation in feeding habitat use by adult female green sea turtles (*Chelonia mydas*): Are they obligately neritic herbivores? *Oecologia* 149:52-64.
- 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.
- Hatch, L. T., C. W. Clark, S. M. V. Parijs, A. S. Frankel, and D. W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a US National Marine Sanctuary. *Conservation Biology* 26(6):983-994.
- Hauser, D. W., and M. Holst. 2009. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Gulf of Alaska, Septmber-October 2008 LGL, Ltd., King City, Canada.
- Hauser, D. W., M. Holst, and V. Moulton. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific, April – August 2008. LGL Ltd., King City, Ontario.
- Hawkes, L. A., A. Broderick, M. H. Godfrey, and B. J. Godley. 2007a. The potential impact of climate change on loggerhead sex ratios in the Carolinas - how important are North Carolina's males? P.153 in: Frick, M.; A. Panagopoulou; A.F. Rees; K. Williams (compilers), 27th Annual Symposium on Sea Turtle Biology and Conservation [abstracts]. 22-28 February 2007, Myrtle Beach, South Carolina. 296p.
- Hawkes, L. A., A. C. Broderick, M. H. Godfrey, B. Godley, and M. J. Witt. 2014. The impacts of climate change on marine turtle reproductive success. Pages 287-310 in B. Maslo, and L. Lockwood, editors. *Coastal Conservation*. Cambridge University Press.
- Hawkes, L. A., A. C. Broderick, M. H. Godfrey, and B. J. Godley. 2007b. Investigating the potential impacts of climate change on a marine turtle population. *Global Change Biology* 13:1-10.
- Hays, G. C., V. J. Hobson, J. D. Metcalfe, D. Righton, and D. W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. *Ecology* 87(10):2647-2656.
- Hays, G. C., J. D. R. Houghton, and A. E. Myers. 2004. Pan-Atlantic leatherback turtle movements. *Nature* 429:522.
- Hazel, J. 2009. Evaluation of fast-acquisition GPS in stationary tests and fine-scale tracking of green turtles. *Journal of Experimental Marine Biology and Ecology* 374(1):58-68.
- Hazel, J., and E. Gyuris. 2006. Vessel-related mortality of sea turtles in Queensland, Australia. *Wildlife Research* 33(2):149-154.
- Hazel, J., I. R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research* 3:105-113.
- HDLNR. 2002. Application for an individual incidental take permit pursuant to the Endangered Species Act of 1973 for listed sea turtles in inshore marine fisheries in the main Hawaiian Islands managed by the State of Hawaii. State of Hawaii, Division of Aquatic Resources.
- Heide-Jorgensen, M. P., E. Garde, N. H. Nielsen, O. N., and ersen. 2010. Biological data from the hunt of bowhead whales in West Greenland 2009 and 2010. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.
- 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.

- Heithaus, M. R., J. J. McLash, A. Frid, L. M. Dill, and G. J. Marshall. 2002. Novel insights into green sea turtle behaviour using animal-borne video cameras. *Journal of the Marine Biological Association of the United Kingdom* 82:1049-1050.
- Henry, J., and P. B. Best. 1983. Organochlorine residues in whales landed at Durban, South Africa. *Marine Pollution Bulletin* 14(6):223-227.
- Heppell, S. S., and coauthors. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. *Chelonian Conservation and Biology* 4(4):767-773.
- Heppell, S. S., L. B. Crowder, D. T. Crouse, S. P. Epperly, and N. B. Frazer. 2003a. Population models for Atlantic loggerheads: Past, present, and future. Chapter 16 *In*: Bolten, A. and B. Witherington (eds), *Loggerhead Sea Turtles*. Smithsonian Books, Washington, D.C. Pp.255-273.
- Heppell, S. S., M. L. Snover, and L. B. Crowder. 2003. Sea turtle population ecology. Chapter 11 *In*: Lutz, P.L., J.A. Musick, and J. Wyneken (eds), *The Biology of Sea Turtles: Volume II*. CRC Press. Pp.275-306.
- 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*.
- Herman, L. M., and coauthors. 2013. Humpback whale song: Who sings? *Behavioral Ecology and Sociobiology* 67(10):1653-1663.
- Hermanussen, S., V. Matthews, O. Papke, C. J. Limpus, and C. Gaus. 2008. Flame retardants (PBDEs) in marine turtles, dugongs and seafood from Queensland, Australia. *Marine Pollution Bulletin* 57(6-12):409-418.
- Hernandez, R., J. Buitrago, H. Guada, H. Hernandez-Hamon, and M. Llano. 2007. Nesting distribution and hatching success of the leatherback, *Dermochelys coriacea*, in relation to human pressures at Playa Parguito, Margarita Island, Venezuela. *Chelonian Conservation and Biology* 6(1):79-86.
- Herraez, P., and coauthors. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. *Journal of Wildlife Diseases* 43(4):770-774.
- 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, H. H. 1963. Hallazgo del area de anidacion de la tortuga marina "lora", *Lepidochelys kempfi* (Garman), en la costa occidental del Golfo de Mexico (Rept., Chel.). *Ciencia, Mexico* 22:105-112.
- Hildebrand, H. H. 1983. Random notes on sea turtles in the western Gulf of Mexico. *Western Gulf of Mexico Sea Turtle Workshop Proceedings*, January 13-14, 1983:34-41.
- Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395:5-20.
- Hirth, H. F. 1997. Synopsis of the biological data on the green turtle, *Chelonia mydas* (Linnaeus 1758).
- Hjort, J., and J. T. Ruud. 1929. Whaling and fishing in the North Atlantic. Permanent International pour l'Exploration de la Mer. *Rapports et Proces-Verbaux des Reunions* 56:1-123.
- Hodge, R. P., and B. L. Wing. 2000. Occurrences of marine turtles in Alaska waters: 1960-1998. *Herpetological Review* 31(3):148-151.

- Holliday, D. V., R. E. Piper, M. E. Clarke, and C. F. Greenlaw. 1987. The effects of airgun energy release on the eggs, larvae, and adults of the northern anchovy (*Engraulis mordax*). American Petroleum Institute, Washington, D.C.
- 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.
- Holst, M. 2009. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's Taiger marine seismic program near Taiwan, April - July 2009 LGL, Ltd., King City, Canada.
- Holst, M. 2010. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's ETOMO marine seismic program in the northeast Pacific Ocean August-September 2009 LGL, Ltd., King City, Canada.
- Holst, M., and J. Beland. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's seismic testing and calibration study in the northern Gulf of Mexico, November 2007-February 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.
- Holst, M., and coauthors. 2006. Effects of large and small-source seismic surveys on marine mammals and sea turtles. EOS Transactions of the American Geophysical Union 87(36):Joint Assembly Supplement, Abstract OS42A-01.
- Holst, M., and M. Smultea. 2008a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off central America, February-April 2008 LGL, Ltd., King City, Canada.
- Holst, M., M. Smultea, W. Koski, and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the eastern tropical Pacific off central America, November-December 2004. LGL, Ltd., King City, Ontario.
- Holst, M., M. Smultea, W. Koski, and B. Haley. 2005b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the Northern Yucatán Peninsula in the Southern Gulf of Mexico, January–February 2005. LGL, Ltd., King City, Ontario.
- Holst, M., and M. A. Smultea. 2008b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off Central America, February-April 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.
- Holst, M., M. A. Smultea, W. R. Koski, and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific Ocean off Central America, November–December 2004. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. Report TA2822-30. 125 p.
- Holt, M. M. 2008. Sound exposure and Southern Resident killer whales (*Orcinus orca*): A review of current knowledge and data gaps. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-89. 59p.
- Holt, M. M., R. C. Dunkin, D. P. Noren, and T. M. Williams. 2013. Are there metabolic costs of vocal responses to noise in marine mammals? Journal of the Acoustical Society of America 133(5 Part 2):3536.

- Hoop, J. M. V. D., A. S. M. Vanderlaan, and C. T. Taggart. 2012. Absolute probability estimates of lethal vessel strikes to North Atlantic right whales in Roseway Basin, Scotian Shelf. *Ecological Applications* 22(7):2021-2033.
- Hotchkin, C. F., S. E. Parks, and C. W. Clark. 2011. Source level and propagation of gunshot sounds produced by North Atlantic right whales (*Eubalanea glacialis*) in the Bay of Fundy during August 2004 and 2005. Pages 136 in Nineteenth Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.
- Hucke-Gaete, R., L. Osman, C. Moreno, K. P. Findlay, and D. Ljungblad. 2004. Discovery of a blue whale feeding and nursing ground in southern Chile. *Proceedings of the Royal Society of London, Series B: Biological Sciences* 271(Suppl.):S170-S173.
- Hughes, G. R., P. Luschi, R. Mencacci, and F. Papi. 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology* 229(1998):209-217.
- Hulin, V., V. Delmas, M. Girondot, M. H. Godfrey, and J. M. Guillon. 2009. Temperature-dependent sex determination and global change: Are some species at greater risk? *Oecologia* 160(3):493-506.
- 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.
- Hurrell, J. W., Y. Kushnir, and M. Visbeck. 2001. The North Atlantic Oscillation. *Science* 291:603-605.
- Hutchinson, B. J., and P. Dutton. 2007. Modern genetics reveals ancient diversity in the loggerhead.
- Ilangakoon, A. D. 2012. Exploring anthropogenic activities that threaten endangered blue whales (*Balaenoptera musculus*) off Sri Lanka. *Journal of Marine Animals and their Ecology* 5(1):3-7.
- Ingebrigtsen, A. 1929. Whales caught in the North Atlantic and other seas. *Conseil Permanent International pour l'Exploration de la Mer. Rapports et Proces-Verbaux des Reunions* 56:123-135.
- 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.
- Innis, C., and coauthors. 2009. Pathologic and parasitologic findings of cold-stunned Kemp's ridley sea turtles (*Lepidochelys kempii*) stranded on Cape Cod, Massachusetts, 2001-2006. *Journal of Wildlife Diseases* 45(3):594-610.
- Innis, C., and coauthors. 2008. Trace metal and organochlorine pesticide concentrations in cold-stunned kuvenile Kemp's ridley turtles (*Lepidochelys kempii*) from Cape Cod, Massachusetts. *Chelonian Conservation and Biology* 7(2):230-239.
- Iorio, L. D., and C. W. Clark. 2009. Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters* in press(in press):in press.
- 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*.
- Ischer, T., K. Ireland, and D. T. Booth. 2009. Locomotion performance of green turtle hatchlings from the Heron Island Rookery, Great Barrier Reef. *Marine Biology* 156(7):1399-1409.
- Issac, J. L. 2009. Effects of climate change on life history: Implications for extinction risk in mammals. *Endangered Species Research* 7(2):115-123.
- IWC. 1980. Sperm Whales. Report of the International Whaling Commission (Special Issue 2):245p.
- IWC. 1992. Report of the comprehensive assessment special meeting on North Atlantic fin whales. Report of the International Whaling Commission 42:595-644.
- IWC. 2004. Scientific committee - Annex K: Report of the standing working group on environmental concerns. Sorrento, Italy.
- IWC. 2006. Report of the Joint NAMMCO/IWC Scientific Workshop on the Catch History, Stock Structure and Abundance of North Atlantic Fin Whales. Reykjavík, Iceland, 23-26 March 2006. IWC Scientific Committee paper SC/58/Rep 3. 25p.
- IWC. 2007. Whale Population Estimates. International Whaling Commission. Accessed 02/07/2007 online at: <http://www.iwcoffice.org/conservation/estimate.htm>.
- IWC. 2014. Whale population estimates. International Whaling Commission.
- Jacobsen, K.-O., M. Marx, and N. Øien. 2004. Two-way trans-Atlantic migration of a North Atlantic right whale (*Eubalaena glacialis*). *Marine Mammal Science* 20(1):161-166.
- 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.
- James, M. C., S. A. Eckert, and R. A. Myers. 2005. Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea*). *Marine Biology* 147:845-853.
- James, M. C., C. A. Ottensmeyer, S. A. Eckert, and R. A. Myers. 2006. Changes in the diel diving patterns accompany shifts between northern foraging and southward migration in leatherback turtles. *Canadian Journal of Zoology* 84:754-765.
- James, M. C., S. A. Sherrill-Mix, and R. A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. *Marine Ecology Progress Series* 337:245-254.
- Jaquet, N., and D. Gendron. 2009. The social organization of sperm whales in the Gulf of California and comparisons with other populations. *Journal of the Marine Biological Association of the United Kingdom* 89(05):975.
- Jaquet, N., and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. *Marine Ecology Progress Series* 135:1-9.
- Jaquet, N., H. Whitehead, and M. Lewis. 1996. Coherence between 19th century sperm whale distributions and satellite-derived pigments in the tropical Pacific. *Marine Ecology Progress Series* 145:1-10.
- Jasny, M., J. Reynolds, C. Horowitz, and A. Wetzler. 2005. Sounding the depths II: The rising toll of sonar, shipping and industrial ocean noise on marine life. Natural Resources Defense Council, New York, New York.

- Jefferson, T. A. P. J. S., and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. *Mammal Review* 21:151-180.
- Jensen, A. S., and G. K. Silber. 2003. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25.
- Jensen, A. S., and G. K. Silber. 2004. Large Whale Ship Strike Database. U.S. Department of Commerce, NMFS-OPR-25.
- Jessop, T. S. 2001. Modulation of the adrenocortical stress response in marine turtles (Cheloniidae): evidence for a hormonal tactic maximizing maternal reproductive investment *Journal of Zoology* 254:57-65.
- Jessop, T. S., M. Hamann, M. A. Read, and C. J. Limpus. 2000. Evidence for a hormonal tactic maximizing green turtle reproduction in response to a pervasive ecological stressor. *General and Comparative Endocrinology* 118:407-417.
- Jessop, T. S., J. Sumner, V. Lance, and C. Limpus. 2004. Reproduction in shark-attacked sea turtles is supported by stress-reduction mechanisms. *Proceedings of the Royal Society Biological Sciences Series B* 271:S91-S94.
- Jochens, A., and coauthors. 2006. Sperm whale seismic study in the Gulf of Mexico; Summary Report 2002-2004. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-034. 352p.
- Jochens, A. E., and D. C. Biggs. 2003. Sperm whale seismic study in the Gulf of Mexico. Minerals Management Service, OCS MMS 2003-069, New Orleans.
- Jochens, A. E., and D. C. Biggs. 2004. Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 2. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-067, 167p.
- Johnson, C. R., and coauthors. 2011. Climate change cascades: Shifts in oceanography, species' ranges and subtidal marine community dynamics in eastern Tasmania. *Journal of Experimental Marine Biology and Ecology*.
- Johnson, D. R., C. Yeung, and C. A. Brown. 1999. Estimates of marine mammal and sea turtle bycatch by the U.S. pelagic longline fleet in 1992-1997. NOAA.
- Johnson, M., and P. Miller. 2002. Sperm whale diving and vocalization patterns from digital acoustic recording tags and assessing responses of whales to seismic exploration. MMS Information Transfer Meeting, Kenner, LA.
- Johnson, S. A., and L. M. Ehrhart. 1994. Nest-site fidelity of the Florida green turtle. Pages 83 in B. A. Schroeder, and B. E. Witherington, editors. Thirteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Johnson, S. R., and coauthors. 2007a. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment Available online at [http://www.springerlink.com/content/?mode=boolean&k=ti%3a\(western+gray+whale\)&sortorder=asc](http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc). DOI 10.1007/s10661-007-9813-0. 19p.
- Johnson, S. R., and coauthors. 2007b. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment.
- Jonsgård, A. 1966. Biology of the North Atlantic fin whale *Balaenoptera physalus* (L.): Taxonomy, distribution, migration, and food. *Hvalrdets Skrifter* 49:1-62.

- Jonsgård, Å., and K. Darling. 1977. On the biology of the eastern North Atlantic sei whales, *Balaenoptera borealis* Lesson. Reports of the International Whaling Commission Special Issue 11:123-129.
- 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.
- Kasamatsu, F., G. Joyce, P. Ensor, and J. Mermoz. 1996. Current occurrence of Baleen whales in Antarctic waters. Reports of the International Whaling Commission 46:293-304.
- 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.
- Kastak, D., B. L. Southall, R. J. Schusterman, and C. R. Kastak. 2005. Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. Journal of the Acoustical Society of America 118(5):3154-3163.
- Kasuya, T. 1991. Density dependent growth in North Pacific sperm whales. Marine Mammal Science 7(3):230-257.
- Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Scientific Reports of the Whales Research Institute, Tokyo 39:31-75.
- Kato, H., T. Miyashita, and H. Shimada. 1995. Segregation of the two sub-species of the blue whale in the Southern Hemisphere. Reports of the International Whaling Commission 45:273-283.
- 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.
- Kaufman, G. A., and D. W. Kaufman. 1994. Changes in body-mass related to capture in the prairie deer mouse (*Peromyscus maniculatus*). Journal of Mammalogy 75(3):681-691.
- Kawamura, G., T. Naohara, Y. Tanaka, T. Nishi, and K. Anraku. 2009. Near-ultraviolet radiation guides the emerged hatchlings of loggerhead turtles *Caretta caretta* (Linnaeus) from a nesting beach to the sea at night. Marine and Freshwater Behaviour and Physiology 42(1):19-30.
- 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.
- Keinath, J. A. 1993. Movements and behavior of wild and head-started sea turtles (*Caretta caretta*, *Lepidochelys kempii*). College of William and Mary, Williamsburg, Virginia.
- Keinath, J. A., J. A. Musick, and D. E. Barnard. 1996. Abundance and distribution of sea turtles off North Carolina. OCS Study, MMS 95-0024 (Prepared under MMS Contract 14-35-0001-30590):156.
- Keller, J. M., and coauthors. 2005. Perfluorinated compounds in the plasma of loggerhead and Kemp's ridley sea turtles from the southeastern coast of the United States. Environmental Science and Technology 39(23):9101-9108.
- Keller, J. M., J. R. Kucklick, C. A. Harms, and P. D. McClellan-Green. 2004a. Organochlorine contaminants in sea turtles: Correlations between whole blood and fat. Environmental Toxicology and Chemistry 23(3):726-738.
- Keller, J. M., J. R. Kucklick, and P. D. McClellan-Green. 2004b. Organochlorine contaminants in loggerhead sea turtle blood: Extraction techniques and distribution among plasma, and red blood cells. Archives of Environmental Contamination and Toxicology 46:254-264.

- Keller, J. M., J. R. Kucklick, M. A. Stamper, C. A. Harms, and P. D. McClellan-Green. 2004c. Associations between organochlorine contaminant concentrations and clinical health parameters in loggerhead sea turtles from North Carolina, USA. *Environmental Health Parameters* 112(10):1074-1079.
- Keller, J. M., and P. McClellan-Green. 2004. Effects of organochlorine compounds on cytochrome P450 aromatase activity in an immortal sea turtle cell line. *Marine Environmental Research* 58(2-5):347-351.
- Keller, J. M., P. D. McClellan-Green, J. R. Kucklick, D. E. Keil, and M. M. Peden-Adams. 2006. Turtle immunity: Comparison of a correlative field study and in vitro exposure experiments. *Environmental Health Perspectives* 114(1):70-76.
- Kenney, R. D. 2001. Anomalous 1992 spring, and summer right whale (*Eubalaena glacialis*) distributions in the Gulf of Maine. *Journal of Cetacean and Research Management (special issue)* 2:209-223.
- Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1985a. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf.
- Kenney, R. D., M. A. M. Hyman, and H. E. Winn. 1985b. 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.
- Kenney, R. D., C. A. Mayo, and H. E. Winn. 2001. Migration and foraging strategies at varying spatial scales in western North Atlantic right whales: a review of hypotheses. *Journal of Cetacean Research and Management (Special Issue 2)*:251-260.
- Kenney, R. D., H. E. Winn, and M. C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979-1989: Right whale (*Eubalaena glacialis*). *Continental Shelf Research* 15:385-414.
- Ketten, D. 1998a. Marine Mammal Auditory Systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts, NOAA-TM-NMFS-SWFSC-256.
- Ketten, D. R. 1997. Structure and function in whale ears. *Bioacoustics* 8:103-135.
- Ketten, D. R. 1998b. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts.
- Ketten, D. R. 1998c. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-256.
- Ketten, D. R. 2012. Marine mammal auditory system noise impacts: Evidence and incidence. Pages 6 in A. N. Popper, and A. Hawkings, editors. *The Effects of Noise on Aquatic Life*. Springer Science.
- Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: An integrative, mechanistic review. *Ecology Letters*.
- Kite-Powell, H. L., A. Knowlton, and M. Brown. 2007. Modeling the effect of vessel speed on right whale ship strike risk. NMFS.
- Kjeld, M., Ö. Ólafsson, G. A. Víkingsson, and J. Sigurjónsson. 2006. Sex hormones and reproductive status of the North Atlantic fin whale (*Balaenoptera physalus*) during the feeding season. *Aquatic Mammals* 32(1):75-84.

- Knowlton, A. R., P. K. Hamilton, M. Marx, H. M. Pettis, and S. D. Kraus. 2012. Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: A 30 yr retrospective. *Marine Ecology Progress Series* 466:293-302.
- Knowlton, A. R., and S. D. Kraus. 2001a. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management Special Issue*(2):193 - 208.
- Knowlton, A. R., and S. D. Kraus. 2001b. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *Journal of Cetacean Research and Management Special Issue* 2:193-208.
- Knowlton, A. R., S. D. Kraus, and R. D. Kenney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Canadian Journal of Zoology* 72(7):1297-1305.
- Knowlton, A. R., M. K. Marx, H. M. Pettis, P. K. Hamilton, and S. D. Kraus. 2005. Analysis of scarring on North Atlantic right whales (*Eubalaena glacialis*): Monitoring rates of entanglement interaction 1980-2002. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- Konishi, K., and coauthors. 2009. Feeding strategies and prey consumption of three baleen whale species within the Kuroshio-Current Extension. *Journal of Northwest Atlantic Fishery Science* 42(Article No.3):27-40.
- Kostyuchenko, L. P. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. *Hydrobiological Journal* 9(5):45-48.
- 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. D., and coauthors. 2005. North Atlantic right whales in crisis. Pages 561-562 *in Science*.
- Kraus, S. D., R. D. Kenney, A. R. Knowlton, and J. N. Ciano. 1993. Endangered right whales of the southwestern North Atlantic. OCS Study MMS 930024. Prepared by the New England Aquarium. Herndon, Virginia: U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region.
- Kraus, S. D., R. M. Pace, and T. R. Frasier. 2007. High investment, low return: The strange case of reproduction in *Eubalaena glacialis*. Pages 172-199 *in* S. D. Kraus, and R. M. Rolland, editors. *The urban whale: North Atlantic right whales at the crossroads*. Harvard University Press, Cambridge, Massachusetts.
- Kremser, U., P. Klemm, and W. D. Kötz. 2005. Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. *Antarctic Science* 17(1):3-10.
- Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: Cochlear nerve degeneration after “temporary” noise-induced hearing loss. *The Journal of Neuroscience* 29(45):14077-14085.
- La Bella, G., and coauthors. 1996a. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227-238 *in* Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana.
- La Bella, G., and coauthors. 1996b. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227 *in* SPE Health, Safety and

- Environment in Oil and Gas Exploration and Production Conference, New Orleans, Louisiana.
- Lafortuna, C. L., and coauthors. 1999. Locomotor behaviour and respiratory patterns in Mediterranean fin whales (*Balaenoptera physalus*) tracked in their summer feeding ground. Pages 156-160 in P. G. H. Evan, and E. C. M. Parsons, editors. Proceedings of the Twelfth Annual Conference of the European Cetacean Society, Monaco.
- Laist, D. W., J. M. Coe, and K. J. O'Hara. 1999. Marine debris pollution. Pages 342-366 in J. Twiss, and R. R. Reeves, editors. Conservation and management of marine mammals. Smithsonian Institution Press, Washington, D.C.
- 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.
- Lake, J., L. R. Haebler, R. McKinney, C. A. Lake, and S. S. Sadove. 1994. PCBs and other chlorinated organic contaminants in tissues of juvenile Kemp's ridley turtles (*Lepidochelys kempii*). *Marine Environmental Research* 38:313-327.
- Lal, A., R. Arthur, N. Marbà, A. W. T. Lill, and T. Alcoverro. 2010. Implications of conserving an ecosystem modifier: Increasing green turtle (*Chelonia mydas*) densities substantially alters seagrass meadows. *Biological Conservation* in press(in press):in press.
- Laloë, J.-O., J. Cozens, B. Renom, A. Taxonera, and G. C. Hays. 2014. Effects of rising temperature on the viability of an important sea turtle rookery. *Nature Climate Change* 4(6):513-518.
- 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. 1986. Disease of the common fin whale (*Balaenoptera physalus*): Crassicaudiosis of the urinary system. *Journal of Mammalogy* 67(2):353-366.
- Lambertsen, R. H. 1990. Disease biomarkers in large whale populations of the North Atlantic and other oceans. Pages 395-417 in J. E. McCarthy, and L. R. Shugart, editors. Biomarkers of Environmental Contamination. Lewis Publishers, Boca Raton, Florida.
- Lambertsen, R. H. 1992. Crassicaudiosis: a parasitic disease threatening the health and population recovery of large baleen whales. *Rev. Sci. Technol., Off. Int. Epizoot.* 11(4):1131-1141.
- Lambertsen, R. H., B. A. Kohn, J. P. Sundberg, and C. D. Buergelt. 1987. Genital papillomatosis in sperm whale bulls. *Journal of Wildlife Diseases* 23(3):361-367.
- Landry, A. M., Jr., and D. Costa. 1999. Status of sea turtle stocks in the Gulf of Mexico with emphasis on the Kemp's ridley. Pages 248-268 in H. Kumpf, K. Steidinger, and K. Sherman, editors. The Gulf of Alaska: Physical Environment and Biological Resources. Blackwell Science, Malden, Massachusetts.
- Landry, A. M. J., and coauthors. 1996. Population Dynamics and Index Habitat Characterization for Kemp's Ridley Sea Turtles in Nearshore Waters of the Northwestern Gulf of Mexico. Report of Texas A&M Research Foundation pursuant to NOAA Award No. NA57FF0062:153.
- Landsberg, J. H., and coauthors. 1999. The potential role of natural tumor promoters in marine turtle fibropapillomatosis. *Journal of Aquatic Animal Health* 11(3):199-210.
- Laurance, W. F., and coauthors. 2008. Does rainforest logging threaten endangered sea turtles? *Oryx* 42:245-251.
- Laursen, D. C., H. L. Olsén, M. d. L. Ruiz-Gomez, S. Winberg, and E. Höglund. 2011. Behavioural responses to hypoxia provide a non-invasive method for distinguishing

- between stress coping styles in fish. *Applied Animal Behaviour Science* 132(3-4):211-216.
- Law, R. J., R. L. Stringer, C. R. Allchin, and B. R. Jones. 1996. Metals and organochlorines in sperm whales (*Physeter macrocephalus*) stranded around the North Sea during the 1994/1995 winter. *Marine Pollution Bulletin* 32(1):72-77.
- Lazar, B., and R. Gračan. 2010. Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea. *Marine Pollution Bulletin*.
- Leaper, R., and coauthors. 2006. Global climate drives southern right whale (*Eubalaena australis*) population dynamics. *Biology Letters* 2(2):289-292.
- Learmonth, J. A., and coauthors. 2006. Potential effects of climate change on marine mammals. *Oceanography and Marine Biology: an Annual Review* 44:431-464.
- LeBlanc, A. M., and coauthors. 2012. Nest temperatures and hatchling sex ratios from loggerhead turtle nests incubated under natural field conditions in Georgia, United States. *Chelonian Conservation and Biology* 11(1):108-116.
- Leblanc, A. M., and T. Wibbels. 2009. Effect of daily water treatment on hatchling sex ratios in a turtle with temperature-dependent sex determination. *Journal of Experimental Zoology Part A-Ecological Genetics and Physiology* 311A(1):68-72.
- Lee Long, W. J., R. G. Coles, and L. J. McKenzie. 2000. Issues for seagrass conservation management in Queensland. *Pacific Conservation Biology* 5:321-328.
- Lee Lum, L. 2003. An assessment of incidental turtle catch in the gillnet fishery in Trinidad and Tobago, West Indies. Institute for Marine Affairs, Chaguaramas, Trinidad.
- Lenhardt, M. L. 1994a. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pages 238-241 in K. A. C. Bjorndal, A. B. C. Bolten, D. A. C. Johnson, and P. J. C. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Lenhardt, M. L. 1994b. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pp.238-241 In: Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (Eds), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum, NMFS-SEFSC-351.
- Lenhardt, M. L. 2002. Sea turtle auditory behavior. *Journal of the Acoustical Society of America* 112(5 Part 2):2314.
- Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins, and J. A. Musick. 1983. Marine turtle reception of bone conducted sound. *The Journal of Auditory Research* 23:119-125.
- Levenson, C. 1974. Source level and bistatic target strength of the sperm whale (*Physeter catodon*) measured from an oceanographic aircraft. *Journal of the Acoustic Society of America* 55(5):1100-1103.
- 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.
- Lewison, R. L., and coauthors. 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proceedings of the National Academy of Sciences of the United States of America* 111(14):5271-5276.
- Lewison, R. L., S. A. Freeman, and L. B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: The impact of pelagic longlines on loggerhead and leatherback sea turtles. *Ecology Letters* 7:221-231.

- LGL Ltd. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the northern Yucatán Peninsula in the southern Gulf of Mexico, January-February 2005.
- LGL Ltd. 2005b. Marine mammal monitoring during Lamont-Doherty Earth Observatory's marine seismic study of the Blanco Fracture Zone in the Northeastern Pacific Ocean, October-November 2004.
- LGL Ltd. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off Central America, February–April 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.
- LGL Ltd. 2007. Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* off Central America, January–March 2008. Prepared for the Lamont-Doherty Earth Observatory, Palisades, NY, and the National Science Foundation, Arlington, VA, by LGL Ltd., environmental research associates, Ontario, Canada. LGL Report TA4342-1.
- LGL Ltd. 2008. Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* in the Gulf of Alaska, September 2008. Prepared by LGL Ltd., environmental research associates, King City, Ontario for the Lamont-Doherty Earth Observatory, Palisades, New York, and the National Science Foundation, Arlington, Virginia. LGL Report TA4412-1. 204p.
- 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.
- Limpus, C., and M. Chaloupka. 1997. Nonparametric regression modeling of green sea turtle growth rates (southern Great Barrier Reef). Marine Ecology Progress Series 149:23-34.
- Limpus, C. J., and N. Nicholls. 1988. The Southern Oscillation regulates the annual numbers of green turtles (*Chelonia mydas*) breeding around northern Australia. Australian Journal of Wildlife Research 15:157-161.
- Linder, C. A., G. G. Garwarkiewicz, and R. S. Pickart. 2004. Seasonal characteristics of bottom boundary layer detachment at the shelfbreak front in the Middle Atlantic Bight. Journal of Geophysical Research 109.
- Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41(3):183-194.
- Lockyer, C. 1972. The age at sexual maturity of the southern fin whale (*Balaenoptera physalus*) using annual layer counts in the ear plug. J. Cons. Int. Explor. Mer 34(2):276-294.
- Lockyer, C. 1981. Estimates of growth and energy budget for the sperm whale, *Physeter catodon*. FAO Fisheries Series 5:489-504.
- Løkkeborg, S. 1991. Effects of geophysical survey on catching success in longline fishing. Pages 1-9 in International Council for the Exploration of the Sea (ICES) Annual Science Conference.
- Løkkeborg, S., E. Ona, A. Vold, A. Salthaug, and J. M. Jech. 2012. Sounds from seismic air guns: Gear- and species-specific effects on catch rates and fish distribution. Canadian Journal of Fisheries and Aquatic Sciences 69(8):1278-1291.
- Løkkeborg, S., and A. V. Soldal. 1993. The influence of seismic explorations on cod (*Gadus morhua*) behaviour and catch rates. ICES Marine Science Symposium 196:62-67.

- Lopez, P., and J. Martin. 2001. Chemosensory predator recognition induces specific defensive behaviours in a fossorial amphibia. *Animal Behaviour* 62:259-264.
- Lurton, X., and S. DeRuiter. 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. *International Hydrographic Review* November:7-17.
- Luschi, P., G. C. Hays, and F. Papi. 2003. A review of long-distance movements by marine turtles, and the possible role of ocean currents. *Oikos* 103:293-302.
- Luschi, P., and coauthors. 2006. A review of migratory behaviour of sea turtles off southeastern Africa. *South African Journal of Science* 102:51-58.
- Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. *Marine Mammal Science* 22(4):802-818.
- Lutcavage, M., and J. A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. *Copeia* 1985(2):449-456.
- Lutcavage, M. E., P. Plotkin, B. Witherington, and P. L. Lutz. 1997a. Human impacts on sea turtle survival. Pages 387-409 in *The Biology of Sea Turtles*. CRC Press, Boca Raton, Florida.
- Lutcavage, M. E., P. Plotkin, B. E. Witherington, and P. L. Lutz. 1997b. Human impacts on sea turtle survival. Pages 387-409 in P. L. Lutz, and J. A. Musick, editors. *The Biology of Sea Turtles*. CRC Press, New York, New York.
- Lyrholm, T., and U. Gyllensten. 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. *Proceedings of the Royal Society of London B* 265(1406):1679-1684.
- Lyrholm, T., O. Leimar, and U. Gyllensten. 1996. Low diversity and biased substitution patterns in the mitochondrial DNA control region of sperm whales: implications for estimates of time since common ancestry. *Molecular Biology and Evolution* 13(10):1318-1326.
- Lyrholm, T., O. Leimar, B. Johannesson, and U. Gyllensten. 1999. Sex-biased dispersal in sperm whales: Contrasting mitochondrial and nuclear genetic structure of global populations. *Philosophical Transactions of the Royal Society of London, Series B: Biological Sciences* 266(1417):347-354.
- MacDonald, B. D., R. L. Lewison, S. V. Madrak, J. A. Seminoff, and T. Eguchi. 2012. Home ranges of East Pacific green turtles *Chelonia mydas* in a highly urbanized temperate foraging ground. *Marine Ecology Progress Series* 461:211-221.
- Mackintosh, N. A. 1965. *The stocks of whales*. Fishing News (Books) Ltd., London, UK.
- 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.
- Madsen, P. T., and coauthors. 2006. Quantitative measurements of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *Journal of the Acoustical Society of America* 120(4):2366-2379.
- Madsen, P. T., B. Møhl, B. K. Nielsen, and M. Wahlberg. 2002. Male sperm whale behaviour during seismic survey pulses. *Aquatic Mammals* 28(3):231-240.
- Maison, K. 2006. Do turtles move with the beach? Beach profiling and possible effects of development on a leatherback (*Dermochelys coriacea*) nesting beach in Grenada. Pages

- 145 in M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.
- Makowski, C., J. A. Seminoff, and M. Salmon. 2006. Home range and habitat use of juvenile Atlantic green turtles (*Chelonia mydas* L.) on shallow reef habitats in Palm Beach, Florida, USA. *Marine Biology* 148:1167-1179.
- Malme, C. I., and P. R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. Pages 253-280 in G. D. Greene, F. R. Engelhard, and R. J. Paterson, editors. Proc. Workshop on Effects of Explosives Use in the Marine Environment. Canada Oil & Gas Lands Administration, Environmental Protection Branch, Ottawa, Canada.
- 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. 1984. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration. Report prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Office under Contract No. 14-12-0001-29033. 357p.
- 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. Minerals Management Service, Anchorage, Alaska.
- Malme, C. I., B. Würsig, J. E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling.
- Malme, C. I. B., B. Würsig, J. E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. W. M. Sackinger, M. O. Jeffries, J. L. Imm, and S. D. Treacy, editors. Port and Ocean Engineering Under Arctic Conditions: Symposium on noise and marine mammals, University of Alaska at Fairbanks.
- Mancia, A., W. Warr, and R. W. Chapman. 2008. A transcriptomic analysis of the stress induced by capture-release health assessment studies in wild dolphins (*Tursiops truncatus*). *Molecular Ecology* 17(11):2581-2589.
- Mann, K. H., and J. R. N. Lazier. 1991. Dynamics of Marine Ecosystems: Biological-physical Interactions in the Oceans. Blackwell Science, Boston.
- Mansfield, K. L. 2006. Sources of mortality, movements, and behavior of sea turtles in Virginia. College of William and Mary.
- Mansfield, K. L., V. S. Saba, J. A. Keinath, and J. A. Musick. 2009. Satellite tracking reveals a dichotomy in migration strategies among juvenile loggerhead turtles in the Northwest Atlantic. *Marine Biology* 156(12):2555-2570.
- Marcovaldi, M. A., and M. Chaloupka. 2007. Conservation status of the loggerhead sea turtle in Brazil: An encouraging outlook. *Endangered Species Research* 3:133-143.
- Margaritoulis, D., and coauthors. 2003. Loggerhead turtles in the Mediterranean Sea: Present knowledge and conservation perspectives. Pages 175-198 in A. B. Bolten, and B. E. Witherington, editors. Loggerhead sea turtles. Smithsonian Books, Washington, D. C.
- Maritime, K. 2005. SBP 120 sub-bottom profiler.

- Marquez-M., R. 1994a. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempii*, (Garman, 1880). NOAA Technical Memorandum NMFS-SEFSC-343, or OCS Study MMS 94-0023. 91p.
- Marquez-M., R. 1994b. Synopsis of biological data on the Kemp's ridley turtle, *Lepidochelys kempii*, (Garman, 1880). U.S. Department of commerce, National Oceanic and Atmospheric Administration, NMFS-SEFSC-343.
- Márquez, M. R. 1990a. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date.
- Márquez, M. R. 1990b. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date. FAO Species Catalog, FAO Fisheries Synopsis 11(125):81p.
- Marquez, M. R., A. Villanueva, and P. M. Burchfield. 1989. Nesting population, and production of hatchlings of Kemp's ridley sea turtle at Rancho Nuevo, Tamaulipas, Mexico. Pages 16-19 in C. W. Caillouet Jr., and A. M. Landry Jr., editors. First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management.
- Marsili, L., and S. Focardi. 1996. Organochlorine levels in subcutaneous blubber biopsies of fin whales (*Balaenoptera physalus*) and striped dolphins (*Stenella coeruleoalba*) from the Mediterranean Sea. *Environmental Pollution* 91(1):1-9.
- Martin, A. R., and M. R. Clarke. 1986. The diet of sperm whales (*Physeter macrocephalus*) between Iceland and Greenland. *Journal of the Marine Biological Association of the United Kingdom* 66:779-790.
- Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural History of Oregon Coast Mammals. U.S. Department of Agriculture, Forest Service, General Technical Report PNW-133. 524p.
- Mate, B. R., and M. Baumgartner. 2001. Summer feeding season movements and fall migration of North Atlantic right whales from satellite-monitored radio tags. Pages 137 in Abstracts, Fourteenth Biennial Conference on the Biology of Marine Mammals. 28 November–3 December 2001, Vancouver, British Columbia.
- Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. *Marine Mammal Science* 15(4):12.
- Mate, B. R., S. L. Nieukirk, and S. D. Kraus. 1997. Satellite-monitored movements of the northern right whale. *Journal of Wildlife Management* 61(4):1393-1405.
- Mate, B. R., K. M. Stafford, and D. K. Ljungblad. 1994. A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustic Society of America* 96(5 part 2):3268–3269.
- Mateo, J. M. 2007. Ecological and hormonal correlates of antipredator behavior in adult Belding's ground squirrels (*Spermophilus beldingi*). *Behavioral Ecology and Sociobiology* 62(1):37-49.
- Matthews, J. N., and coauthors. 2001. Vocalisation rates of the North Atlantic right whale (*Eubalaena glacialis*). *Journal of Cetacean Research and Management* 3(3):271-282.
- 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.
- Maybaum, H. L. 1990. Effects of 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. *EOS Transactions of the American Geophysical Union* 71(2):92.

- Maybaum, H. L. 1993. Responses of humpback whales to sonar sounds. *Journal of the Acoustical Society of America* 94(3 Pt. 2):1848-1849.
- Mayo, C. A., and M. K. Marx. 1990. Surface foraging behaviour of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. *Canadian Journal of Zoology* 68:2214-2220.
- Mazaris, A. D., A. S. Kallimanis, S. P. Sgardelis, and J. D. Pantis. 2008. Do long-term changes in sea surface temperature at the breeding areas affect the breeding dates and reproduction performance of Mediterranean loggerhead turtles? Implications for climate change. *Journal of Experimental Marine Biology and Ecology*.
- Mazaris, A. D., A. S. Kallimanis, J. Tzanopoulos, S. P. Sgardelis, and J. D. Pantis. 2009a. Sea surface temperature variations in core foraging grounds drive nesting trends and phenology of loggerhead turtles in the Mediterranean Sea. *Journal of Experimental Marine Biology and Ecology*.
- Mazaris, A. D., G. Matsinos, and J. D. Pantis. 2009b. Evaluating the impacts of coastal squeeze on sea turtle nesting. *Ocean & Coastal Management* 52(2):139-145.
- McCall Howard, M. P. 1999. Sperm whales *Physeter macrocephalus* in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Dalhousie University, Halifax, Nova Scotia.
- McCarthy, A. L., S. Heppell, F. Royer, C. Freitas, and T. Dellinger. 2010. Identification of likely foraging habitat of pelagic loggerhead sea turtles (*Caretta caretta*) in the North Atlantic through analysis of telemetry track sinuosity. *Progress in Oceanography*.
- McCauley, R. D., and J. Fewtrell. 2013a. Experiments and observations of fish exposed to seismic survey pulses. *Bioacoustics* 17:205-207.
- McCauley, R. D., and J. Fewtrell. 2013b. Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses. *Bioacoustics* 17:315-318.
- McCauley, R. D., and coauthors. 2000a. Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Prepared for the Australian Petroleum Production Exploration Association by the Centre for Marine Science and Technology, Project CMST 163, Report R99-15. 203p.
- McCauley, R. D., and coauthors. 2000b. Marine seismic surveys - a study of environmental implications. Australian Petroleum Production & Exploration Association (APPEA) *Journal* 40:692-708.
- McCauley, R. D., J. Fewtrell, and A. N. Popper. 2003. High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America* 113:5.
- McCauley, R. D., M.-N. Jenner, C. Jenner, K. A. McCabe, and J. Murdoch. 1998. 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.
- McCauley, S. J., and K. A. Bjorndal. 1999. Conservation implications of dietary dilution from debris ingestion: Sublethal effects in post-hatchling loggerhead sea turtles. *Conservation Biology* 13(4):925-929.
- McClellan, C. M., A. J. Read, B. A. Price, W. M. Cluse, and M. H. Godfrey. 2009. Using telemetry to mitigate the bycatch of long-lived marine vertebrates. *Ecological Applications* 19(6):1660-1671.

- McDonald Dutton, D., and P. H. Dutton. 1998. Accelerated growth in San Diego Bay green turtles? Pages 175-176 in S. P. Epperly, and J. Braun, editors. Seventeenth Annual Sea Turtle Symposium.
- McDonald, M. A., J. Calambokidis, A. M. Teranishi, and J. A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. *Journal of the Acoustic Society of America* 109:1728-1735.
- McDonald, M. A., J. A. Hildebrand, S. Webb, L. Dorman, and C. G. Fox. 1993. Vocalizations of blue and fin whales during a midocean ridge airgun experiment. *Journal of the Acoustic Society of America* 94(3 part 2):1849.
- McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995a. Blue and fin whales observed on a seafloor array in the Northeast Pacific. *Journal of the Acoustical Society of America* 98(2 Part 1):712-721.
- McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995b. Blue and fin whales observed on a seafloor array in the northeast Pacific. *Journal of the Acoustical Society of America* 98(2 Part 1):712-721.
- McDonald, M. A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. *Journal of the Acoustical Society of America* 118(6):3941-3945.
- McDonald, M. A., S. L. Mesnick, and J. A. Hildebrand. 2006. Biogeographic characterization of blue whale song worldwide: using song to identify populations. *Journal of Cetacean Research and Management* 8(1):55-65.
- McDonald, M. A., and S. E. Moore. 2002. Calls recorded from North Pacific right whales (*Eubalaena japonica*) in the eastern Bering Sea. *Journal of Cetacean Research and Management* 4(3):261-266.
- McGowan, A., and coauthors. 2008. Down but not out: Marine turtles of the British Virgin Islands. *Animal Conservation* 11(2):92-103.
- McKenna, M. F. 2011. Blue whale response to underwater noise from commercial ships. University of California, San Diego.
- Mckenzie, C., B. J. Godley, R. W. Furness, and D. E. Wells. 1999. Concentrations and patterns of organochlorine contaminants in marine turtles from Mediterranean and Atlantic waters. *Marine Environmental Research* 47:117-135.
- 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.
- McMahon, C. R., and G. C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. *Global Change Biology* 12:1330-1338.
- Mead, J. G. 1977. Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean. Report of the Special Meeting of the Scientific Committee on Sei and Bryde's Whales, International Whaling Commission, La Jolla, California. p.113-116.
- 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.

- Meylan, A. B., B. W. Bowen, and J. C. Avise. 1990. A genetic test of the natal homing versus social facilitation models for green turtle migration. *Science* 248:724-727.
- Meylan, A. B., B. A. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Department of Environmental Protection (52):63.
- Miao, X., G. H. Balazsb, S. K. K. Murakawa, and Q. X. Li. 2001. Congener-specific profile, and toxicity assessment of PCBs in green turtles (*Chelonia mydas*) from the Hawaiian Islands. *The Science of the Total Environment* 281:247-253.
- Miller, G. W., R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales. R. W.J., editor. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998.
- Miller, G. W., and coauthors. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Pages 511-542 in S. L. Armsworthy, P. J. Cranford, and K. Lee, editors. *Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies*. Battelle Press, Columbus, Ohio.
- Miller, J. D., K. A. Dobbs, C. J. Limpus, N. Mattocks, and A. M. Landry Jr. 1998. Long-distance migrations by the hawksbill turtle, *Eretmochelys imbricata*, from north-eastern Australia. *Wildlife Research* 25(1):89-95.
- Miller, P. J. O., and coauthors. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep-Sea Research* in press.
- Mills, S. K., and J. H. Beatty. 1979. The propensity interpretation of fitness. *Philosophy of Science* 46:263-286.
- Milton, S. L., and P. L. Lutz. 2003. Physiological and genetic responses to environmental stress. Pages 163-197 in P. L. Lutz, J. A. Musick, and J. Wyneken, editors. *The Biology of Sea Turtles*, volume II. CRC Press, Boca Raton, Florida.
- Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. In: W.E. Schevill (Ed.) *The Whale Problem: A Status Report*. Harvard University Press, Cambridge, MA. Pp.108-169.
- Mitchell, E. 1975. Trophic relationships and competition for food in northwest Atlantic right whales. *Proceedings of the Canadian Society of Zoology Annual Meeting 1974*:123-133.
- Mitchell, E., and D. G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Report of the International Whaling Commission (Special Issue 1):117-120.
- 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., D. W. Rice, and J. M. Breiwick. 1984. The sei whale, *Balaenoptera borealis*. *Marine Fisheries Review* 46(4):25-29.
- MMS. 2007. Gulf of Mexico OCS oil and gas lease sales: 2007-2012, Western planning area sales 204, 207, 210, 215, and 218; Central planning area sales 205, 206, 208, 213, 216, and 222. Final environmental impact statement. U.S. Department of the Interior, Minerals Management Service.
- Moein Bartol, S., and D. R. Ketten. 2006. Turtle and tuna hearing. Pp.98-103 In: Swimmer, Y. and R. Brill (Eds), *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-7.

- Moein, S. E., and coauthors. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Final Report submitted to the U.S. Army Corps of Engineers, Waterways Experiment Station. Virginia Institute of Marine Science (VIMS), College of William and Mary, Gloucester Point, Virginia. 42p.
- Møhl, B., M. Wahlberg, P. T. Madsen, A. Heerfordt, and A. Lund. 2003. The monopulsed nature of sperm whale clicks. *Journal of the Acoustical Society of America* 114:12.
- Moline, M. A., H. Claustre, T. K. Frazer, O. Schofield, 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.
- Monagas, P., J. Oros, J. Anana, and O. M. Gonzalez-Diaz. 2008. Organochlorine pesticide levels in loggerhead turtles (*Caretta caretta*) stranded in the Canary Islands, Spain. *Marine Pollution Bulletin* 56:1949-1952.
- Montie, E. W., and coauthors. 2010. Brominated flame retardants and organochlorine contaminants in winter flounder, harp and hooded seals, and North Atlantic right whales from the Northwest Atlantic Ocean. *Marine Pollution Bulletin* 60(8):1160-1169.
- Monzon-Arguello, C., and coauthors. 2009. Variation in spatial distribution of juvenile loggerhead turtles in the eastern Atlantic and western Mediterranean Sea. *Journal of Experimental Marine Biology and Ecology* 373(2):79-86.
- Moore, J. C., and E. Clark. 1963. Discovery of right whales in the Gulf of Mexico. *Science* 141(3577):269.
- Moore, M. J., and coauthors. 2005. Morbidity and mortality of chronically entangled North Atlantic right whales: A major welfare issue. Pages 197 in Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
- Moore, S. E., and R. P. Angliss. 2006. Overview of planned seismic surveys offshore northern Alaska, July-October 2006. Paper SC/58/E6 presented to IWC Scientific Committee, St Kitts and Nevis.
- Morano, J. L., and coauthors. 2012. Acoustically detected year-round presence of right whales in an urbanized migration corridor. *Conservation Biology* 26(4):698-707.
- Moreira, L., and K. A. Bjorndal. 2006. Estimates of green turtle (*Chelonia mydas*) nests on Trindade Island, Brazil, South Atlantic. Pages 174 in N. Pilcher, editor Twenty-third Annual Symposium on Sea Turtle Biology and Conservation.
- Morreale, S. J., P. T. Plotkin, D. J. Shaver, and H. J. Kalb. 2007. Adult migration and habitat utilization. Pages 213-229 in P. T. Plotkin, editor. *Biology and conservation of Ridley sea turtles*. Johns Hopkins University Press, Baltimore, Maryland.
- Morreale, S. J., and E. A. Standora. 1998. Early Life Stage Ecology of Sea Turtles in Northeastern U.S. Waters. NOAA Technical Memorandum NMFS-SEFSC-413:49 pp.
- Morreale, S. J., E. A. Standora, F. V. Paladino, and J. R. Spotila. 1994. Leatherback migrations along deepwater bathymetric contours. Pp.109-110 In: Schoeder, B.A. and B.E. Witherington (Eds), *Proceedings of the 13th Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-341, Miami, Florida.
- Moulton, V. D., B. D. Mactavish, and R. A. Buchanan. 2006a. Marine mammal and seabird monitoring of Conoco-Phillips' 3-D seismic program in the Laurentian Sub-basin, 2005.
- Moulton, V. D., B. D. Mactavish, R. E. Harris, and R. A. Buchanan. 2006b. Marine mammal and seabird monitoring of Chevron Canada Limited's 3-D seismic program on the Orphan Basin, 2005.

- Moulton, V. D., and G. W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003.
- Mrosovsky, N. 1994. Sex ratios of sea turtles. *The Journal of Experimental Zoology* 270:16-27.
- Mrosovsky, N., S. R. Hopkins-Murphy, and J. I. Richardson. 1984. Sex ratio of sea turtles: seasonal changes. *Science* 225(4663):739-741.
- Mrosovsky, N., G. D. Ryan, and M. C. James. 2009. Leatherback turtles: The menace of plastic. *Marine Pollution Bulletin* 58(2):287-289.
- Mullin, K., and coauthors. 1994. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. *Fishery Bulletin* 92(773-786).
- Murakawa, S. K. K., G. H. Balazs, D. M. Ellis, S. Hau, and S. M. Eames. 2000. Trends in fibropapillomatosis among green turtles stranded in the Hawaiian Islands, 1982-98. K. H. J., and T. Wibbels, editors. *Nineteenth Annual Symposium on Sea Turtle Biology and Conservation*.
- Murison, L. D., and D. E. Gaskin. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. *Canadian Journal of Zoology* 67:1411-1420.
- Murphy, T. M., and S. R. Hopkins. 1984. Aerial and ground surveys of marine turtle nesting beaches in the southeast region. Final Report to NOAA/NMFS/SEFC, U.S. Department of Commerce, 73p.
- Musick, J. A., D. E. Barnard, and J. A. Keinath. 1994. Aerial estimates of seasonal distribution and abundance of sea turtles near the Cape Hatteras faunal barrier. Pages 121-123 in B. A. Schroeder, and B. E. Witherington, editors. *Thirteenth Annual Symposium on Sea Turtle Biology and Conservation*.
- Musick, J. A., and C. J. Limpus. 1997. Habitat utilization, and migration in juvenile sea turtles. Pages 137-163 in P. L. Lutz, and J. A. Musick, editors. *The biology of sea turtles*. CRC Press, Boca Raton, Florida.
- Mussoline, S. E., and coauthors. 2012. Seasonal and diel variation in North Atlantic right whale up-calls: Implications for management and conservation in the northwestern Atlantic Ocean. *Endangered Species Research* 17(1):17-26.
- Mysing, J. O., and T. M. Vanselous. 1989. Status of satellite tracking of Kemp's ridley sea turtles. Pages 122-115 in C. W. Caillouet Jr., and A. M. Landry Jr., editors. *First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management*. Texas A&M University
- Nance, J., and coauthors. 2008. Estimation of effort, maximum sustainable yield, and maximum economic yield in the shrimp fishery of the Gulf of Mexico. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center.
- Nasu, K. 1974. Movement of baleen whales in relation to hydrographic conditions in the northern part of the North Pacific Ocean and the Bering Sea. In: *Oceanography of the Bering Sea with Emphasis on Renewable Resources*: Hood, D.W. and E.J. Kelley (eds). *International Symposium for Bering Sea Study*, Hakodate, Japan, 31 January - 4 February 1972. p345-361.
- Nations, C. S., and coauthors. 2009. Effects of seismic exploration in the Beaufort Sea on bowhead whale call distributions. *Journal of the Acoustical Society of America* 126(4):2230.
- Nelson, M., M. Garron, R. L. Merrick, R. M. Pace III, and T. V. N. Cole. 2007a. Mortality and serious injury determinations for baleen whale stocks along the United States eastern

- seaboard and adjacent Canadian Maritimes, 2001-2005. U.S. Department of Commerce. Northeast Fisheries Science Center Reference Document 07-05.
- Nelson, M., M. Garron, R. L. Merrick, R. M. Pace III, and T. V. N. Cole. 2007b. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2001-2005. U.S. Department of Commerce, NOAA, Northeast Fisheries Science Center.
- Nelson, W. G., R. Brock, H. Lee II, J. O. Lamberson, and F. Cole. 2007c. 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. 1964. School of baleen whales in the feeding areas. Scientific Reports of the Whales Research Institute 18:89-110.
- New, L. F., and coauthors. 2013. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. *Functional Ecology* 27(2):314-322.
- Nichols, O. C., R. D. Kenney, and M. W. Brown. 2008. Spatial and temporal distribution of North Atlantic right whales (*Eubalaena glacialis*) in Cape Cod Bay, and implications for management. *Fishery Bulletin* 106(3):270-280.
- Nieukirk, S. L., K. M. Stafford, D. k. Mellinger, R. P. Dziak, and C. G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean *Journal of the Acoustical Society of America* 115:1832-1843.
- NMFS. 1987. Marine Mammal Protection Act of 1972. National Marine Fisheries Service.
- NMFS. 1995. Small takes of marine mammals incidental to specified activities; offshore seismic activities in southern California: Notice of issuance of an incidental harassment authorization. *Federal Register* 60(200):53753-53760.
- NMFS. 1997. Biological opinion on Navy activities off the southeastern United States along the Atlantic coast, National Marine Fisheries Service, Office of Protected Resources and the Southeast Regional Office.
- NMFS. 1998a. Draft recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 1998b. Recovery plan for the blue whale (*Balaenoptera musculus*). Prepared by Reeves, R.L., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the National Marine Fisheries Service, Silver Spring, Maryland. 42pp.
- NMFS. 2001a. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455.
- NMFS. 2001b. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic.
- NMFS. 2002a. Endangered Species Act - Section 7 consultation, biological opinion. Shrimp trawling in the southeastern United States under the sea turtle conservation regulations and as managed by the fishery management plans for shrimp in the South Atlantic and Gulf of Mexico. National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida.

- NMFS. 2002b. Endangered Species Act Section 7 consultation on shrimp trawling in the southeastern United States, under the sea turtle conservation regulations and as managed by the fishery management plans for shrimp in the South Atlantic and Gulf of Mexico. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- NMFS. 2003. Biological Opinion (Opinion) on the continued operation of Atlantic shark fisheries (commercial shark bottom longline and drift gillnet fisheries and recreational shark fisheries) under the Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks (HMS FMP) and the Proposed Rule for Draft Amendment 1 to the HMS FMP, July 2003. National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida. 65p.
- NMFS. 2004. Biological opinion on the authorization of pelagic fisheries under the fisheries management plan for the pelagic. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. 2005a. Biological Opinion on the Issuance of ESA Section 10(a)(1)(A) Permit No. 1451 to the National Marine Fisheries Service - Office of Sustainable Fisheries for Research on Sea Turtles. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 48p.
- NMFS. 2005b. Biological Opinion on the Issuance of Scientific Research Permits (batched) in the North Pacific Ocean for Research on Large Whales and Pinnipeds (Permit Nos. 545-1761, 587-1767, 1071-1770, 731-1774, 393-1772, 945-1776, 1000-1617, 774-1719-02, 774-1714). NMFS Office of Protected Resources, Silver Spring, Maryland. 61p.
- NMFS. 2005c. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). National Marine Fisheries Service.
- NMFS. 2006a. Biological Opinion on Sinking Exercises (SINKEX) in the Western North Atlantic Ocean. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland. 119p.
- NMFS. 2006b. Draft Recovery Plan for the Sperm Whale (*Physeter Macrocephalus*). National Marine Fisheries Service, Silver Spring, Maryland. 92p.
- NMFS. 2006c. National Marine Fisheries Service, Office of Protected Resources website: <http://www.nmfs.noaa.gov/pr/>.
- NMFS. 2006b. Draft Recovery Plan for the Sperm Whale (*Physeter Macrocephalus*). National Marine Fisheries Service, Silver Spring, Maryland. 92p.
- NMFS. 2006d. Biological Opinion on the issuance of an incidental harassment authorization to Scripps Institution of Oceanography for a marine seismic survey in the Eastern Tropical Pacific Ocean. National Marine Fisheries Service, Silver Spring, Maryland. 76p.
- NMFS. 2006e. Biological Opinion on Permitting Structure Removal Operations on the Gulf of Mexico Outer Continental Shelf and the Authorization for Take of Marine Mammals Incidental to Structure Removals on the Gulf of Mexico Outer Continental Shelf. National Marine Fisheries Service, Silver Spring, Maryland. 131p.
- NMFS. 2006g. Biological Opinion on the 2006 Rim-of-the-Pacific Joint Training Exercises (RIMPAC). National Marine Fisheries Service, Silver Spring, Maryland. 123p.
- NMFS. 2006h. Biological Opinion on the Funding and Permitting of Seismic Surveys by the National Science Foundation and the National Marine Fisheries Service in the Eastern Tropical Pacific Ocean from March to April 2006. National Marine Fisheries Service, Silver Spring, Maryland. 76p.

- NMFS. 2008. Draft U.S. Atlantic marine mammal stock assessments 2008.
- NMFS. 2011. Biological opinion on the continued authorization of reef fish fishing under the Gulf of Mexico (Gulf) Reef Fish Fishery Management Plan (RFFMP). NMFS.
- NMFS, and USFWS. 1998. Recovery plan for U.S. Pacific populations of the green turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, Maryland.
- NMFS, and USFWS. 2007a. Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, MD.
- NMFS, and USFWS. 2007b. Kemp's Ridley sea turtle (*Lepidochelys kempii*) 5-year review: Summary and evaluation. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources
- U.S. Department of the Interior, U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, Florida.
- NMFS, and USFWS. 2008. Draft recovery plan for the northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*): Second revision. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS, USFWS, and SEMARNAT. 2010. Draft bi-national recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*), second revision. National Marine Fisheries Service, U.S. Fish and Wildlife Service, and SEMARNAT, Silver Spring, Maryland.
- NMFS and USFWS. 1991b. Recovery Plan for U.S. Population of Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Washington, D.C.
- NMFS and USFWS. 1998d. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.
- NMFS and USFWS. 2010. Final draft report: Summary report of a meeting of the NMFS/USFWS cross-agency working group on joint listing of North Pacific and northwest Atlantic loggerhead turtle distinct population segments. NMFS and USFWS, Washington, D.C.
- NMFS USFWS. 2013. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: Summary and evaluation. NOAA, National Marine Fisheries Service, Office of Protected Resources and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Office.
- NMFS/SEFSC. 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the western North Atlantic. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-455.
- Noda, K., H. Akiyoshi, M. Aoki, T. Shimada, and F. Ohashi. 2007. Relationship between transportation stress and polymorphonuclear cell functions of bottlenose dolphins, *Tursiops truncatus*. Journal of Veterinary Medical Science 69(4):379-383.
- Norrgard, J. 1995. Determination of stock composition and natal origin of a juvenile loggerhead turtle population (*Caretta caretta*) in Chesapeake Bay using mitochondrial DNA analysis. Master's thesis. College of William and Mary, Williamsburg, Virginia.
- Norris, K. S., and G. W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale. Pages 393-417 in S. R. Galler, editor. Animal Orientation and Navigation.

- Norris, K. S., and G. W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale (*Physeter catodon* L.). *Animal Orientation and Navigation*. S. R. Galler, T. Schmidt-Koenig, G. J. Jacobs and R. E. Belleville (eds.). p.397-417. National Air and Space Administration, Washington, DC.
- Notarbartolo-Di-Sciara, G., C. W. Clark, M. Zanardelli, and S. Panigada. 1999. Migration patterns of fin whales, *Balaenoptera physalus*: Shaky old paradigms and local anomalies. Pages 118 in P. G. H. Evan, and E. C. M. Parsons, editors. Twelfth Annual Conference of the European Cetacean Society, Monaco.
- Nowacek, D., P. Tyack, and M. Johnson. 2003. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm signal. *Environmental Consequences of Underwater Sound (ECOUS) Symposium*, San Antonio, Texas
- Nowacek, D. P., M. P. Johnson, and P. L. Tyack. 2004a. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London B* 271:227-231.
- Nowacek, D. P., M. P. Johnson, and P. L. Tyack. 2004b. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society of London Series B Biological Sciences* 271(1536):227-231.
- Nowacek, D. P., and P. L. Tyack. 2013. Assessing effects of anthropogenic noise on the behaviour of marine mammals. *Bioacoustics* 17:338-341.
- NRC. 1990a. *Decline of the sea turtles: Causes and prevention*. National Research Council, Washington, D. C.
- NRC. 1990b. *Decline of the Sea Turtles: Causes and Prevention*. National Academy of Sciences, National Academy Press, Washington, D.C.
- NRC. 1990c. *Decline of the sea turtles: Causes and prevention*. (National Research Council). National Academy Press, Washington, D.C.
- 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.
- NSF. 2014. *Draft environmental assessment of a marine geophysical survey by the R/V Marcus G. Langseth in the Atlantic Ocean off New Jersey, June–July 2014*. National Science Foundation.
- O'Hara, J., and J. R. Wilcox. 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia* 1990(2):564-567.
- O'Hara, K. J., S. Iudicello, and R. Bierce. 1988. *A citizens guide to plastics in the ocean: More than a litter problem*. Center for Marine Conservation, Washington, D.C.
- Ogren, L. H. 1989. Distribution of juvenile and subadult Kemp's ridley sea turtles: Preliminary results from 1984-1987 surveys. Pages 116-123 in C. W. Caillouet Jr., and A. M. Landry Jr., editors. *First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation, and Management*.
- Øien, N. 1990. Sightings surveys in the northeast Atlantic in July 1988: distribution and abundance of cetaceans. *Report of the International Whaling Commission* 40:499-511.

- 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.
- Okuyama, J., and coauthors. 2009. Ontogeny of the dispersal migration of green turtle (*Chelonia mydas*) hatchlings. *Journal of Experimental Marine Biology and Ecology*.
- ONR. 2001. Final Environmental Impact Statement for the North Pacific Acoustic Laboratory. Prepared by the Office of Naval Research, Arlington, Virginia.
- Oros, J., O. M. Gonzalez-Diaz, and P. Monagas. 2009. High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain. *Chemosphere* 74(3):473-478.
- Orvik, L. M. 1997. Trace metal concentration in blood of the Kemp's ridley sea turtle (*Lepidochelys kempii*). Master's thesis. Texas A&M University, College Station, Texas.
- Overholtz, W. J., and J. R. Nicolas. 1979. Apparent feeding by the fin whale, *Balaenoptera physalus*, and humpback whale, *Megaptera novaeangliae*, on the American sand lance, *Ammodytes americanus*, in the northwest Atlantic. *Fishery Bulletin* 77(1):285-287.
- Pace III, R. M., and R. L. Merrick. 2008. Northwest Atlantic Ocean habitats important to the conservation of North Atlantic right whales (*Eubalaena glacialis*). Northeast Fisheries Science Center Reference Document 08-07.
- Pack, A. A., and coauthors. 2012. Size-assortative pairing and discrimination of potential mates by humpback whales in the Hawaiian breeding grounds. *Animal Behaviour* 84(4):983-993.
- Pack, A. A., and coauthors. 2009. Male humpback whales in the Hawaiian breeding grounds preferentially associate with larger females. *Animal Behaviour* 77(3):653-662.
- Palacios, D. M., and B. R. Mate. 1996. Attack by false killer whales (*Pseudorca crassidens*) on sperm whales (*Physeter macrocephalus*) in the Galápagos Islands. *Marine Mammal Science* 12(4):582-587.
- Palka, D. 2012. Cetacean abundance estimates in U.S. northwestern Atlantic Ocean waters from summer 2011 line transect survey. Pages 37 in N. F. S. Center, editor Northeast Fisheries Science Center Reference Document 12-29. National Marine Fisheries Service, Woods Hole, MA.
- Palsbøll, P. J., and coauthors. 1997. Genetic tagging of humpback whales. *Nature* 388:767-769.
- Panigada, S., and coauthors. 2008. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. *Remote Sensing of Environment* 112(8):3400-3412.
- Parente, C. L., J. P. Araujo, and M. E. Araujo. 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. *Biota Neotropica* 7(1).
- Parker, D. M., and G. H. Balazs. in press. Diet of the oceanic green turtle, *Chelonia mydas*, in the North Pacific. Twenty-fifth Annual Symposium on Sea Turtle Biology and Conservation.
- Parker, D. M., W. J. Cooke, and G. H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (*Caretta caretta*) in the central North Pacific. *Fishery Bulletin* 103:142-152.
- Parks, S. E., and C. W. Clark. 2007. Acoustic communication: Social sounds and the potential impacts of noise. Pages 310-332 in S. D. Kraus, and R. Rolland, editors. *The Urban Whale: North Atlantic Right Whales at the Crossroads*. Harvard University Press, Cambridge, Massachusetts.

- Parks, S. E., C. W. Clark, and P. L. Tyack. 2005a. North Atlantic right whales shift their frequency of calling in response to vessel noise. Pages 218 in Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
- Parks, S. E., C. W. Clark, and P. L. Tyack. 2007a. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America* 122(6):3725-3731.
- Parks, S. E., C. W. Clark, and P. L. Tyack. 2013. Long- and short-term changes in right whale acoustic behaviour in increased low-frequency noise. *Bioacoustics* 17:179-180.
- Parks, S. E., P. K. Hamilton, S. D. Kraus, and P. L. Tyack. 2005b. The gunshot sound produced by male North Atlantic right whales (*Eubalaena glacialis*) and its potential function in reproductive advertisement. *Marine Mammal Science* 21(3):458-475.
- Parks, S. E., C. F. Hotchkiss, K. A. Cortopassi, and C. W. Clark. 2012a. Characteristics of gunshot sound displays by North Atlantic right whales in the Bay of Fundy. *Journal of the Acoustical Society of America* 131(4):3173-3179.
- Parks, S. E., M. Johnson, D. Nowacek, and P. L. Tyack. 2011a. Individual right whales call louder in increased environmental noise. *Biology Letters* 7(1):33-35.
- Parks, S. E., M. Johnson, and P. Tyack. 2010. Changes in vocal behavior of individual North Atlantic right whales in increased noise. *Journal of the Acoustical Society of America* 127(3 Pt 2):1726.
- Parks, S. E., M. P. Johnson, D. P. Nowacek, and P. L. Tyack. 2012b. Changes in vocal behavior of North Atlantic right whales in increased noise. Pages 4 in A. N. Popper, and A. Hawkings, editors. *The Effects of Noise on Aquatic Life*. Springer Science.
- Parks, S. E., D. R. Ketten, J. T. O'Malley, and J. Arruda. 2007b. Anatomical predictions of hearing in the North Atlantic right whale. *Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology* 290(6):734-744.
- Parks, S. E., K. M. Kristrup, S. D. Kraus, and P. L. Tyack. 2003. Sound production by North Atlantic right whales in surface active groups. Pages 127 in Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.
- Parks, S. E., S. E. Parks, C. W. Clark, and P. L. Tyack. 2006. Acoustic Communication in the North Atlantic Right Whale (*Eubalaena glacialis*) and Potential Impacts of Noise. *EOS, Transactions, American Geophysical Union* 87(36):Ocean Sci. Meet. Suppl., Abstract OS53G-03.
- Parks, S. E., and P. L. Tyack. 2005. Sound production by North Atlantic right whales (*Eubalaena glacialis*) in surface active groups. *Journal of the Acoustical Society of America* 117(5):3297-3306.
- Parks, S. E., I. Urazghildiiev, and C. W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. *Journal of the Acoustical Society of America* 125(2):1230-1239.
- Parks, S. E., J. D. Warren, K. Stamieszkin, C. A. Mayo, and D. Wiley. 2011b. Dangerous dining: Surface foraging of North Atlantic right whales increases risk of vessel collisions. *Biology Letters* 8(1):57-60.
- Parsons, T. R., M. Takahashi, and B. Hargraves. 1984. *Biological Oceanographic Processes*. Pergamon Press, oXFORD.
- Patterson, B., and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. W. N. Tavolga, editor. *Marine bioacoustics*.
- Patterson, P. D. 1966. Hearing in the turtle. *Journal of Auditory Research* 6:453.

- Payne, J. F., and coauthors. 2013. Are seismic surveys an important risk factor for fish and shellfish? *Bioacoustics* 17:262-265.
- Payne, J. F., J. Coady, and D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (*Lophius americanus*) and larvae., St. John's, Newfoundland.
- Payne, K., and R. Payne. 1985. Large scale changes over 19 years in songs of humpback whales in Bermuda. *Zeitschrift Fur Tierpsychologie* 68:89-114.
- 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. 1990a. 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.
- Payne, P. M., and coauthors. 1990b. 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.
- Payne, R., and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences* 188:110-141.
- Payne, R. S. 1970. Songs of the humpback whale. Capital Records, Hollywood.
- Pearson, W. H., J. R. Skalski, and C. I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49:1343-1356.
- Pelletier, D., D. Roos, and S. Ciccione. 2003. Oceanic survival and movements of wild and captive-reared immature green turtles (*Chelonia mydas*) in the Indian Ocean. *Aquatic Living Resources* 16:35-41.
- Pendleton, D. E., and coauthors. 2009. Regional-scale mean copepod concentration indicates relative abundance of North Atlantic right whales. *Marine Ecology Progress Series* 378:211-225.
- 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.
- Perrault, J. R., D. L. Miller, J. Garner, and J. Wyneken. 2013. Mercury and selenium concentrations in leatherback sea turtles (*Dermochelys coriacea*): Population comparisons, implications for reproductive success, hazard quotients and directions for future research. *Science of the Total Environment* 463-464:61-71.
- 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.
- Pershing, A. J., and coauthors. 2001. Oceanographic responses to climate in the Northwest Atlantic. *Oceanography* 14(3):76-82.
- Perugini, M., and coauthors. 2006. Polychlorinated biphenyls and organochlorine pesticide levels in tissues of *Caretta caretta* from the Adriatic Sea. *Diseases of Aquatic Organisms* 71(2):155-161.
- Petersen, S. L., M. B. Honig, P. G. Ryan, R. Nel, and L. G. Underhill. 2009. Turtle bycatch in the pelagic longline fishery off southern Africa. *African Journal of Marine Science* 31(1):87-96.

- Picanco, C., I. Carvalho, and C. Brito. 2009. Occurrence and distribution of cetaceans in Sao Tome and Principe tropical archipelago and their relation to environmental variables. *Journal of the Marine Biological Association of the United Kingdom* 89(5):1071-1076.
- Pickard, G. L., and W. J. Emery. 1990. *Descriptive Physical Oceanography: An Introduction*, 5th edition. Pergamon Press, Oxford.
- Pickett, G. D., D. R. Eaton, R. M. H. Seaby, and G. P. Arnold. 1994. Results of bass tagging in Poole Bay during 1992. MAFF Direct. Fish. Res., Lowestoft, England.
- Pike, D. A. 2009. Do green turtles modify their nesting seasons in response to environmental temperatures? *Chelonian Conservation and Biology* 8(1):43-47.
- Pike, D. A. 2014. Forecasting the viability of sea turtle eggs in a warming world. *Global Change Biology* 20(1):7-15.
- 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. Vikingsson. 2009a. Trends in the distribution and abundance of cetaceans from aerial surveys in Icelandic coastal waters, 1986-2001. *NAMMCO Scientific Publications* 7:117-142.
- Pike, D. G., G. A. Vikingsson, T. Gunnlaugsson, and N. Øien. 2009b. A note on the distribution and abundance of blue whales (*Balaenoptera musculus*) in the Central and Northeast North Atlantic. *NAMMCO Scientific Publications* 7:19-29.
- Pike, G. C., and I. B. MacAskie. 1969. Marine mammals of British Columbia. *Bulletin of the Fisheries Research Board of Canada* 171:1-54.
- 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*.
- Pinela, A. M., and coauthors. 2009. Population genetics and social organization of the sperm whale (*Physeter macrocephalus*) in the Azores inferred by microsatellite analyses. *Canadian Journal of Zoology* 87(9):802-813.
- Piniak, W. E. D. 2012. *Acoustic ecology of sea turtles: Implications for conservation*. Duke University.
- 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.
- Pitman, R. L., L. T. Ballance, S. I. Mesnick, and S. J. Chivers. 2001. Killer whale predation on sperm whales: observations and implications. *Marine Mammal Science* 17(3):494-507.
- Pitman, R. L., and P. H. Dutton. 2004. Killer whale predation on a leatherback turtle in the Northeast Pacific. *Northwest Science* 58:497-498.
- Pivorunas, A. 1979. The feeding mechanisms of baleen whales. *American Scientist* 67:432-440.
- Plotkin, P. 2003. Adult migrations and habitat use. Pages 225-241 *in* P. L. Lutz, J. A. Musick, and J. Wyneken, editors. *Biology of sea turtles, volume II*. CRC Press, Boca Raton, Florida.
- Plotkin, P. T., (Ed). 1995. *National Marine Fisheries Service and the U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973*. National Marine Fisheries Service, Silver Spring, Maryland.

- Podreka, S., A. Georges, B. Maher, and C. J. Limpus. 1998. The environmental contaminant DDE fails to influence the outcome of sexual differentiation in the marine turtle *Chelonia mydas*. *Environmental Health Perspectives* 106(4):185-188.
- 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.
- Popper, A. N., and coauthors. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America* 117(6):3958-3971.
- Poppi, L., and coauthors. 2012. Post-mortem investigations on a leatherback turtle *Dermochelys coriacea* stranded along the Northern Adriatic coastline. *Diseases of Aquatic Organisms* 100(1):71-76.
- Potter, J. R., and coauthors. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. *IEEE Journal of Oceanic Engineering* 32(2):469-483.
- Prescott, R. 2000. Sea turtles in New England waters. *Conservation Perspectives*.
- Pritchard, P. C. H. 1971. The leatherback or leathery turtle, *Dermochelys coriacea*. IUCN Monograph 1:1-39.
- Pritchard, P. C. H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea* in Pacific Mexico, with a new estimate of the world population status. *Copeia* 1982 (4):741-747.
- Pritchard, P. C. H. 1997. Evolution, phylogeny, and current status. Pages 1-28 *in* P. L. Lutz, and J. A. Musick, editors. *The Biology of Sea Turtles*. CRC Press, Boca Raton, Florida.
- Pritchard, P. C. H., and M. R. Marquez. 1973. Kemp's ridley turtle or Atlantic ridley, *Lepidochelys kempi*.
- Pugh, R. S., and P. R. Becker. 2001a. Sea turtle contaminants: A review with annotated bibliography. U.S. Department of Commerce, National Institute of Standards and Technology, Chemical Science and Technology Laboratory, Charleston, South Carolina.
- Pugh, R. S., and P. R. Becker. 2001b. Sea turtle contaminants: A review with annotated bibliography. U.S. Department of Commerce, National Institute of Standards and Technology, Chemical Science and Technology Laboratory, Charleston, South Carolina.
- 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. Cowlshaw, and G. M. Mace. 2000. Predicting extinction risk in declining species. *Proceedings of the Royal Society B-Biological Sciences* 267:1947-1952.
- 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.
- Ramírez-Gallego, C., C. E. Diez, K. Barrientos-Muñoz, A. White, and A. M. Roman. 2013. Continued decline of nesting leatherback turtles at Culebra Island, Puerto Rico. Pages

- 193 in T. Tucker, and coeditors, editors. Thirty-Third Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Baltimore, Maryland.
- Rankin-Baransky, K. 1997. Origin of loggerhead turtles (*Caretta caretta*) in the western North Atlantic Ocean as determined by mtDNA analysis. Masters Thesis submitted to Drexel University, June 1997. 49p.
- Rankin, S., and J. Barlow. 2007a. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. *Bioacoustics - The International Journal of Animal Sound and Its Recording* 16(2):137-145.
- Rankin, S., and J. Barlow. 2007b. Vocalizations of the sei whale *Balaenoptera borealis* off the Hawaiian Islands. *Bioacoustics* 16(2):137-145.
- Reep, R. L., and coauthors. 2011. Manatee vibrissae: Evidence for a lateral line function. *Annals of the New York Academy of Sciences* 1225(1):101-109.
- Rees, A. F., and D. Margaritoulis. 2004. Beach temperatures, incubation durations, and estimated hatchling sex ratio for loggerhead sea turtle nests in southern Kyparissia Bay, Greece. *British Chelonia Group Testudo* 6(1):23-36.
- Reeves, R. R. 2001. Overview of catch history, historic abundance, and distribution of right whales in the western North Atlantic, and in Cintra Bay, West Africa. *Journal of Cetacean Research and Management* 2:187-192.
- Reeves, R. R., P. J. Clapham, R. L. B. Jr., and G. K. Silber. 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). Office of Protected Resources, Silver Spring, MD.
- Reeves, R. R., P. J. Clapham, and S. E. Wetmore. 2002. 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., and coauthors. 2014. Distribution of endemic cetaceans in relation to hydrocarbon development and commercial shipping in a warming Arctic. *Marine Policy* 44:375-389.
- 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., J. Mead, and S. Katona. 1978. The right whale, *Eubalaena glacialis*, in the western North Atlantic. *Report of the International Whaling Commission* 28:303-312.
- Reeves, R. R., T. D. Smith, and E. Josephson. 2007. Near annihilation of a species: right whaling in the North Atlantic. Pages 39-74 in S. D. Kraus, and R. M. Rolland, editors. *The urban whale: North Atlantic right whales at the crossroads*. Harvard University Press, Cambridge, Massachusetts.
- Reeves, R. R., T. D. Smith, E. A. Josephson, P. J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. *Marine Mammal Science* 20(4):774-786.
- Reeves, R. R., 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.
- Reeves, R. R., and H. Whitehead. 1997. Status of the sperm whale, *Physeter macrocephalus*, in Canada. *Canadian Field-Naturalist* 111(2):293-307.
- Reich, K. J., and coauthors. 2010. Polymodal foraging in adult female loggerheads (*Caretta caretta*). *Marine Biology* 157:113-121.

- 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.
- Reid, K. A., D. Margaritoulis, and J. R. Speakman. 2009. Incubation temperature and energy expenditure during development in loggerhead sea turtle embryos. *Journal of Experimental Marine Biology and Ecology* 378:62-68.
- Reilly, S. B., and V. G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the Eastern Tropical Pacific. *Marine Mammal Science* 6(4):265-277.
- Reina, R., and coauthors. 2013. Historical versus contemporary climate forcing on the annual nesting variability of loggerhead sea turtles in the northwest Atlantic Ocean. *PLoS ONE* 8(12):e81097.
- Reina, R., and coauthors. 2012. Inferring foraging areas of nesting loggerhead turtles using satellite telemetry and stable isotopes. *PLoS ONE* 7(9):e45335.
- Reina, R. D., J. R. Spotila, F. V. Paladino, and A. E. Dunham. 2008. Changed reproductive schedule of eastern Pacific leatherback turtles *Dermochelys coriacea* following the 1997–98 El Niño to La Niña transition. *Endangered Species Research*.
- Reiner, F., M. E. Dos Santos, and F. W. Wenzel. 1996. Cetaceans of the Cape Verde archipelago. *Marine Mammal Science* 12(3):434-443.
- Reiner, F., J. M. Gonçalves, and R. S. Santos. 1993. Two new records of Ziphiidae (Cetacea) for the Azores with an updated checklist of cetacean species. *Arquipélago (Life and Marine Sciences)* 11A:113-118.
- Renaud, M. L. 1995a. Movements and submergence patterns of Kemp's ridley turtles (*Lepidochelys kempii*). *Journal of Herpetology* 29(No. 3):370-374.
- Renaud, M. L. 1995b. Movements and submergence patterns of Kemp's ridley turtles (*Lepidochelys kempii*). *Journal of Herpetology* 29(3):370-374.
- Renaud, M. L., J. A. Carpenter, J. A. Williams, and A.M. Landry, Jr. 1996. Kemp's ridley sea turtle (*Lepidochelys kempii*) tracked by satellite telemetry from Louisiana to nesting beach at Rancho Nuevo, Tamaulipas, Mexico. *Chelonian Conservation and Biology* 2(1):108-109.
- Renault, T., and coauthors. 2000. Haplosporidiosis in the Pacific oyster *Crassostrea gigas* from the French Atlantic coast. *Diseases of Aquatic Organisms* 42:207–214.
- Rendell, L., S. L. Mesnick, M. L. Dalebout, J. Burtenshaw, and H. Whitehead. 2011. Can genetic differences explain vocal dialect variation in sperm whales, *Physeter macrocephalus*? *Behavior Genetics*.
- Rice, D. W. 1974. Whales and whale research in the eastern North Pacific. Pages 170-195 in: Schevill, W.E. editor. *The whale problem, a status report*. Harvard University Press, Cambridge, Massachusetts.
- Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Report of the International Whaling Commission (Special Issue 1):92-97.
- Rice, D. W. 1978. Sperm whales.p.82-87 *In*: D. Haley (ed), *Marine Mammals of the Eastern North Pacific and Arctic Waters*. Pacific Search Press, Seattle, Washington. 256p.
- Rice, D. W. 1989a. Sperm whale, *Physeter macrocephalus* Linnaeus, 1758. Pp.177-233 *In*: S. H. Ridgway and R. Harrison (Eds), *Handbook of Marine Mammals: Volume 4, River Dolphins and the Larger Toothed Whales*. Academy Press, London.

- Rice, D. W. 1989b. Sperm whale, *Physeter macrocephalus* Linnaeus, 1758. Pages 177-233 in S. H. Ridgway, and R. Harrison, editors. Handbook of marine mammals: Volume 4: River dolphins and the larger toothed whales. Academy Press, London.
- Rice, D. W. 1998a. Marine Mammals of the World. Systematics and Distribution. Special Publication Number 4. The Society for Marine Mammalogy, Lawrence, Kansas.
- Rice, D. W. 1998b. Marine mammals of the world.: Systematics and distribution. Special Publication Number 4. The Society for Marine Mammalogy, Lawrence, Kansas.
- Richardson, P. B., and coauthors. 2012. Leatherback turtle conservation in the Caribbean UK overseas territories: Act local, think global? Marine Policy.
- Richardson, T. H., J. I. Richardson, C. Ruckdeshel, and M. W. Dix. 1978. Remigration patterns of loggerhead sea turtles (*Caretta caretta*) nesting on Little Cumberland and Cumberland Islands, Georgia. Florida Marine Research Publications 33:39-44.
- Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995a. Marine mammals and noise. Academic Press, San Diego, California.
- Richardson, W. J., M. A. Fraker, B. Würsig, and R. S. Wells. 1985. Behavior of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: Reactions to industrial activities. Biological Conservation 32(3):195-230.
- Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson. 1995b. Marine mammals and noise. MMS Contr. 14-12-0001-30673. Acad. Press, San Diego, Calif., 576 p.
- Richardson, W. J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995c. Marine mammals and noise. Academic Press; San Diego, California.
- Richardson, W. J., G. W. Miller, and J. C.R. Greene. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America 106(4-2):2281.
- Richardson, W. J., B. Würsig, and C. R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4):1117-1128.
- 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.
- Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin, and J. H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. Proceedings of the National Academies of Science 64.
- Rivalan, P., and coauthors. 2005. Trade-off between current reproductive effort and delay to next reproduction in the leatherback sea turtle. Oecologia 145(4):564-574.
- Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.
- 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.
- Roark, A. M., K. A. Bjorndal, and A. B. Bolten. 2009. Compensatory responses to food restriction in juvenile green turtles (*Chelonia mydas*). Ecology 90(9):2524-2534.
- Robertson, F. C., and coauthors. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endangered Species Research 21(2):143-160.

- Robinson, R. A., and coauthors. 2008. Travelling through a warming world: climate change and migratory species. *Endangered Species Research*.
- Roe, J. H., P. R. Clune, and F. V. Paladino. 2013. Characteristics of a leatherback nesting beach and implications for coastal development. *Chelonian Conservation and Biology* 12(1):34-43.
- Rolland, R. M., and coauthors. 2012a. Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society of London Series B Biological Sciences* 279(1737):2363-2368.
- Rolland, R. M., and coauthors. 2012b. Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences*.
- Roman, J., and S. R. Palumbi. 2003. Whales before whaling in the North Atlantic. *Science* 301:508-510.
- Romero, A., A. I. Agudo, S. M. Green, and G. Notarbartolo Di Sciara. 2001. Cetaceans of Venezuela: Their Distribution and Conservation Status. NOAA Technical Report NMFS-151. Seattle, Washington. 60p.
- 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.
- Rosenbaum, H. C., and coauthors. 2000. World-wide genetic differentiation of *Eubalana*: questioning the number of right whale species. *Molecular Ecology* 9:1793-1802.
- Rostal, D. C. 2007. Reproductive physiology of the ridley sea turtle. Pages 151-165 in: Plotkin P.T., editor. *Biology and conservation of ridley sea turtles*. Johns Hopkins University Press, Baltimore, Maryland.
- Rostal, D. C., J. S. Grumbles, R. A. Byles, M. R. Márquez, and D. W. Owens. 1997. Nesting physiology of wild Kemp's ridley turtles, *Lepidochelys kempii*, at Rancho Nuevo, Tamaulipas, Mexico. *Chelonian Conservation and Biology* 2:538-547.
- Ruegg, K., and coauthors. 2013. Long-term population size of the North Atlantic humpback whale within the context of worldwide population structure. *Conservation Genetics* 14(1):103-114.
- Ruud, J. T. 1956. The blue whale. *Scientific American* 195:46-50.
- Ryan, C., and coauthors. 2014. Levels of persistent organic pollutants in eastern North Atlantic humpback whales. *Endangered Species Research* 22(3):213-223.
- Ryan, J. P., J. A. Yoder, J. A. Barth, and P. C. Cornillon. 1999a. Chlorophyll enhancement and mixing associated with meanders of the shelf break front in the Mid-Atlantic Bight. *Journal of Geophysical Research* 104(C10):23479-23493.
- Ryan, J. P., J. A. Yoder, and P. C. Cornillon. 1999b. Enhanced chlorophyll at the shelfbreak of the Mid-Atlantic Bight and Georges Bank during the spring transition. *Limnology and Oceanography* 44(1):1-11.
- Rybitski, M. J., R. C. Hale, and J. A. Musick. 1995. Distribution of organochlorine pollutants in Atlantic sea turtles. *Copeia* 1995 (2):379-390.
- Saeki, K., H. Sakakibara, H. Sakai, T. Kunito, and S. Tanabe. 2000. Arsenic accumulation in three species of sea turtles. *Biometals* 13(3):241-250.
- Sale, A., and P. Luschi. 2009. Navigational challenges in the oceanic migrations of leatherback sea turtles. *Proceedings of the Royal Society B-Biological Sciences* 276(1674):3737-3745.

- Sale, A., and coauthors. 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. *Journal of Experimental Marine Biology and Ecology* 328:197-210.
- 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.
- Samaran, F., C. Guinet, O. Adam, J.-F. o. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. *The Journal of the Acoustical Society of America* 127(6):3800.
- Samuel, Y., S. J. Morreale, C. W. Clark, C. H. Greene, and M. E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. *The Journal of the Acoustical Society of America* 117(3):1465-1472.
- Santana Garcon, J., A. Grech, J. Moloney, and M. Hamann. 2010. Relative Exposure Index: An important factor in sea turtle nesting distribution. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20:140-149.
- Santidrián Tomillo, P., and coauthors. 2007. Reassessment of the leatherback turtle (*Dermochelys coriacea*) nesting population at Parque Nacional Marino Las Baulas, Costa Rica: Effects of conservation efforts. *Chelonian Conservation and Biology* 6(1):54-62.
- Santulli, A., and coauthors. 1999. Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. *Marine Pollution Bulletin* 38(12):1105-1114.
- Sarmiento-Ramirez, J. M., and coauthors. 2014. Global distribution of two fungal pathogens threatening endangered sea turtles. *PLoS ONE* 9(1):e85853.
- Sasso, C. R., S. P. Epperly, and C. Johnson. 2011. Annual survival of loggerhead sea turtles (*Caretta caretta*) nesting in peninsular Florida: A cause for concern. *Herpetological Conservation and Biology* 6(3):443-448.
- Scarff, J. E. 1986. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50°N and east of 180°W. *Report of the International Whaling Commission (Special Issue 10):43-63*.
- Schilling, M. R., and coauthors. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. *Fishery Bulletin* 90:749-755.
- Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *Journal of the Acoustical Society of America* 107(6):3496-3508.
- Schmeits, M. J., and H. A. Dijkstra. 2000. Physics of the 9-month variability in the Gulf Stream region: Combining data and dynamical systems analyses. *Journal of Physical Oceanography* 30(8):1967-1987.
- Schmid, J. R. 1998a. Marine turtle populations on the west-central coast of Florida: Results of tagging studies at the Cedar Keys, Florida, 1986-1995. *Fishery Bulletin* 96(3):589-602.

- Schmid, J. R. 1998b. Marine turtle populations on the west central coast of Florida: Results of tagging studies at the Cedar Keys, Florida, 1986-1995. *Fishery Bulletin* 96:589-602.
- Schmid, J. R., A. B. Bolten, K. A. Bjorndal, and W. J. Lindberg. 2002. Activity patterns of Kemp's ridley turtles, *Lepidochelys kempii*, in the coastal waters of the Cedar Keys, Florida. *Marine Biology* 140(2):215-228.
- Schmid, J. R., and W. N. Witzell. 1997a. Age and growth of wild Kemp's ridley turtles (*Lepidochelys kempi*): Cumulative results of tagging studies in Florida. *Chelonian Conservation and Biology* 2(4):20 pp.
- Schmid, J. R., and W. N. Witzell. 1997b. Age and growth of wild Kemp's ridley turtles (*Lepidochelys kempii*): Cumulative results of tagging studies in Florida. *Chelonian Conservation and Biology* 2(4):532-537.
- Schmidly, D. J., C. O. Martin, and G. F. Collins. 1972. First occurrence of a black right whale (*Balaena glacialis*) along the Texas coast. *Southwestern Naturalist* 17(2):214-215.
- Schoenherr, J. R. 1991. Blue whales feeding on high concentrations of euphausiids in around Monterey Submarine Canyon. *Canadian Journal of Zoology* 69: 583-594.
- Schofield, G., and coauthors. 2009. Microhabitat selection by sea turtles in a dynamic thermal marine environment. *Journal of Animal Ecology* 78(1):14-21.
- Schroeder, B. A., and N. B. Thompson. 1987. Distribution of the loggerhead turtle, *Caretta caretta*, and the leatherback turtle, *Dermochelys coriacea*, in the Cape Canaveral, Florida area: Results of aerial surveys. Pages 45-53 in W. N. Witzell, editor *Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop*.
- 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, T. M., and S. Sadove. 1997. Sperm whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. *Marine Mammal Science* 13(2):4.
- Sears, C. J. 1994. Preliminary genetic analysis of the population structure of Georgia loggerhead sea turtles. NOAA Technical Memorandum NMFS-SEFSC-351. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.
- Sears, C. J., and coauthors. 1995. Demographic composition of the feeding population of juvenile loggerhead sea turtles (*Caretta caretta*) off Charleston, South Carolina: evidence from mitochondrial DNA markers. *Marine Biology* 123:869-874.
- Sears, R., C. Ramp, A. B. Douglas, and J. Calambokidis. 2014. Reproductive parameters of eastern North Pacific blue whales *Balaenoptera musculus*. *Endangered Species Research* 22(1):23-31.
- Sears, R., and coauthors. 1987. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Report of the International Whaling Commission (Special Issue 12):335-342.
- Sears, R., and coauthors. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Reports of the International Whaling Commission Special Issue 12:335-342.
- Seminoff, J. A. 2004a. 2004 global status assessment: Green turtle (*Chelonia mydas*). The World Conservation Union (International Union for Conservation of Nature and Natural

- Resources), Species Survival Commission Red List Programme, Marine Turtle Specialist Group.
- Seminoff, J. A. 2004b. 2004 global status assessment: Green turtle (*Chelonia mydas*). IUCN Marine Turtle Specialist Group Review.
- Seminoff, J. A., and T. T. Jones. 2006. Diel movements and activity ranges of green turtles (*Chelonia mydas*) at a temperate foraging area in the Gulf of California, Mexico. *Herpetological Conservation and Biology* 1(2):81-86.
- Seminoff, J. A., T. T. Jones, A. Resendiz, W. J. Nichols, and M. Y. Chaloupka. 2003. Monitoring green turtles (*Chelonia mydas*) at a coastal foraging area in Baja California, Mexico: Multiple indices to describe population status. *Journal of the Marine Biological Association of the United Kingdom* 83:1355-1362.
- Seminoff, J. A., A. Resendiz, and W. J. Nichols. 2002a. Diet of East Pacific green turtles (*Chelonia mydas*) in the central Gulf of California, Mexico. *Journal of Herpetology* 36(3):447-453.
- Seminoff, J. A., A. Resendiz, W. J. Nichols, and T. T. Jones. 2002b. Growth rates of wild green turtles (*Chelonia mydas*) at a temperate foraging area in the Gulf of California, México. *Copeia* 2002(3):610-617.
- Seney, E. E., and A. M. Landry. 2011. Movement patterns of immature and adult female Kemp's ridley sea turtles in the northwestern Gulf of Mexico. *Marine Ecology Progress Series* 440:241-254.
- Senko, J., and coauthors. 2010a. Fine scale daily movements and habitat use of East Pacific green turtles at a shallow coastal lagoon in Baja California Sur, Mexico. *Journal of Experimental Marine Biology and Ecology* in press(in press):in press.
- Senko, J., M. C. Lopez-Castro, V. Koch, and W. J. Nichols. 2010b. Immature East Pacific green turtles (*Chelonia mydas*) use multiple foraging areas off the Pacific Coast of Baja California Sur, Mexico: First evidence from mark-recapture data. *Pacific Science* 64(1):125-130.
- Sergeant, D. E. 1977. Stocks of fin whales *Balaenoptera physalus* L. in the North Atlantic Ocean. Report of the International Whaling Commission 27:460-473.
- Shamblin, B. M., and coauthors. 2014. Geographic patterns of genetic variation in a broadly distributed marine vertebrate: New insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences. *PLoS ONE* 9(1):e85956.
- Shaver, D. J. 1999. Kemp's ridley sea turtle project at Padre Island National Seashore, Texas. Pages 342-347 in: McKay, M., and J. Nides, editors. Proceedings of the Seventeenth Annual Gulf of Mexico Information Transfer Meeting, U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, MMS 99-0042.
- Shaver, D. J. 2002. Kemp's ridley sea turtle project at Padre Island National Seashore and Texas sea turtle nesting, and stranding 2001 report. U.S. Department of the Interior, U.S. Geological Survey, Corpus Christi, Texas.
- Shaver, D. J., A. F. Amos, B. Higgins, and J. Mays. 2005a. Record 42 Kemp's ridley nests found in Texas in 2004. *Marine Turtle Newsletter* 108:1-3.
- Shaver, D. J., and coauthors. 2005b. Movements and home ranges of adult male kemp's ridley sea turtles (*Lepidochelys kempii*) in the Gulf of Mexico investigated by satellite telemetry. *Chelonian Conservation and Biology* 4(4):817-827.

- Shaver, D. J., and T. Wibbels. 2007a. Head-starting the Kemp's ridley sea turtle. Pages 297-323 in: Plotkin P.T., editor. *Biology and conservation of ridley sea turtles*. Johns Hopkins University Press, Baltimore, Maryland.
- Shaver, D. J., and T. Wibbels. 2007b. Head-starting the Kemp's ridley sea turtle. Pages 297-323 in P. T. Plotkin, editor. *Biology and Conservation of Ridley Sea Turtles*. The Johns Hopkins University Press, Baltimore, Maryland.
- Shirihai, H. 2002. *A complete guide to Antarctic wildlife*. Alula Press, Degerby, Finland.
- Shoop, C. R., and R. D. Kenney. 1992a. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. *Herpetological Monographs* 6:43-67.
- Shoop, C. R., and R. D. Kenney. 1992b. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. *Herpetological Monographs* 6:43-67.
- Sigurjónsson, J., and T. Gunnlaugsson. 1989. NASS-87: Shipboard sightings surveys in Icelandic and adjacent waters June-July 1987. Report of the International Whaling Commission 39:395-409.
- Sigurjónsson, 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.
- Sigurjónsson, J., and T. Gunnlaugsson. 1990. Recent trends in abundance of blue (*Balaenoptera musculus*) and humpback whales (*Megaptera novaeangliae*) off West and Southwest Iceland, with a note on occurrence of other cetacean species. Report of the International Whaling Commission 40:537-551.
- Silber, G. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). *Canadian Journal of Zoology* 64:2075-2080.
- Silva, M. A., and coauthors. 2012. Winter sighting of a known western North Atlantic right whale in the Azores. *Journal of Cetacean Research and Management* 12(1):65-69.
- Simard, Y., N. Roy, and C. Gervaise. 2013. Masking of blue and fin whales low-frequency vocalizations by shipping noise in the Saguenay-St. Lawrence Marine Park. *Bioacoustics* 17:183-185.
- Simmonds, M. P., and W. J. Elliott. 2009. Climate change and cetaceans: Concerns and recent developments. *Journal of the Marine Biological Association of the United Kingdom* 89(1):203-210.
- Simon, M., K. M. Stafford, K. Beedholm, C. M. Lee, and P. Madsen. 2010. Singing behavior of fin whales in the Davis Strait with implications for mating, migration and foraging. *Journal of the Acoustical Society of America* 128(5):3200-3210.
- Sims, D. W., M. J. Genner, A. J. Southward, and S. J. Hawkins. 2001. Timing of squid migration reflects the North Atlantic climate variability. *Proceedings of the Royal Society of London Part B* 268:2607-2611.
- Skalski, J. R., W. H. Pearson, and C. I. Malme. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49:1357-1365.
- Slijper, E. 1962. *Whales*. Basic Books. New York, New York.

- Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* 67:143-150.
- Smith, A. W., and A. B. Latham. 1978. Prevalence of vesicular exanthema of swine antibodies among feral animals associated with the southern California coastal zones. *American Journal of Veterinary Research* 39:291–296.
- Smith, 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., K. Barthelmeß, and R. R. Reeves. 2006. Using historical records to relocate a long-forgotten summer feeding ground of North Atlantic right whales. *Marine Mammal Science* 22(3):723-734.
- 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.
- Smultea, M., and M. Holst. 2003. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic study in the Hess Deep area of the eastern equatorial tropical Pacific, July 2003. Prepared for Lamont-Doherty Earth Observatory, Palisades, New York, and the National Marine Fisheries Service, Silver Spring, Maryland, by LGL Ltd., environmental research associates. LGL Report TA2822-16.
- Smultea, M. A., M. Holst, W. R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. LGL Rep. TA2822-26. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. 106 p.
- Snover, M. L., A. A. Hohn, L. B. Crowder, and S. S. Heppell. 2007a. Age and growth in Kemp's ridley sea turtles: Evidence from mark-recapture and skeletochronology. Pages 89-106 in: Plotkin P.T., editor. *Biology and conservation of ridley sea turtles*. Johns Hopkins University Press, Baltimore, Maryland.
- Snover, M. L., A. A. Hohn, L. B. Crowder, and S. S. Heppell. 2007b. Age and growth in Kemp's ridley sea turtles: Evidence from mark-recapture and skeletochronology. P. T. Plotkin, editor. *Biology and Conservation of Ridley Sea Turtles*. The Johns Hopkins University Press, Baltimore, Maryland.
- Solow, A. R., K. A. Bjorndal, and A. B. Bolten. 2002. Annual variation in nesting numbers of marine turtles: The effect of sea surface temperature on re-migration intervals. *Ecology Letters* 5:742-746.
- Southall, B. L., and coauthors. 2007a. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33(4):411-521.
- Southall, B. L., and coauthors. 2007b. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33:411-521.

- Southall, B. L., T. Rowles, F. Gulland, R. W. Baird, and P. D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melonheaded whales (*Peponocephala electra*) in Antsohihy, Madagascar. Independent Scientific Review Panel.
- Spotila, J. R. 2004. Sea turtles: A complete guide to their biology, behavior, and conservation. John Hopkins University Press, Baltimore. 227p.
- Spotila, J. R., and coauthors. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? *Chelonian Conservation and Biology* 2(2):209-222.
- Spring, D. 2011. L-DEO seismic survey turtle mortality. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.
- St. Aubin, D. J., and J. R. Geraci. 1988. Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whale, *Delphinapterus leucas*. *Physiological Zoology* 61(2):170-175.
- 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.
- Stafford, K. M., S. L. Niekirk, and C. G. Fox. 2001. Geographic and seasonal variation of Blue whale calls in the North Pacific. *Journal of Cetacean Research and Management* 3(1):65-76.
- Stamper, M. A., C. W. Spicer, D. L. Neiffer, K. S. Mathews, and G. J. Fleming. 2009. Morbidity in a juvenile green sea turtle (*Chelonia mydas*) due to ocean-borne plastic. *Journal of Zoo and Wildlife Medicine* 40(1):196-198.
- Starbird, C. H., A. Baldrige, and J. T. Harvey. 1993. Seasonal occurrence of leatherback sea turtles (*Dermochelys coriacea*) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. *California Fish and Game* 79(2):54-62.
- 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.
- Steiner, L., and coauthors. 2012. A link between male sperm whales, *Physeter macrocephalus*, of the Azores and Norway. *Journal of the Marine Biological Association of the United Kingdom* 92(8):1751-1756.
- Stenseth, N. C., and coauthors. 2002a. Ecological effects of climate fluctuations. *Science* 297(5585):1292-1296.
- Stenseth, N. C., and coauthors. 2002b. Ecological effects of climate fluctuations. *Science* 297:1292-1296.
- 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.
- Stewart, K., and coauthors. 2011. Leatherback nests increasing significantly in Florida, USA; trends assessed over 30 years using multilevel modeling. *Ecological Applications* 21(1):263-273.
- Stewart, K. R. 2007. Establishment and growth of a sea turtle rookery: The population biology of the leatherback in Florida. Duke University, Durham, North Carolina.

- Stewart, K. R., M. C. James, S. Roden, P. H. Dutton, and G. Hays. 2013. Assignment tests, telemetry and tag-recapture data converge to identify natal origins of leatherback turtles foraging in Atlantic Canadian waters. *Journal of Animal Ecology* 82(4):791-803.
- Stinson, M. L. 1984. Biology of sea turtles in San Diego Bay, California, and in northeastern Pacific Ocean. San Diego State University, San Diego, California.
- Stone, C. J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. Joint Nature Conservation Committee, Aberdeen, Scotland.
- 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.
- Storelli, M., M. G. Barone, and G. O. Marcotrigiano. 2007a. Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle *Caretta caretta*. *Science of the Total Environment* 273 (2-3):456-463.
- Storelli, M., M. G. Barone, and G. O. Marcotrigiano. 2007b. Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle *Caretta caretta*. *Science of the Total Environment* 273(2-3):456-463.
- Storelli, M., M. G. Barone, A. Storelli, and G. O. Marcotrigiano. 2008. Total and subcellular distribution of trace elements (Cd, Cu and Zn) in the liver and kidney of green turtles (*Chelonia mydas*) from the Mediterranean Sea. *Chemosphere* 70(5):908-913.
- 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).
- Talavera-Saenz, A., S. C. Gardner, R. R. Rodriguez, and B. A. Vargas. 2007. Metal profiles used as environmental markers of green turtle (*Chelonia mydas*) foraging resources. *Science of the Total Environment* 373(1):94-102.
- Tamura, T., and coauthors. 2009. Some examinations of uncertainties in the prey consumption estimates of common minke, sei and Bryde's whales in the western North Pacific. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.
- Tanaka, E. 2009. Estimation of temporal changes in the growth of green turtles *Chelonia mydas* in waters around the Ogasawara Islands. *Fisheries Science* 75(3):629-639.
- Taquet, C., and coauthors. 2006. Foraging of the green sea turtle *Chelonia mydas* on seagrass beds at Mayotte Island (Indian Ocean), determined by acoustic transmitters. *Marine Ecology Progress Series* 306:295-302.
- Tarpy, C. 1979. Killer Whale Attack! *National Geographic* 155(4):542-545.
- Taylor, A. H., M. B. Jordon, and J. A. Stephens. 1998. Gulf Stream shifts following ENSO events. *Nature* 393:68.
- Taylor, A. H., and J. A. Stephens. 1998. The North Atlantic Oscillation and the latitude of the Gulf Stream. *Tellus* 50(A):134-142.
- Taylor, J. K. D., and coauthors. 2013. Shark predation on North Atlantic right whales (*Eubalaena glacialis*) in the southeastern United States calving ground. *Marine Mammal Science* 29(1):204-212.
- 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.

- TEWG. 1998a. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the Western North Atlantic. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation.
- TEWG. 1998b. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western North Atlantic. A report of the Turtle Expert Working Group (TEWG); NOAA Technical Memorandum NMFS-SEFSC-409. 96p.
- TEWG. 2000a. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444.
- TEWG. 2000b. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. Turtle Expert Working Group (TEWG), NMFS-SEFSC-444.
- TEWG. 2007a. An assessment of the leatherback turtle population in the Atlantic Ocean. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Turtle Expert Working Group.
- TEWG. 2007b. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555. 116p.
- TEWG. 2007c. An assessment of the leatherback turtle population in the Atlantic Ocean. Turtle Expert Working Group, Department of Commerce, NMFS-SEFSC-555.
- Thompson, P. O., W. C. Cummings, and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. *Journal of the Acoustical Society of America* 80:735-740.
- Thompson, P. O., L. T. Findley, and O. Vidal. 1992a. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *Journal of the Acoustical Society of America* 92:3051-3057.
- Thompson, P. O., L. T. Findley, O. Vidal, and W. C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. *Marine Mammal Science* 12(2):288-293.
- Thompson, P. O., L. T. Findley, and O. Vidal. 1992b. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *Journal of the Acoustical Society of America* 92(6):3051-3057.
- Thompson, P. O., and W. A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. *Cetology* 45:1-19.
- Thomsen, B. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen, Aberdeen, Scotland.
- Thomson, C. A., and J. R. Geraci. 1986. Cortisol, aldosterone, and leukocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. *Canadian Journal of Fisheries and Aquatic Sciences* 43(5):1010-1016.
- Thomson, D. H., and W. J. Richardson. 1995. Marine mammal sounds. Pages 159-204 in W. J. Richardson, C. R. G. Jr., C. I. Malme, and D. H. Thomson, editors. *Marine Mammals and Noise*. Academic Press, San Diego.
- Threlfall, W. 1978. First record of the Atlantic leatherback turtle (*Dermochelys coriacea*) from Labrador. *Canadian Field Naturalist* 92(3):287.
- Tiwari, M., K. A. Bjorndal, A. B. Bolten, and B. M. Bolker. 2005. Intraspecific application of the mid-domain effect model: Spatial, and temporal nest distributions of green turtles, *Chelonia mydas*, at Tortuguero, Costa Rica. *Ecology Letters* 8:918-924.

- Tiwari, M., K. A. Bjorndal, A. B. Bolten, and B. M. Bolker. 2006. Evaluation of density-dependent processes, and green turtle *Chelonia mydas* hatchling production at Tortuguero, Costa Rica. *Marine Ecology Progress Series* 326:283-293.
- Todd, S., J. Lien, and A. Verhulst. 1992. Orientation of humpback whales (*Megaptera novaengliae*) and minke whales (*Balaenoptera acutorostrata*) to acoustic alarm devices designed to reduce entrapment in fishing gear. J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. *Marine mammal sensory systems*. Plenum Press, New York, New York.
- Tolstoy, M., and coauthors. 2009. Broadband calibration of R/V Marcus G. Langseth four-string seismic sources. *Geochemistry Geophysics Geosystems* 10.
- Tomas, J., and J. A. Raga. 2008. Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. *Marine Biodiversity Records* 1(01).
- Tourinho, P. S., J. A. I. d. Sul, and G. Fillmann. 2009. Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil? *Marine Pollution Bulletin* in press(in press):in press.
- Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whalerships. *Zoologica (N.Y.)* 19(1):1-50.
- Triessnig, P., A. Roetzer, and M. Stachowitsch. 2012. Beach condition and marine debris: New hurdles for sea turtle hatchling survival. *Chelonian Conservation and Biology* 11(1):68-77.
- Troeng, S., D. Chacon, and B. Dick. 2004. Leatherback turtle *Dermochelys coriacea* nesting along the Caribbean coast of Costa Rica. Pages 13 in M. S. Coyne, and R. D. Clark, editors. *Twenty-First Annual Symposium on Sea Turtle Biology and Conservation*.
- Troëng, S., and M. Chaloupka. 2007. Variation in adult annual survival probability and remigration intervals of sea turtles. *Marine Biology* 151:1721-1730.
- Troëng, S., P. H. Dutton, and D. Evans. 2005. Migration of hawksbill turtles *Eretmochelys imbricata* from Tortuguero, Costa Rica. *Ecography* 28(3):394-402.
- Troëng, S., E. Harrison, D. Evans, A. d. Haro, and E. Vargas. 2007. Leatherback turtle nesting trends and threats at Tortuguero, Costa Rica. *Chelonian Conservation and Biology* 6(1):117-122.
- Troëng, S., and E. Rankin. 2005. Long term conservation efforts contribute to positive green turtle *Chelonia mydas* nesting trend at Tortuguero, Costa Rica. *Biological Conservation* 121:111-116.
- Trumble, S. J., E. M. Robinson, M. Berman-Kowalewski, C. W. Potter, and S. Usenko. 2013. Blue whale earplug reveals lifetime contaminant exposure and hormone profiles. *Proceedings of the National Academy of Sciences* 110(42):16922-16926.
- Tryonis, V., E. Gerstein, J. Moir, and S. McCulloch. 2013. Vocalization characteristics of North Atlantic right whale surface active groups in the calving habitat, southeastern United States. *Journal of the Acoustical Society of America* 134(6):4518-4531.
- Tucholke, B. E. 1987. Submarine geology. J. D. Milliman, and W. R. Wright, editors. *The Marine Environment of the U.S. Atlantic Continental Slope and Rise*. Jones and Bartlett Publishers, Inc., Boston/Woods Hole, Massachusetts.
- Tucker, A. D. 2009. Nest site fidelity and clutch frequency of loggerhead turtles are better elucidated by satellite telemetry than by nocturnal tagging efforts: Implications for stock estimation. *Journal of Experimental Marine Biology and Ecology* in press(in press):in press.

- Turnpenny, A. W. H., and J. R. Nedwell. 1994. The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Consultancy Report, Fawley Aquatic Research Laboratories, Ltd. FCR 089/94. 50p.
- Turnpenny, A. W. H., K. P. Thatcher, and J. R. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Research Report for the Defence Research Agency, Fawley Aquatic Research Laboratories, Ltd., FRR 127/94. 34p.
- 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. 1983. Differential response of humpback whales, *Megaptera novaeangliae*, to playback of song or social sounds. *Behavioral Ecology and Sociobiology* 13(1):49-55.
- Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. Pages 115-120 in A. E. Jochens, and D. C. Biggs, editors. Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1, volume OCS Study MMS 2003-069. Texas A&M University and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.
- Tyack, P., and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. *Behaviour* 83:132-153.
- Tyack, P. L. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. *Behavioral Ecology and Sociobiology* 8:105-116.
- Tyack, P. L. 1999. Communication and cognition. Pages 287-323 in J. E. R. III, and S. A. Rommel, editors. *Biology of Marine Mammals*. Smithsonian Institution Press, London.
- Tyson, R. B., and D. P. Nowacek. 2005. Nonlinear dynamics in North Atlantic right whale (*Eubalaena glacialis*) vocalizations. Pages 286 in Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, California.
- U.S. Department of Commerce. 1983. Draft Management Plan and Environmental Impact Statement for the Proposed Hawaii Humpback Whale National Marine Sanctuary. Prepared by the NOAA Office of Ocean and Coastal Resource Management and the State of Hawaii. 172p.
- U.S. Department of the Navy. 2010. Marine species monitoring for the U.S. Navy's Virginia Capes, Cherry Point and Jacksonville Range Complexes. U.S. Department of the Navy, United States Fleet Forces Command.
- University of Delaware Sea Grant. 2000. Sea turtles count on Delaware Bay. University of Delaware Sea Grant Reporter 19(1):7.
- USDOJ. 2011. Salazar announces approval of Cape Wind energy project construction and operation plan. U.S. Department of the Interior.
- USFWS. 1999. South Florida multi-species recovery plan. United States Fish and Wildlife Service, Atlanta, Georgia.
- USFWS. 2000. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS. 2001. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS. 2002. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.

- USFWS. 2003. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS. 2004. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS. 2005. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS. 2006. Report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaulipas, and Veracruz, Mexico. United States Fish and Wildlife Service.
- USFWS, and NMFS. 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). National Marine Fisheries Service, St. Petersburg, Florida.
- USFWS, N. a. 1995. Status reviews for sea turtles listed under the Endangered Species Act of 1973. National Marine Fisheries Service, Silver Spring, Maryland.
- USFWS, N. a. 1998. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, Maryland.
- Van Banning, P. 1987. Further results of the *Bonamia ostreae* challenge tests in Dutch oyster culture. *Aquaculture* 67(1-2):191-194.
- Van de Merwe, J. P. V., and coauthors. 2009. Chemical contamination of green turtle (*Chelonia mydas*) eggs in peninsular Malaysia: Implications for conservation and public health. *Environmental Health Perspectives* 117(9):1397-1401.
- Van der Hoop, J. M., and coauthors. 2013. Assessment of management to mitigate anthropogenic effects on large whales. *Conservation Biology* 27(1):121-33.
- Van Scheppingen, W. B., A. J. I. M. Verhoeven, P. Mulder, M. J. Addink, and C. Smeenk. 1996. Polychlorinated-biphenyls, dibenzo-p-dioxins, and dibenzofurans in harbor porpoises *Phocoena phocoena* stranded on the Dutch coast between 1990 and 1993. *Archives of Environmental Contamination and Toxicology* 30:492-502.
- Vander Zanden, H. B., K. A. Bjorndal, and A. B. Bolten. 2013. Temporal consistency and individual specialization in resource use by green turtles in successive life stages. *Oecologia* 173(3):767-777.
- Vander Zanden, H. B., K. A. Bjorndal, K. J. Reich, and A. B. Bolten. 2010. Individual specialists in a generalist population: results from a long-term stable isotope series. *Biology Letters* in press(in press):in press.
- Vanderlaan, A. S., and C. T. Taggart. 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Marine Mammal Science* 23(1):144-156.
- Vanderlaan, A. S. M., A. E. Hay, and C. T. Taggart. 2003. Characterization of North Atlantic right-whale (*Eubalaena glacialis*) sounds in the Bay of Fundy. *IEEE Journal of Oceanic Engineering* 28(2):164-173.
- Vanderlaan, A. S. M., C. T. Taggart, A. R. Serdyska, 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.
- Vera, V. 2007. Nesting of green turtles in Aves Island Wildlife Refuge. 2006 season. Pages 275 in M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams, editors. Twenty-Seventh

- Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Myrtle Beach, South Carolina.
- Verity, P. G., and coauthors. 1993. Outer shelf processes. Pages 45-74 in D. W. Menzel, editor. Ocean Processes: U. S. Southeast Continental Shelf: A Summary of Research Conducted in the South Atlantic Bight under the Auspices of the U.S. Department of Energy from 1977 to 1991, volume DOE/OSTI-11674. U.S. Department of Energy, Washington, D.C.
- 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.
- Víkingsson, G. A., and coauthors. 2009. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the Northeast and Central Atlantic as inferred from the North Atlantic sightings surveys 1987-2001. NAMMCO Scientific Publications 7:49-72.
- Villegas-Amtmann, S., and D. P. Costa. 2010. Oxygen stores plasticity linked to foraging behaviour and pregnancy in a diving predator, the Galapagos sea lion. Functional Ecology 24(4):785-795.
- Visbeck, M. 2002. The ocean's role in Atlantic climate variability. Science 297:2223-2225.
- Von Benda-Beckmann, A. M., and coauthors. 2014. Modeling effectiveness of gradual increases in source level to mitigate effects of sonar on marine mammals. Conservation Biology 28(1):119-128.
- Vu, E. T., and coauthors. 2012. Humpback whale song occurs extensively on feeding grounds in the western North Atlantic Ocean. Aquatic Biology 14(2):175-183.
- 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.
- Wall, D., I. O'Kelly, P. Whooley, and P. Tyndall. 2009. New records of blue whales (*Balaenoptera musculus*) with evidence of possible feeding behaviour from the continental shelf slopes to the west of Ireland. Marine Biodiversity Records 2: e128.
- Wallace, B. P., L. Avens, J. Braun-McNeill, and C. M. McClellan. 2009. The diet composition of immature loggerheads: Insights on trophic niche, growth rates, and fisheries interactions. Journal of Experimental Marine Biology and Ecology 373(1):50-57.
- Wallace, B. P., and coauthors. 2010. Global patterns of marine turtle bycatch. Conservation Letters.
- 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.
- Wardle, C. S., and coauthors. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21:1005-1027.
- Waring, G., D. Belden, M. Vecchione, and R. Gibbons. 2003. Mid-water prey in beaked whale and sperm whale deep-water habitat south of Georges Bank. Pages 172 in Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.
- Waring, G. T., C. P. Fairfield, C. M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2(2):101-105.

- Waring, G. T., E. Josephson, C. P. Fairfield, and K. M.-F. (Eds). 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2008. NOAA Technical Memorandum NMFS-NE-210. 440pp.
- Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2006. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2005. NOAA Technical Memorandum NMFS-NE-194. Woods Hole, Massachusetts. 358p.
- Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2007. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2006. U.S. Department of Commerce. NOAA Technical Memorandum NMFS NE:201.
- Waring, G. T., E. Josephson, C. P. Fairfield, and K. Maze-Foley. 2008. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2007. U.S. Department of Commerce. NOAA Technical Memorandum NMFS NE:205.
- Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. R. (Eds). 2010. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2010. NMFS.
- Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel. 2012. US Atlantic and Gulf of Mexico marine mammal stock assessments - 2011. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.
- 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. 1999. U.S. Atlantic Marine Mammal Stock Assessments - 1998. NOAA Technical Memorandum NMFS-NEFSC: Woods Hole, Mass. 193p.
- Waring, G. T., and coauthors. 2000. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 1999. NOAA Technical Memorandum NMFS-NE-153:Woods Hole, Massachusetts. 193p.
- 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.
- Watkins, W. A. 1977. Acoustic behavior of sperm whales. *Oceanus* 20:50-58.
- Watkins, W. A. 1981. Activities and underwater sounds of fin whales. *Scientific Reports of the International Whaling Commission* 33:83-117.
- Watkins, W. A., K. E. Moore, J. Sigujónsson, D. Wartzok, and G. N. di Sciara. 1984. Fin Whale (*Balaenoptera physalus*) tracked by radio in the Irminger Sea. *Rit Fiskideildar* 8:1-14.
- Watkins, W. A., K. E. Moore, and P. Tyack. 1985. Sperm whale acoustic behavior in the southeast Caribbean. *Cetology* 49:1-15.
- Watkins, W. A., K. E. Moore, D. Wartzok, and J. H. Johnson. 1981. Radio tracking of finback (*Balaenoptera physalus*), and humpback (*Megaptera novaeangliae*) whales in Prince William Sound, Alaska, USA. *Deep Sea Research Part A. Oceanographic Research Papers* 28(6):577-588.
- Watkins, W. A., and W. E. Schevill. 1975. Sperm whales (*Physeter catodon*) react to pingers. *Deep-Sea Research* 22:123-129.
- Watkins, W. A., and W. E. Schevill. 1976. Right whale feeding and baleen rattle. *Journal of Mammalogy* 57:58-66.

- Watkins, W. A., and W. E. Schevill. 1979. Aerial observation of feeding behavior in four baleen whales: *Eubalaena glacialis*, *Balaenoptera borealis*, *Megaptera novaeangliae*, and *Balaenoptera physalus*. *Journal of Mammalogy* 60:155-163.
- Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987a. The 20-Hz signals of finback whales (*Balaenoptera physalus*). *Journal of the Acoustical Society of America* 82(6):1901-1912.
- Watkins, W. A., P. Tyack, K. E. Moore, and J. E. Bird. 1987b. The 20 Hz signals of finback whales (*Balaenoptera physalus*). *Journal of the Acoustical Society of America* 8(6):1901-1912.
- Waycott, M. B., J. Longstaff, and J. Mellors. 2005. Seagrass population dynamics and water quality in the Great Barrier Reef region: A review and future research directions. *Marine Pollution Bulletin* 51:343-350.
- Weijerman, M. L., H. G. v. Tienen, A. D. Schouten, and W. E. J. Hoekert. 1998. Sea turtles of Galibi, Suriname. Pages 142-144 in R. Byles, and Y. Fernandez, editors. Sixteenth Annual Symposium on Sea Turtle Biology and Conservation.
- Weilgart, L., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. *Canadian Journal of Zoology* 71(4):744-752.
- Weilgart, L. S., and H. Whitehead. 1997. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology* 40:277-285.
- Weinrich, M. T., J. Bove, and N. Miller. 1993. Return and survival of humpback whale (*Megaptera novaeangliae*) calves born to a single female in three consecutive years. *Marine Mammal Science* 9(3):325-328.
- Weinrich, M. T., and coauthors. 1992. Behavioral reactions of humpback whales *Megaptera novaeangliae* to biopsy procedures. *Fishery Bulletin* 90:588-598.
- Weir, C. R. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. *Marine Turtle Newsletter* 116:17-20.
- Weir, C. R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. *Aquatic Mammals* 34(1):71-83.
- Weir, C. R., A. Frantzis, P. Alexiadou, and J. C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). *Journal of the Marine Biological Association of the U.K.* 87(1):39-46.
- Weirathmueller, M. J., W. S. D. Wilcock, and D. C. Soule. 2013. Source levels of fin whale 20Hz pulses measured in the Northeast Pacific Ocean. *Journal of the Acoustical Society of America* 133(2):741-749.
- Weisbrod, A. V., S. D., M. M. J., and S. J. J. 2000. Organochlorine exposure and bioaccumulation in the endangered northwest Atlantic right whale (*Eubalaena glacialis*) population. *Environmental Toxicology and Chemistry* 19:654-666.
- Weller, D. W., and coauthors. 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. *Marine Mammal Science* 12(4):588-594.
- Wenzel, F. W., D. K. Mattila, and P. J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. *Marine Mammal Science* 4(2):172-175.
- Wever, E. G., and J. A. Vernon. 1956. The sensitivity of the turtle's ear as shown by its electrical potentials. *Proceedings of the National Academy of Sciences of the United States of America* 42:213-222.

- Whitehead, H. 1995. Status of Pacific sperm whale stocks before modern whaling. Report of the International Whaling Commission 45:407-412.
- 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. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242:295-304.
- Whitehead, H. 2003. Sperm whales: social evolution in the ocean. University of Chicago Press, Chicago, Illinois. 431p.
- Whitehead, H., and coauthors. 2012. Multilevel societies of female sperm whales (*Physeter macrocephalus*) in the Atlantic and Pacific: Why are they so different? International Journal of Primatology 33(5):1142-1164.
- Whitehead, H., and T. Arnbo. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. Canadian Journal of Zoology 65(4):913-919.
- Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361:291-300.
- Whitehead, H., and M. J. Moore. 1982. Distribution, and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.
- Whitehead, H., S. Waters, and T. Lyrholm. 1991. Social organization of female sperm whales and their offspring: Constant companions and casual acquaintances. Behavioral Ecology and Sociobiology 29(5):385-390.
- Whitt, A. D., K. Dudzinski, and J. R. Laliberte. 2013. North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA, and implications for management. Endangered Species Research 20(1):59-69.
- Wibbels, T. 2003. Critical approaches to sex determination in sea turtle biology and conservation. Pages 103-134 in P. Lutz, J. Musik, and J. Wynekan, editors. Biology of sea turtles, volume 2. CRC Press.
- Wibbels, T. 2007. Sex determination and sex ratio in ridley turtles. Pages 167-189 in: Plotkin P.T., editor. Biology and conservation of ridley sea turtles. Johns Hopkins University Press, Baltimore, Maryland.
- Wibbels, T., K. Marion, D. Nelson, J. Dindo, and A. Geis. 2005. Evaluation of the bay systems of Alabama (US) as potential foraging habitat for juvenile sea turtles. Pages 275-276 in: Mosier, A., A. Foley, and B. Brost, editors. Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.
- Wiebe, P. H., and coauthors. 1987. Biological oceanography. Pages 140-201 in J. D. Milliman, and W. R. Wright, editors. The Marine Environment of the U.S. Atlantic Continental Slope and Rise. Jones and Bartlett Publishers, Inc., Boston/Woods Hole, Massachusetts.
- 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., and coauthors. 2013. Evidence for density-dependent changes in body condition and pregnancy rate of North Atlantic fin whales over four decades of varying environmental conditions. International Council For the Exploration of the Seas Journal of Marine Science 70(6):1273-1280.

- Winn, H. E., R. K. Edell, 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., J. D. Goodyear, R. D. Kenney, and R. O. Petricig. 1995. Dive patterns of tagged right whales in the Great South Channel. *Continental Shelf Research* 15:593-611.
- Winn, H. E., P. J. Perkins, and T. Poulter. 1970. Sounds of the humpback whale. 7th Annual Conf Biological Sonar. Stanford Research Institute, Menlo Park, California.
- Winn, H. E., C. A. Price, and P. W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Report of the International Whaling Commission (Special Issue 10):129-138.
- Winn, H. E., and N. E. Reichley. 1985. Humpback whale - *Megaptera novaeangliae*. Handbook of Marine Mammals: Vol. 3 The Sirenians and Baleen Whales:241-274.
- Winsor, M. H., and B. R. Mate. 2006. Seismic survey activity and the proximity of satellite tagged sperm whales.
- Winsor, M. H., and B. R. Mate. 2013. Seismic survey activity and the proximity of satellite-tagged sperm whales *Physeter macrocephalus* in the Gulf of Mexico. *Bioacoustics* 17:191-193.
- Wise, J. P., Sr., and coauthors. 2009. A global assessment of chromium pollution using sperm whales (*Physeter macrocephalus*) as an indicator species. *Chemosphere* 75(11):1461-1467.
- Wise, J. P., and coauthors. 2008. Hexavalent chromium is cytotoxic and genotoxic to the North Atlantic right whale (*Eubalaena glacialis*) lung and testes fibroblasts. *Mutation Research* 650:30–38.
- Wishner, K., and coauthors. 1988. Copepod patches and right whales in the Great South Channel off New England. *Bulletin of Marine Science* 43(3):825-844.
- Witherington, B., S. Hirama, and A. Mosier. 2003. Effects of beach armoring structures on marine turtle nesting. Florida Fish and Wildlife Conservation Commission.
- Witherington, B., S. Hirama, and A. Mosier. 2007. Change to armoring and other barriers to sea turtle nesting following severe hurricanes striking Florida beaches. Florida Fish and Wildlife Conservation Commission.
- Witherington, B., P. Kubilis, B. Brost, and A. Meylan. 2009. Decreasing annual nest counts in a globally important loggerhead sea turtle population. *Ecological Applications* 19(1):30-54.
- Witherington, B. E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. *Herpetologica* 48(1):31-39.
- Witherington, B. E., and K. A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. *Biological Conservation* 55:139-149.
- Witherington, B. E., R. Herren, and M. Bresette. 2006. *Caretta caretta* – Loggerhead Sea Turtle. *Chelonian Research Monographs* 3:74-89.
- Witherington, B. E., R. Herren, and M. Bresette. 2006b. *Caretta caretta* – Loggerhead Sea Turtle. *Chelonian Research Monographs* 3:74-89.
- 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.

- Witzell, W. N. 1981. Predation on Juvenile Green Sea Turtles, *Chelonia mydas*, By a Grouper, *Promicrops lanceolatus* (Pisces: Serranidae) in the Kingdom of Tonga, South Pacific. *Bulletin of Marine Science*. Vol. 31:no. 4.
- Witzell, W. N., A. A. Geis, J. R. Schmid, and T. Wibbels. 2005a. Sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, southwest Florida. *Journal of the Marine Biological Association of the U.K.* 85:205-208.
- Witzell, W. N., A. A. Geis, J. R. Schmid, and T. Wibbels. 2005b. Sex ratio of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, southwest Florida. *Journal of the Marine Biological Association of the United Kingdom* 85:205-208.
- Witzell, W. N., and J. R. Schmid. 2005. Diet of immature Kemp's ridley turtles (*Lepidochelys kempii*) from Gullivan Bay, Ten Thousand Islands, southwest Florida. *Bulletin of Marine Science* 77(2):191-199.
- Wood, J., Southall, B.L., and Tollit, D.J. . 2012. PG&E offshore 3-D Seismic Survey Project EIR. SMRU Ltd.
- Woodley, T. H., M. W. Brown, S. D. Kraus, and D. E. Gaskin. 1991. Organochlorine levels in North Atlantic right whales (*Eubalaena glacialis*) blubber. *Archives of Environmental Contamination and Toxicology* 21:141-145.
- Work, P. A., A. L. Sapp, D. W. Scott, and M. G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology*.
- Work, T. M., and coauthors. 2009. In vitro biology of fibropapilloma-associated turtle herpesvirus and host cells in Hawaiian green turtles (*Chelonia mydas*). *Journal of General Virology* 90:1943-1950.
- Wormuth, J. H., P. H. Ressler, R. B. Cady, and E. J. Harris. 2000. Zooplankton and micronekton in cyclones and anticyclones in the northeast Gulf of Mexico. *Gulf of Mexico Science* 18(1):23-34.
- Woude, S. v. d. 2013. Assessing effects of an acoustic marine geophysical survey on the behaviour of bottlenose dolphins *Tursiops truncatus*. *Bioacoustics* 17:188-190.
- Wright, A. J. 2005. Lunar cycles and sperm whale (*Physeter macrocephalus*) strandings on the north Atlantic coastlines of the British isles and eastern Canada. *Marine Mammal Science* 21(1):145-149.
- Würsig, B., T. A. Jefferson, and D. J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. Texas A&M University Press, College Station. 232p.
- Würsig, B. G., and coauthors. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report. Sakhalin Energy Investment Co. Ltd and Exxon Neftegaz Ltd, Yuzhno-Sakhalinsk, Russia.
- Yablokov, A. V., and V. A. Zemsky. 2000. Soviet whaling data (1949-1979). Center for Russian Environmental Policy, Moscow.
- Yablokov, A. V., V. A. Zemsky, Y. A. Mikhalev, V. V. Tormosov, and A. A. Berzin. 1998. Data on Soviet whaling in the Antarctic in 1947-1972 (population aspects). *Russian Journal of Ecology* 29:38-42.
- Yan, N. D., R. Girard, and S. Boudreau. 2002. An introduced predator (*Bythotrephes*) reduces zooplankton species richness. *Ecological Letters* 5:481-485.

- Yazvenko, S. B., and coauthors. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment Available online at [http://www.springerlink.com/content/?mode=boolean&k=ti%3a\(western+gray+whale\)&sortorder=asc](http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc). DOI 10.1007/s10661-007-9809-9. 29p.
- Yazvenko, S. B., and coauthors. 2007b. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Available online at [http://www.springerlink.com/content/?mode=boolean&k=ti%3a\(western+gray+whale\)&sortorder=asc](http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc). DOI 10.1007/s10661-007-9810-3. 14p.
- Yeung, C. 1999. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1998. U.S. Department of Commerce.
- Yochem, P. K., and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). In: Ridgway SH, Harrison R, editors. Handbook of Marine Mammals, vol. 3: The Sirenians and Baleen Whales.:London: Academic Press. p 193-240.
- Yudhana, A., Sunardi, J. Din, S. Abdullah, and R. B. R. Hassan. 2010. Turtle hearing capability based on ABR signal assessment. *Telkommika* 8:187- 194.
- Zug, G. R., G. H. Balazs, J. A. Wetherall, D. M. Parker, and S. K. K. Murakawa. 2002. Age and growth of Hawaiian green sea turtles (*Chelonia mydas*): An analysis based on skeletochronology. *Fishery Bulletin* 100:117-127.
- Zug, G. R., and R. E. Glor. 1998. Estimates of age and growth in a population of green sea turtles (*Chelonia mydas*) from the Indian River Lagoon system, Florida: A skeletochronological analysis. *Canadian Journal of Zoology* 76:1497-1506.
- Zug, G. R., H. J. Kalb, and S. J. Luzzar. 1997. Age and growth on wild Kemp's ridley sea turtles *Lepidochelys kempii* from skeletochronological data. *Biological Conservation* 80:261-268.
- Zug, G. R., and J. F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea*: A skeletochronological analysis. *Chelonian Conservation and Biology* 2:244-249.
- Zurita, J. C., and coauthors. 2003. Nesting loggerhead and green sea turtles in Quintana Roo, Mexico. Pp.25-127 In: Seminoff, J.A. (Ed), 22nd Annual Symposium on Sea Turtle Biology and Conservation, 4-7 April, 2002, Miami, FL. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-503.