NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

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TABLE OF CONTENTS

Page

1 Introduction ... 10

1.1 Background ... 11

1.2 Consultation History ... 11

2 The Assessment Framework ... 12

3 Description of the Proposed Action ... 15

3.1 Seismic Survey Overview and Objectives ... 15

3.2 Research Vessel Specifications ... 16

3.3 Airgun Description ... 16

3.4 Conservation Measures ... 17

3.4.1 Exclusion and Buffer Zones ... 18

3.4.2 Shutdown and Ramp-Up Procedures ... 18

3.4.3 Vessel-Based Visual Monitoring ... 19

3.4.4 Reporting ... 19

4 Potential Stressors ... 19

4.1 Pollution ... 20

4.2 Vessel Strike ... 20

4.3 Visual and Acoustic Disturbance ... 21

4.4 Gear Entanglement and Interaction ... 21

5 Action Area ... 22

6 Endangered Species Act-Listed Species and Designated Critical Habitat in the Action Area ... 23

7 Species and Designated Critical Habitat Not Likely to be Adversely Affected ... 24

7.1 Stressors Not Likely to Adversely Affect Species or Designated Critical Habitat ... 25

7.1.1 Pollution ... 25

7.1.2 Vessel Strike ... 26

7.1.3 Vessel Noise and Visual Disturbance ... 27

7.1.4 Gear Entanglement and Interaction ... 28

7.1.5 Potential Stressors Considered Further ... 28

7.2 Elasmobranchs ... 28

7.3 Hawksbill Sea Turtle 29
7.4 Designated Critical Habitat – Loggerhead Turtle Northwest Atlantic Ocean Distinct Population Segment 30
8 Species Likely to be Adversely Affected 32
8.1 Green turtle – North Atlantic Distinct Population Segment 33
8.1.1 Life History 33
8.1.2 Population Dynamics 34
8.1.3 Vocalization and Hearing 37
8.1.4 Status 37
8.1.5 Status in the Action Area 38
8.2 Kemp's ridley turtle 38
8.2.1 Life History 39
8.2.2 Population Dynamics 40
8.2.3 Vocalization and Hearing 41
8.2.4 Status 41
8.2.5 Status in the Action Area 41
8.3 Leatherback turtle 42
8.3.1 Life History 43
8.3.2 Population Dynamics 45
8.3.3 Vocalization and Hearing 47
8.3.4 Status 48
8.3.5 Status in the Action Area 48
8.4 Loggerhead turtle – Northwest Atlantic Ocean DPS 49
8.4.1 Life History 49
8.4.2 Population Dynamics 51
8.4.3 Vocalization and Hearing 53
8.4.4 Status 54
8.4.5 Status in the Action Area 54
9 Environmental Baseline 55
9.1 Climate Change 55
9.2 Oceanic Temperature Regimes 57

9.3 Sea Turtle Harvesting 58
9.4 Vessel Interactions 58
9.5 Fisheries 59
9.6 Pollution 60
9.6.1 Marine Debris 60
9.6.2 Pollutants and Contaminants 60
9.6.3 Noise pollution 66
9.7 Aquatic Nuisance Species 69
9.8 Scientific Research Activities 70
9.9 Impact of the Baseline on Endangered Species Act-Listed Species 71
10 Effects of the Action 71
10.1 Stressors Associated with the Proposed Action 72
10.2 Exposure Analysis 72
10.2.1 Exposure Estimates of ESA-Listed Sea Turtles 73
10.3 Response Analysis 78
10.3.1 Potential Response of Sea Turtles to Acoustic Sources 79
10.3.2 Potential Responses of Sea Turtle Prey to Acoustic Sources 81
10.4 Summary of Effects 85
11 Cumulative Effects 86
12 Integration and Synthesis 87
12.1 Jeopardy Analysis 87
12.2 Green Turtle – North Atlantic Distinct Population Segment 87
12.3 Kemp’s Ridley Turtle 89
12.4 Leatherback Turtle 90
12.5 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment 92
13 Conclusion 93
14 Incidental Take Statement 94
14.1 Amount or Extent of Take 94
14.2 Reasonable and Prudent Measures 95
14.3 Terms and Conditions 96
15 Conservation Recommendations 96

16 Reinitiation Notice ... 98

17 References ... 99

LIST OF TABLES

Table 1. Specifications of the 2 GI airguns to be used by the Research Vessel *Brooks McCall* during the seismic survey in the Gulf of Mexico 17

Table 2. Endangered Species Act-Listed threatened and endangered species and designated critical habitat that potentially occur in the action area 24

Table 3. Densities of Endangered Species Act-Listed Sea Turtles in the Action Area during the Department of Energy and University of Texas at Austin's Seismic Survey off Texas 75

Table 4. Predicted Distances to Received Sound Level of 175 dB re 1 µPa (rms) from 2 GI Airguns for Sea Turtles during the Proposed Seismic Survey... 75

Table 5. 175 dB re 1 µPa (rms) Harassment Isopleths, Trackline Distance, Ensonified Area, Number of Survey Days, and Total Ensonified Areas During the Department of Energy and University of Texas at Austin's Seismic Survey off Texas... 76

Table 6. Predicted Distances for Sea Turtles to Noise-Induced Hearing Loss Thresholds for the Department of Energy and University of Texas at Austin's Seismic Survey off Texas 76

Table 7. Calculated Exposures for Endangered Species Act-Listed Sea Turtles during the Department of Energy and University of Texas at Austin's Seismic Survey off Texas... 77

Table 8. Estimated Amount of Incidental Take of Endangered Species Act-Listed Sea Turtles Anticipated Because of the Proposed Action off Texas 95

LIST OF FIGURES

Figure 1. Map of the Department of Energy National Energy Technology Laboratory and University of Texas at Austin's proposed seismic survey in the Gulf of Mexico off Texas (DOE 2023)... 23

Figure 2. Designated critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of loggerhead sea turtles... 31

Figure 3. Map of geographic range of the North Atlantic distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015) 33

Figure 4. Map identifying the range of the endangered Kemp's ridley turtle off the U.S. coast... 39

Figure 5. Map identifying the range of the endangered leatherback turtle. Adapted from Wallace et al. 2013 43

Figure 6. Map identifying the range of threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle 49

LIST OF ACRONYMS AND UNITS

°C – Degrees Celsius

°N – Degrees North

°S – Degrees South

°W – Degrees West

3-D – Three-dimensional

AMAPPS – Atlantic Marine Assessment Program for Protected Species

C.F.R – Code of Federal Regulations

cm – centimeters

cm^3 – centimeters cubed

dB – Decibels

dB re 1 μPa – Decibels referenced to a pressure of 1 microPascal (unit to specify intensity of a sound underwater)

dB re 1 $\mu Pa^2 s$ – Decibels referenced to a pressure of 1 microPascal squared second (unit of sound exposure level)

dB re 1 $\mu Pa^2/Hz$ at 1m – Decibels referenced to a pressure of 1 microPascal squared per hertz (decibel unit for the pressure spectral density in underwater acoustics)

DDT – Dichlorodiphenyltrichoroethane

DNA – Deoxyribonucleic acid

DOE – Department of Energy

DPS – Distinct Population Segment

ESA – Endangered Species Act

FR – Federal Register

ft – feet

g – grams

gal – gallon

GI – Generator Injector

GPS – Global Positioning System

h – hour

hp – horsepower

HR3D – High-resolution Three-dimensional

Hz – Hertz

IHA – Incidental Harassment Authorization

in – inch

in^3 – inches cubed

ITS – Incidental Take Statement

kHz – kilohertz

km – kilometers

km/h – kilometers per hour

km^2 – kilometers squared

kts – knots

lbs – pounds

L-DEO – Lamont-Doherty Earth Observatory

m – meter

m/m % – percent by mass

m^3 – meters cubed

mi - miles

mi^2 – miles squared

min – minutes

MMPA – Marine Mammal Protection Act

mph – miles per hour

NEFSC – Northeast Fisheries Science Center

NM – nautical miles

NMFS – National Marine Fisheries Service

NSF – National Science Foundation

OBIS-SEAMAP – Ocean Biodiversity Information System Spatial Ecological Analysis of Megavertebrate Populations

PAM – Passive Acoustic Monitoring

PBFs – Physical and Biological Features

PCBs – Polychlorinated biphenyls

psi – pounds per square inch

PSOs – Protected Species Observers

PTS – Permanent Threshold Shift

R/V – Research Vessel

rms – root mean square

RPMs – Reasonable and Prudent Measures

s – seconds

SD – Standard Deviation

SEFSC – Southeast Fisheries Science Center

SEL_{cum} – Cumulative Sound Exposure Level

SERO – Southeast Regional Office

SIO – Scripps Institution of Oceanography

SPL_{peak} – Peak Sound Pressure Level

SWOT – State of the World’s Sea Turtles

TEDs – Turtle Excluder Devices

TTS – Temporary Threshold Shift

U.S. – United States

U.S.C – United States Code

USFWS – United States Fish and Wildlife Service

UT – University of Texas at Austin

1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of threatened or endangered species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" ESA-listed species or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 CFR §402.13(c)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency is able to insure its action is not likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If incidental take of an ESA-listed species is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS), which exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including necessary or appropriate reasonable and prudent measures (RPMs) to minimize such impacts and terms and conditions to implement the RPMs. NMFS, by regulation, has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action (50 C.F.R. §402.14(g)(7)).

The Federal action agency for this consultation is the United States (U.S.) Department of Energy National Energy Technology Laboratory (henceforth referred to as DOE). The DOE is proposing to partially fund the University of Texas at Austin (UT) to conduct a marine geophysical (seismic) survey in the northwestern Gulf of Mexico in late fall (October or November) of 2023.

This formal consultation was conducted and this opinion and ITS were prepared by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division (hereafter referred to as "we") in accordance with section 7(a)(2) of the ESA (16 U.S.C. 1536 (a)(2)) and associated implementing regulations at 50 C.F.R. §§402.01–402.17, and agency policy and guidance.

In August 2019, the USFWS and NMFS (i.e., the Services) enacted a series of regulations that modified how the Services implemented the ESA. On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 C.F.R. Part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 1, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5, 2022 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order 2 days later on November 16, 2022. As a result, the 2019 regulations are in effect and we are applying the 2019 regulations here. For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed action articulated in the opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on threatened and endangered species and critical habit that has been designated for those species (Section 6) in the action area. A complete record of this consultation is on file electronically at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

Marine seismic surveys have occurred in every ocean basin and ESA section 7 consultations have been completed for them in waters off the U.S. in the Pacific and Atlantic Oceans, Gulf of Mexico, Gulf of Alaska, Caribbean, and Arctic and Antarctic waters. The DOE is proposing to fund UT's seismic survey in the northwestern Gulf of Mexico, off the coast of Texas. Data collected from this project will characterize the upper ~1 km (~0.62 mi) of the geologic subsurface. These data will then be used for field validation of monitoring, verification, and accounting technology of sub-seabed carbon storage. In conjunction with this action, UT, on behalf of itself and DOE, requested an Incidental Harassment Authorization from the NMFS Permits Division to authorize incidental harassment of small numbers of marine mammals under the Marine Mammal Protection Act, should this occur during the survey. Because the Incidental Harassment Authorization will not authorize take of ESA-listed marine mammals, that action is not included in this opinion. Previous ESA section 7 consultations that addressed seismic surveys around the world, including those of substantially higher energy than this proposed survey, determined that the authorized activities were not likely to jeopardize the continued existence of proposed or ESA-listed species, or result in the destruction or adverse modification of designated critical habitat, when applicable.

1.2 Consultation History

We were given the consultation by our Southeast Regional Office (SERO). Our communication with the NMFS SERO and DOE regarding this consultation is summarized as follows:

- On January 11, 2023, SERO received a request from DOE for ESA section 7 consultation for a proposed seismic survey in the northwestern Gulf of Mexico in the fall of 2023.
- On March 27, 2023, SERO received a revised request for consultation and draft Environmental Assessment from DOE.
- On July 17, 2023, SERO transferred the consultation to the NMFS ESA Interagency Cooperation Division.

- On July 21, 2023, we provided DOE with questions on their draft Environmental Assessment. DOE provided responses to our questions on July 27 and July 28, 2023. DOE declined to conference on the proposed North Atlantic DPS of green turtle and Rice's whale critical habitat.
- On July 28, 2023 we determined that there was sufficient information to initiate formal consultation with DOE. We provided DOE with an initiation letter on August 1, 2023.

2 THE ASSESSMENT FRAMEWORK

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

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical and biological features (PBFs) essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02).

The final designations of critical habitat for various species used the term primary constituent element or essential features prior to 2016. The critical habitat regulation revisions (81 FR 7414; February 11, 2016) replaced this term with physical and biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified primary constituent elements, PBFs, or essential features. In this opinion, we use the term PBFs to mean primary constituent elements or essential features, as appropriate for the specific designated critical habitat in the action area.

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species and designated critical habitat.

Potential Stressors (Section 4): We identify and describe the stressors that could occur as a result of the proposed action that may result in effects on the physical, chemical, and biotic environment within the action area.

Action Area (Section 5): We describe the action area with the spatial extent of those stressors caused by the proposed action.

Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area (Section 6): We identify the ESA-listed species and designated critical habitat that are subject to this consultation because they co-occur with the stressors produced by the proposed action in space and time.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 7): During consultation, we determined that some ESA-listed species and critical habitat that occur in the action area were not likely to be adversely affected by the stressors produced by the proposed action, and we detail our effects analysis for these species and critical habitats.

Species Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species that are likely be adversely affected. In this section, we describe the status of ESA-listed species that may be adversely affected by the proposed action.

Environmental Baseline *(*Section 9): We describe the environmental baseline, which refers to the condition of the ESA-listed species in the action area, without the consequences to the ESA-listed species caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02).

Effects of the Actions (Section 10): Effects of the action are all consequences to ESA-listed species that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.02). The effects analysis is broken into analyses of exposure and response. To characterize exposure, we identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and populations or sub-populations to which those individuals belong. We also consider whether the PBFs of designated critical habitat will be exposed. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how the PBFs of designated critical habitat exposed to stressors from the proposed action will respond. This is our response analysis.

Cumulative Effects (Section 11): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 12): In this section we integrate and synthesize the analyses in the opinion to summarize the consequences to ESA-listed species and designated critical habitat under NMFS's jurisdiction.

With full consideration of the status of the species and the designated critical habitat, we consider the effects of the actions within the action area on populations or subpopulations and on PBFs of designated critical habitat when added to the environmental baseline and the cumulative effects to determine whether the action would reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or
- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

The results of our jeopardy and destruction and adverse modification analyses are summarized in the Conclusion (Section 13). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (50 C.F.R. §402.14).

In addition, we include an ITS (Section 14), if necessary, that specifies the impact of the take, RPMs to minimize the impact of the take, and terms and conditions to implement the RPMs (ESA section 7(b)(4); 50 C.F.R. §402.14(i)). We also provide discretionary Conservation Recommendations (Section 15) that may be implemented by the action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which Reinitiation of Consultation is required (Section 16; 50 C.F.R. §402.16).

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of *Google Scholar*, literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the DOE;
- Government reports (including NMFS biological opinions and 5-year reviews);
- NOAA technical memorandums;
- Monitoring reports; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS's jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species. Collectively, we consider the foregoing to comprise the best scientific information available for this biological opinion.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 C.F.R. §402.02).

The proposed action addressed by this consultation is DOE's proposal to fund UT to conduct a seismic survey in the northwestern Gulf of Mexico in fall of 2023.

The DOE has a continuing need to fund research that meets their vision to deliver integrated solutions to enable transformation to a sustainable energy future. The seismic survey will be used to fulfill a research project under the DOE funding opportunity announcement for "Development of Technologies for Sensing, Analyzing, and Utilizing Novel Subsurface Signals in Support of the Subsurface Technology and Engineering Crosscut Initiative," which has undergone the DOE merit review process and meets the agency's mission to drive innovation and deliver solutions for an environmentally sustainable and prosperous energy future.

The information presented here is based primarily on the draft Environmental Assessment provided by the DOE (DOE 2023) as part of their initiation package.

3.1 Seismic Survey Overview and Objectives

Researchers from UT, with funding from the DOE, propose to conduct a marine seismic survey to validate novel dynamic acoustic positioning technology for improving the accuracy in time and space of HR3D marine seismic technology. The main goal for the seismic survey proposed by Principle Investigator Dr. T. Meckle is to collect data using HR3D marine seismic technology to interpret the upper ~1 km (~0.62 mi) of the geologic substrate. In particular, the collected data will be used for field validation of monitoring, verification, and accounting technology of sub-seabed carbon storage. This will help identify offshore carbon sequestration potential in the Gulf of Mexico.

The proposed survey will take place in the Gulf of Mexico, off Texas, in the fall of 2023. DOE and UT determined fall to be the most feasible time for the proposed survey due to favorable weather conditions, operational requirements, availability of the researchers, and because it does not coincide with sea turtle nesting season in the Gulf of Mexico when sea turtle densities are highest. The survey will occur over 10 days (7 days of seismic acquisition, 3 days of transit to and from either the Port of Galveston or the Port of Freeport). The survey area is located at approximately 28.9–29.1°N and 94.9–95.2°W, within Texas state waters and within the U.S. Exclusive Economic Zone. The survey will occur offshore of San Luis Pass (the southern tip of Galveston Island, Texas) 22 km (~13.67 mi) northeast of Freeport, Texas, ~3 km from shore, and encompass an area of 222 km^2 (~85.71 mi^2). Water depths of the survey area are no deeper than 20 m (~65.6 ft). The closest approach to shore would be 3.2 km (~2 mi).

3.2 Research Vessel Specifications

The airguns and hydrophone streamers will be towed by a single source vessel, the R/V *Brooks McCall*, or similar vessel, owned by TDI-Brooks. TDI-Brooks has over 25 years of chartering vessels and the R/V *Brooks McCall* operates primarily in the Gulf of Mexico and U.S. East Coast. The R/V *Brooks McCall* has a length of ~48.5 m (~159 ft), a beam of ~12.2 m (~40 ft), and a maximum draft of ~3 m (~9.8 ft). Its maximum speed is 11 kts (~20.4 km/h); however, during the seismic survey, the vessel will travel at ~4–5 kts (7.4–9.3 km/h). The R/V *Brooks McCall* propulsion system uses 3 Detroit 16V92 diesel engines, each of which produces 700 hp. The maximum continuous power is 2,100 hp. The R/V *Brooks McCall* can hold ~238 m^3 (~62,872 gal) of fuel and will use low-sulfur fuel.

The research vessel will be self-contained, UT researchers and technicians, and the ship's crew, will live aboard the R/V *Brooks McCall* for the entirety of the seismic survey. The R/V *Brooks McCall* has a maximum capacity of 32 persons. All waste will be retained and returned to shore, rather than being appropriately disposed of at sea. The R/V *Brooks McCall* will also serve as the platform for protected species observers (PSOs), from which they will visually monitor the surrounding area for protected species.

3.3 Airgun Description

The R/V *Brooks McCall* will tow up to 2 Generator-Injector (GI) airguns. A 2 GI airgun source was chosen by DOE and UT to be the lowest practical source that could meet the scientific objectives. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor. It generally consists of a steel cylinder that is charged with high-pressure (compressed) air. The release of the compressed air into the water column produces a pressurized air bubble, which produces a sound wave. The sound wave propagates outward, reflecting or refracting off the seafloor and subsurface. That reflected or refracted signal is detected by the receiving system (usually towed behind the vessel) and then analyzed later on a computer. A GI airgun is slightly different in that it has 2 independent air chambers within the same cylinder casing: the Generator, which generates the primary pulse creating the main air bubble, and the Injector, which injects air into the main air bubble, causing it to collapse quickly. This improves data quality because the quick collapse of the main air bubble reduces bubble oscillation and leads to a cleaner acoustic signal.

Each GI airgun will have a volume of ~1,721 cm^3 (105 in^3), for a total possible discharge volume of ~3,441 cm^3 (210 in^3). The airguns will be towed 2 m (~6.6 ft) apart and at a depth of 3 m (~9.8 ft). Airguns will fire at a shot interval of 12.5 m or ~41 ft (~5–10 s). Total firing pressure of the airguns would be approximately 2,000 psi. During firing, a brief pulse of sound (~0.1 s) is emitted, and airguns would be silent during the intervening periods. Airguns will be operated 24 h a day during the survey, excluding transit time to and from the port and the survey area (a total of approximately 168 h of airgun operations) and any unscheduled shutdowns. The total distance the seismic source would be towed while active during the survey is 1,704 km (~1,058.8 mi). See Table 1 for specifications of the 2 GI airgun source.

Table 1. Specifications of the 2 GI airguns to be used by the Research Vessel *Brooks McCall* during the seismic survey in the Gulf of Mexico

2 GI Airgun Specifications	
Energy Source – Number of Airguns	2 Sercel GI aiguns (105 in^3 each) Firing pressure of 2,000 psi
Source Output (Downward)	Peak-to-Peak = 239.6 dB re 1 µPa m [rms] 0-to-Peak = 233.8 dB re 1 µPa m [rms]
Position	2 string, in-line 2 m apart
Tow Depth	3–4 m
Air Discharge Volume	Approximately 210 in^3
Dominant Frequency Components	0–188 Hz
Pulse Duration	Approximately 0.113 s
Shot Interval	Approximately 12.5 m or 5–10 s

in^3=cubic inches, psi=pounds per square inch, dB=decibel, µPa=micro Pascal, rms=root mean square, m=meters, Hz=Hertz

The receiving system consists of 4 solid-state (solid flexible polymer, not gel or oil filled) hydrophone streamers. Each hydrophone streamer is 25 m (~82 ft) long and will be spaced 10 m (~32.8 ft) apart (i.e., the total spread of the hydrophone streamers will be 30 m or ~98.4 ft). Hydrophone streamers will be towed at a depth of 2 m (~6.6 ft). The towed hydrophone streamers receive the returning acoustic signals and transfer the data to an onboard processing system. The UT Gulf Coast Carbon Center designed and built GPS receivers, which can be used to accurately position the receivers on the hydrophone streamer and the acoustic source (airguns) via tail buoys. The turning rate of the R/V *Brooks McCall* will be limited when towing the airguns and hydrophone streamers.

3.4 Conservation Measures

DOE and UT plan to implement conservation measures (i.e., mitigation [during pre-survey planning and operations], monitoring, and reporting measures) to reduce the likelihood of adverse effects to ESA-listed species and their designated critical habitat from their proposed action. Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA-listed species. Monitoring is used to observe or check the progress of the mitigation over time and to ensure that any measure implemented to reduce or avoid adverse effects on ESA-listed species are successful.

In the draft Environmental Assessment provided by DOE, DOE and UT have considered mitigation and monitoring measures implemented during previous seismic surveys (including past NMFS Permits Division Incidental Harassment Authorizations and ITSs) and recommended best practices in Simmonds et al. (2014), Wright (2014), and Dolman and Jasny (2015). They have incorporated the following mitigation and monitoring measures into the proposed action based on the above sources:

- Exclusion and buffer zones;
- Shutdown and ramp-up procedures;
- Vessel-based monitoring by NMFS-approved PSOs;
- Additional measures considered; and
- Reporting.

Details on the above conservation measures are in the sections below.

3.4.1 Exclusion and Buffer Zones

DOE and UT will implement exclusion and buffer zones around the R/V *Brooks McCall* to minimize any potential adverse effects of sound from the 2 GI airguns on ESA-listed species. The exclusion zone is the area within which an occurrence of an ESA-listed species triggers a shutdown of the airguns. This reduces the exposure of ESA-listed species to sound levels that would be expected to have adverse effects on the species or habitats. The buffer zone is an area beyond the exclusion zone that will be monitored for the presence of ESA-listed species that may enter the exclusion zone. In the past, NMFS required a 100 m (~328.08 ft) exclusion zone and a 100 m (~328.08 ft) buffer zone for low-energy seismic surveys. Thus, DOE and UT will establish and monitor a 100 m (~328.08 ft) exclusion zone and a 100 m (~328.08 ft) buffer zone beyond the exclusion zone.

3.4.2 Shutdown and Ramp-Up Procedures

Shutdown of the airguns is the immediate deactivation of all airguns. Shutdown will occur if an ESA-listed species is observed within or approaching the 100 m (~328.08 ft) exclusion zone. Any PSO on duty will have the authority to delay the start of seismic survey activities or to call for a shutdown of the airguns if an ESA-listed species is observed within the exclusion zone. When a shutdown is called for by a PSO, the airguns must be immediately deactivated and any dispute regarding a PSO shutdown must be resolved only following deactivation. Following a shutdown, airgun activity will not resume until the ESA-listed species has cleared the exclusion zone.

The animal will be considered cleared from the exclusion zone if:

- It was visually observed to have left the exclusion zone, or
- It was not seen within the exclusion zone for 15 min (for sea turtles).

A ramp-up will begin by activating a single GI airgun and adding the second GI airgun 5 min later. During ramp-up, PSOs will monitor the exclusion and buffer zone, and, if an ESA-listed species is observed within or entering the exclusion zone, a shutdown will be implemented. If an ESA-listed species has not cleared the exclusion zone described in the shutdown procedures, a ramp-up will not occur.

A ramp-up will be implemented if a shutdown lasts 30 min or longer, as long as PSOs have maintained constant visual observation and no ESA-listed species were observed within the exclusion zone. A ramp-up will also be implemented if a shutdown is less than 30 min and PSOs have not maintained constant visual observation. If a shutdown lasts longer than 30 min and PSOs have not maintained constant visual observation, PSOs will monitor the exclusion and buffer zones for 30 min before ramp-up begins.

3.4.3 Vessel-Based Visual Monitoring

Visual monitoring of the exclusion and buffer zone is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of ESA-listed species, thereby reducing the potential for adverse effects.

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of protected species (e.g., marine mammals, sea turtles, and fish). The area to be scanned visually includes primarily the exclusion zone, within which observation of certain protected species requires shutdown of the airgun array, but also the buffer zone. The buffer zone means an area beyond the shutdown zone to be monitored for the presence of protected species that may enter the shutdown zone.

Three independently contracted PSOs will be onboard the survey vessel during all seismic survey operations. During daytime, PSOs will scan the area around the vessel systematically with reticle binoculars (e.g., 7x50 Fujinon), Big-eye binoculars (25x150), and with the naked eye. No nighttime visual monitoring will be conducted. PSOs will have rotating shifts to allow for at least 1 observer (2 observers are recommended, although there will be times [e.g., breaks, meal times] when only 1 observer will be on duty) where to monitor for protected species.

3.4.4 Reporting

A monitoring report will be provided to NMFS. This comprehensive report detailing all seismic survey activities and monitoring results will be provided to NMFS ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey.

4 POTENTIAL STRESSORS

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may induce an adverse effect either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to occur from the proposed action. These can be categorized as pollution (e.g., exhaust, fuel, oil, and trash), vessel strike, visual and acoustic disturbance (research vessel, airguns, and hydrophone streamers), and entanglement and/or interaction with towed seismic equipment (airguns and hydrophone streamers).

Below we provide information on the effects of these potential stressors. The proposed action includes several conservation measures (Section 3.3) that are designed to minimize effects from these potential stressors. Although these conservation measures are important and we expect them to be effective in minimizing the effects of these potential stressors, they do not completely eliminate the stressors. We treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action.

4.1 Pollution

Operation of the R/V *Brooks McCall* may result in pollution from exhaust, fuel, oil, and trash. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Chance et al. 2015; Duce et al. 1991). Emissions include carbon dioxide, methane, nitrous oxide, and other fluorinated gases that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). Pollutants in discharges of gray water and wastewater from the research vessel can degrade habitat for marine life.

Release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species by risk of entanglement or ingestion (Gall and Thompson 2015). While lethal and non-lethal effects to air-breathing marine animals are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015).

4.2 Vessel Strike

Transit of any vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries or death.

The probability of a vessel strike and associated response depends on the size and speed of the vessel, as well as the distribution, abundance, and behavior of the species. Vessel strike risk in sea turtles is not as well understood as it is in marine mammals. However, vessel strike is still considered a significant threat to sea turtles, which generally swim slower than other mobile marine species. Vessel strike is of particular concern for sea turtles occupying shallow coastal waters with high recreational boat density (Fuentes et al. 2021). Evidence of vessel strike has been documented in stranded and dead sea turtles in the Gulf of Mexico and U.S. Atlantic Ocean, as well as internationally (Barco et al. 2016; Denkinger et al. 2013; Foley et al. 2019; Hazel and Gyuris 2006; Reneker et al. 2018; Sobin and Tucker 2008; Tomás et al. 2008). Based on behavioral observations of green turtle avoidance of a small vessel (6 m in length), green turtles may be susceptible to vessel strikes at speeds as low as ~2 kts (4 km/h; Hazel et al. 2007a).

ESA-listed fishes considered in this opinion are elasmobranchs (e.g., sharks, rays, skates, and sawfish), which spend at least some time throughout their life in the upper portions of the water column where they may be susceptible to vessel strike.

4.3 Visual and Acoustic Disturbance

The proposed action will produce different sounds (vessel noise, noise from seismic survey equipment) that may produce an acoustic disturbance or otherwise affect ESA-listed species (e.g., auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, and physical or physiological responses). The presence of the research vessel and towed seismic survey equipment may also produce a visual disturbance that may affect ESA-listed species.

The research vessel associated with the proposed action may cause visual or auditory disturbance to ESA-listed species that spend time near the surface of the water. There have been limited studies on how sea turtles and fishes respond to vessel presence; however, avoidance behaviors (i.e., diving, swimming away) have been documented in green turtles and fish exposed to an approaching vessel (Brehmer et al. 2019; De Robertis and Handegard 2013; Hazel et al. 2007a). For elasmobranchs in particular, it is uncertain how they may or may not be disturbed by vessel presence and noise. However, they are able to detect particle motion (the movement of the water), and in addition to visual cues, are able to sense an oncoming vessel and move away.

Documented behavioral changes in sea turtles and fishes due to seismic survey noise include avoidance, habituation, dive/startle responses, higher levels of stress hormones, and disrupted schooling of fish (DeRuiter and Larbi Doukara 2012; McCauley et al. 2003a; Nelms et al. 2016; Weilgart 2018). Loggerhead and green turtles displayed avoidance behavior such as faster swimming speeds, changes in swimming direction, and rapid dives in response to airgun noise (DeRuiter and Larbi Doukara 2012; McCauley et al. 2003a). For some species of shark, behavioral changes have been documented in response to the presence of loud and high intensity sound sources (Klimley and Myrberg 1979; Myrberg et al. 1978) and in the presence of artificially generated sound (Chapuis et al. 2019). In a study off Australia, some acoustically tagged sharks displayed possible avoidance to seismic survey operations (i.e., changing their swimming speed during seismic survey operations or changing their diel movement patterns post-survey) but others moved in and out of the area and even into the seismic survey area (Bruce et al. 2018). However, other studies show that some shark species may be attracted to low frequency pulsed sounds (Myrberg 2001). Thus, noise from both the research vessel and airguns remains a potential stressor associated with the proposed action.

4.4 Gear Entanglement and Interaction

The towed seismic equipment (i.e., airguns and towed hydrophone streamers) may pose an entanglement risk to ESA-listed species. Entanglement can result in injury or death of ESA-listed species. Sea turtles that are entangled in gear may starve from restricted movement, be injured from line or rope leading to lacerations and amputations, and may die from drowning/asphyxiation or even exertional myopathy, a muscle disease resulting from strenuous exercise or exercise under extreme stress (e.g., Duncan et al. (2017); Hamelin et al. 2017; Phillips et al. 2015). Injury and death from entanglement have been documented during all life stages of ESA-listed sea turtles (Duncan et al. 2017).

Entanglement of elasmobranchs is relatively understudied compared to marine mammal and sea turtle entanglements; however, studies have documented entanglement in both sharks and rays (see Parton et al. 2019 for a review). Entanglement in elasmobranchs can also result in injury, including laceration and abnormal anatomical development, and mortality (Afonso and Fidelis 2023).

Though unlikely, the towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglement has occurred in towed gear from seismic survey vessels. For example, a National Science Foundation-funded seismic survey off the coast of Costa Rica in 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the deflector foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the deflector foil pre- or post-mortem (Spring 2011).

5 ACTION AREA

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

The proposed DOE action will occur at approximately 28.9–29.1°N and 94.9–95.2°W, within Texas state waters and within the U.S. Exclusive Economic Zone (Figure 1). Tracklines could occur anywhere in the proposed survey area (Figure 1), with ~222 km (~138 mi) of tracklines surveyed in one day, and a total of 1,704 km (~1,058.8 mi) of seismic acquisition.

The action area also includes all areas where stressors from the proposed action could occur: transit routes from the Port of Galveston or Port of Freeport and areas to which the sound from the airguns would travel (the ensonified area). It is difficult to measure the entire area that would be ensonified by the airguns, because to do so would require information on the ambient, or background, noise levels in the proposed survey area and then calculating at what distance from the source vessel the sound from the airguns would be similar to ambient noise levels. Ambient noise level measurements are difficult to find for a specific area because they can vary based on location, time, and environmental conditions such as water depth, wind, rain, sea ice coverage, and presence of vocalizing marine species (Hildebrand 2009a; Wenz 2005). However, as an alternative, sound propagation loss was estimated using a spreading loss equation to the 120 dB level. The 120 dB level is a lower threshold than any threshold used by NMFS to estimate acoustic impacts to ESA-listed species (see Summary of Endangered Species Act Acoustic Thresholds at https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance), meaning that it is a conservative estimate of how far we would expect the sound from the airguns to travel and still have some effect on ESA-listed species. The distance to the 120 dB level based on the estimate source level of 2 GI airguns is

78–123 km or ~48.5–76.4 mi (M. Lusk, DOE, pers. comm to E. Chou, NMFS ESA Interagency Cooperation Division, July 27, 2023). This is less than approximately half the distance of trackline the research vessel would survey in 1 day.

The action area would not extend beyond the total area shown in Figure 1 (survey area in the red box). We do not anticipate any effects outside the area shown in Figure 1.

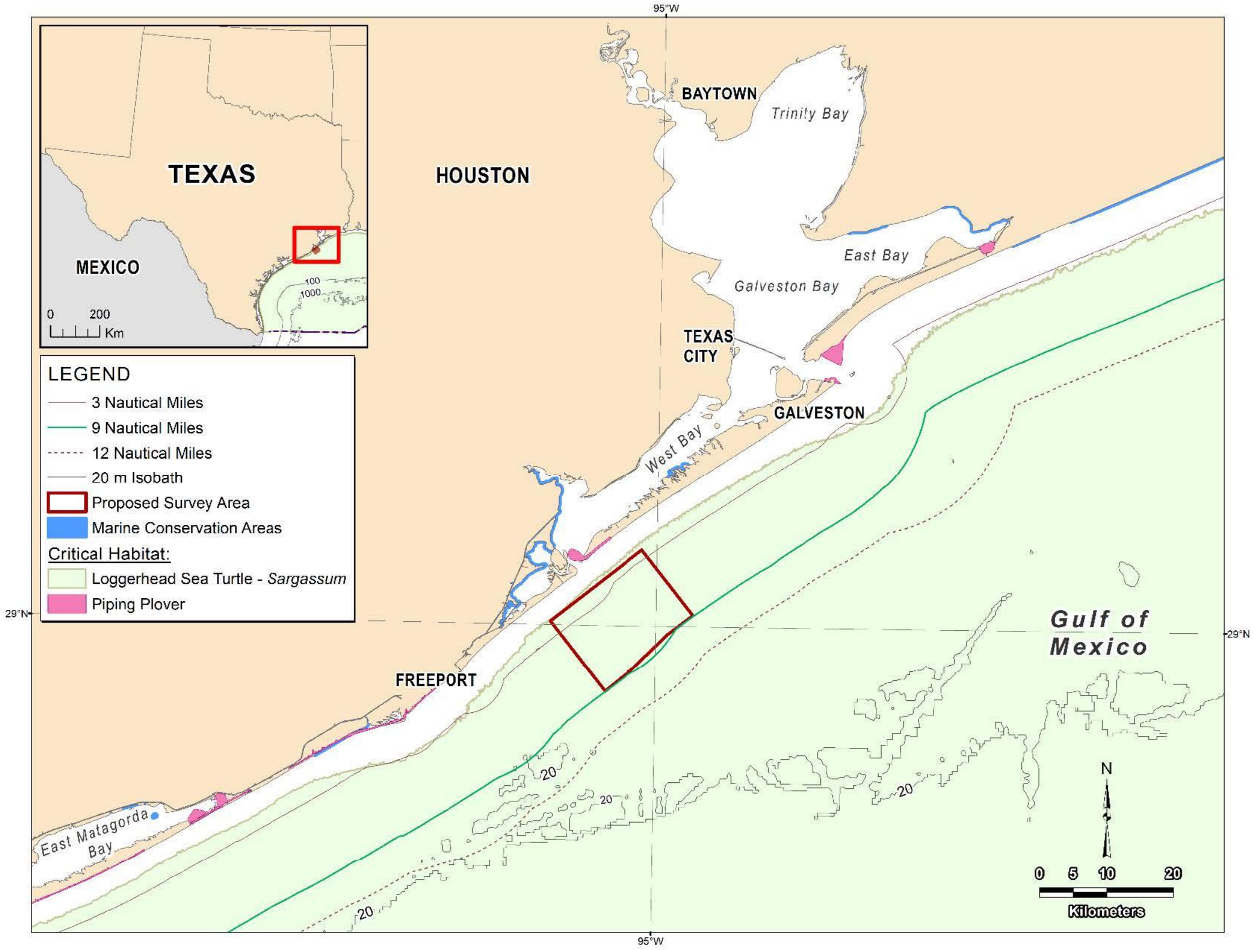

Figure 1. Map of the Department of Energy National Energy Technology Laboratory and University of Texas at Austin's proposed seismic survey in the Gulf of Mexico off Texas (DOE 2023)

6 ENDANGERED SPECIES ACT-LISTED SPECIES AND DESIGNATED CRITICAL HABITAT IN THE ACTION AREA

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area (Table 2) and thus may be affected by the stressors introduced to the action area by the proposed action.

Table 2. Endangered Species Act-Listed threatened and endangered species and designated critical habitat that potentially occur in the action area

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693* and 88 FR 46572 (Proposed)	10/1991 – U.S. Atlantic
Hawksbill Turtle (*Eretmochelys imbricata*)	E – 35 FR 8491	63 FR 46693*	57 FR 38818 08/1992 – U.S. Caribbean, Atlantic, and Gulf of Mexico
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	03/2010 – U.S. Caribbean, Atlantic, and Gulf of Mexico 09/2011
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170*	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 01/2009 – Northwest Atlantic
Fishes			
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	10/2019 (Outline)
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018 (Outline)

ESA= Endangered Species Act, T=Threatened, E=Endangered, FR=*Federal Register*, DPS=Distinct Population Segment, * = critical habitat not in action area

7 SPECIES AND DESIGNATED CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

NMFS uses 2 criteria to identify the ESA-listed species or designated critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are consequences of the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between 1 or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a response given exposure. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action, but is not likely to respond to the stressor, is also not likely to be adversely affected by the proposed action. We applied these 2 criteria to the ESA-listed species and designated critical habitat in Section 6 and we summarize our results below.

The applicable standard to find that a proposed action is not likely to adversely affect (NLAA) ESA-listed species or designated critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or wholly beneficial. Discountable effects are those that could occur while an ESA-listed species is in the action area, but because of the intensity, magnitude, frequency, duration, or timing of the stressor, exposure to the stressor is extremely unlikely to occur. Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when species or critical habitat will be exposed to stressors, but the response will not be detectable outside of normal behaviors/habitat function. Beneficial effects have an immediate positive effect without any adverse effects to the species or habitat.

This same decision model applies to individual stressors associated with the proposed action. For stressors that meet these criteria for wholly beneficial, discountable, or insignificant, the appropriate conclusion is NLAA.

In Section 7.1, we evaluate the proposed action’s stressors (Section 4) that are not likely to adversely affect ESA-listed species and designated critical habitat. In Sections 7.2–7.4, we also identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by all stressors from the proposed action.

Stressors that may affect, but are not likely to adversely affect the ESA-listed sea turtles, fishes, and designated critical habitat considered in this opinion (see Table 2) include pollution, vessel strike, vessel noise and visual disturbance, and gear entanglement and interaction. The following sections describe how we reached our effects determinations for these stressors.

7.1 Stressors Not Likely to Adversely Affect Species or Designated Critical Habitat

Stressors that may affect, but are not likely to adversely affect the ESA-listed sea turtles, fishes, and designated critical habitat considered in this opinion (see Table 2) include pollution, vessel strike, vessel noise and visual disturbance, and gear entanglement and interaction. The following sections describe how we reached our effects determinations for these stressors.

7.1.1 Pollution

Pollution in the form of exhaust, fuel or oil spills or leaks, and trash or other debris resulting from the use of the research vessel as part of the proposed action could result in impacts to ESA-listed sea turtles, fishes, and PBFs for the Northwest Atlantic Ocean Distinct Population Segment (DPS) of loggerhead turtle designated critical habitat.

Exhaust (i.e., air pollution, including carbon dioxide, nitrogen oxides, and sulfur oxides) from the research vessel would occur during the entirety of the proposed action (transit and operations), and could affect air-breathing ESA-listed species such as sea turtles. The R/V

Brooks McCall (or similar vessel) uses low-sulfur fuel (sulfur content between 0.1 and 1.5 m/m %). It is unlikely that exhaust resulting from the operation of the R/V *Brooks McCall* (or similar vessel) will have a measureable effect on ESA-listed sea turtles given the relatively short duration of the seismic survey (10 days) and the brief amount of time that sea turtles spend at the water's surface. In addition, due to the relatively large size of the action area and overall small contribution of air emissions from the R/V *Brooks McCall* (or similar vessel) compared to all ocean-going vessels in the action area, we expect that potential effects to ESA-listed species from vessel exhaust during the proposed action is immeasurable. For these reasons, the effects that may result from exhaust on ESA-listed sea turtles, fishes, and the Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat are insignificant.

Discharges into the water from the research vessel (e.g., wastewater, leakages of fuel or oil) are unlikely, and effects of any spills to ESA-listed sea turtles, fishes, and designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtles will be minimal, if they occur at all. The potential for fuel or oil leakages is extremely unlikely. The R/V *Brooks McCall* has not had a spill in over 5 years. DOE and UT will dispose of all project-related wastes in accordance with international, U.S. state, and federal requirements. In particular, for a vessel that remains close to shore, as the R/V *Brooks McCall* will in the proposed seismic survey, all waste will be retained onboard and returned to shore rather than appropriately disposed of at sea. Thus, we expect the risk from fuel or oil spills, leaks, and waste, on ESA-listed sea turtles, fishes, and the Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat to be extremely unlikely to occur and thus discountable.

Trash or other debris resulting from the proposed action may affect ESA-listed sea turtles, fishes, and designated critical habitat. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The gear used in the proposed seismic survey may also result in marine debris if lost at sea. However, because the potential for accidental release of trash or loss of gear is extremely unlikely to occur, we expect that the effects from debris on ESA-listed sea turtles, fishes, and the Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat are discountable.

For the reasons stated above, we conclude that pollution by vessel exhaust, waste, fuel or oil spills or leaks, and trash or other debris, may affect, but is not likely to adversely affect ESA-listed species and designated critical habitat in the action area.

7.1.2 Vessel Strike

While vessel strikes of sea turtles and fishes during the seismic survey are possible, we are not aware of any definitive case of a sea turtle or fish being struck by a vessel associated with seismic surveys. While the risk of vessel strike to sea turtles is of particular concern in shallow coastal waters (Fuentes et al. 2021), we believe vessel strike to be extremely unlikely due to the general expected movement of sea turtles and fishes away from or parallel to the research vessel, as well as the relatively slow speed of the research vessel. The research vessel used for the proposed seismic survey will be traveling at a relatively slow speed (~4–5 kts [7.4–9.3 km/h]) during airgun operations, with a maximum transit speed of 11 kts (~20.4 km/h), thereby reducing the potential for vessel strike. We also expect vessel strike risk to ESA-listed elasmobranchs considered in this opinion to be extremely unlikely because they are able to detect approaching vessels, through visual cues or hearing, and move away. Elasmobranchs are able to detect particle motion, especially in shallow water, and are able to move quickly to avoid vessel strike (Myrberg 2001; Popper and Hawkins 2016).

In addition to the rationale above, adherence to conservation measures such as vessel-based visual monitoring of exclusion and buffer zones, is expected to further reduce the likelihood of vessel strikes of ESA-listed sea turtles and fishes. We expect that vessel strikes to ESA-listed sea turtles and fishes in the action area are extremely unlikely to occur, and the effect is therefore discountable. We conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species.

7.1.3 Vessel Noise and Visual Disturbance

The research vessel to be used for the proposed seismic survey may cause visual or auditory disturbance to ESA-listed species that spend time near the surface or upper parts of the water column, such as sea turtles and fishes. Visual and auditory disturbance may also affect the PBFs for loggerhead turtle designated critical habitat, particularly important species in *Sargassum* habitat (i.e., copepods that make up the PBF for available prey). Vessel noise and visual disturbance may disrupt species' behavior resulting in avoidance when a vessel moves towards them. However, it is difficult to distinguish whether these responses are caused by the physical presence of a vessel, the underwater noise generated by the vessel, or an interaction between the two.

The research vessel's passage past ESA-listed sea turtles or fishes would be brief, and not likely to significantly impact any individual's ability to feed, reproduce, or avoid predators. Conservation measures proposed by DOE and UT (e.g., shutdown and ramp-up procedures, and vessel-based visual monitoring) will also minimize the risk of noise from the airguns. In addition, sea turtles are most likely to habituate to the vessel noise, and were observed to be less affected by vessel noise at distances greater than 10 m or ~32.8 ft (Hazel et al. 2007a). The relatively slow traveling speed of the research vessel would also reduce underwater noise (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007).

Regarding impacts on the PBFs for the Northwest Atlantic Ocean DPS of loggerhead turtle, impacts of vessel presence (visual and auditory, though most scientific literature is focused on the auditory impacts) on prey species such as copepods are largely unknown. Some studies have shown vessel noise to elicit anti-predatory defense behavior and a reduction in egg production and size of copepods (Aspirault 2019); however, other studies have shown a lack of response in zooplankton (Prosnier et al. 2022; Sabet et al. 2019).

Because the potential visual and auditory disturbance from the research vessel is expected to be nearly undetectable, or so minor that it cannot be meaningfully evaluated, we expect that this risk to ESA-listed sea turtles, fishes, and the Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat is insignificant. Therefore, we conclude that vessel noise and visual disturbance may affect, but is not likely to adversely affect ESA-listed species or designated critical habitat.

7.1.4 Gear Entanglement and Interaction

The towed seismic survey equipment (airguns and hydrophone streamers) may pose a risk of entanglement and interaction to ESA-listed sea turtles and fishes. Although the towed seismic survey equipment could come in direct contact with an ESA-listed species, resulting in entanglement or interaction, we expect this to be extremely unlikely. The airguns and towed hydrophone streamers are rigid and, as such, are not expected to encircle, wrap around, or, in any other way, entangle any ESA-listed sea turtles or fishes considered in this opinion. Furthermore, we expect sea turtles and fishes to avoid areas where the airguns are actively being used, meaning they would likely avoid the towed hydrophone streamers as well. Instances of entanglement and interaction of ESA-listed species in towed seismic survey equipment are unknown to us. Based upon the material of the gear, the conservation measures that will be implemented by DOE and UT (e.g., vessel-based visual monitoring, exclusion and buffer zones), and the extensive deployments of this type of equipment with no reported entanglements or interactions, we find the probability of adverse impacts to ESA-listed sea turtles and fishes from this stressor to be extremely unlikely to occur, and any effects are discountable. Therefore, we conclude that gear entanglement and interaction may affect, but are not likely to adversely affect ESA-listed sea turtles and fishes.

7.1.5 Potential Stressors Considered Further

The remaining potential stressor that may affect ESA-listed species and designated critical habitat within the action area is the sound produced by the 2 GI airguns. This stressor associated with the proposed seismic survey may affect ESA-listed species and designated critical habitat. ESA-listed species and designated critical habitat that are not likely to be adversely affected by this stressor are evaluated in the sections below. ESA-listed species that are likely to be adversely affected by this stressor are further analyzed and evaluated in Section 10.

7.2 Elasmobranchs

ESA-listed elasmobranchs considered in this opinion (giant manta ray and oceanic whitetip shark) may be exposed to and be able to detect sound generated by the 2 GI airguns used in the seismic survey. Elasmobranchs are able to detect particle motion, rather than sound pressure, because they lack a swim bladder like most teleost fish (Myrberg 2001; Popper and Hawkins 2016). They use their inner ears and lateral line, which is capable of detecting relative motion between the body's surface and the surrounding water, to detect nearby (generally within 2 body lengths) sound sources (Popper et al. 2014a). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low-frequency sound from the airguns, if exposed. However, the duration and intensity of low-frequency sound sources and implementation of conservation measures (e.g., shutdown and ramp-up procedures, vessel-based visual monitoring) will likely minimize the effect of airgun noise on elasmobranchs. Furthermore, elasmobranchs generally are not considered especially sensitive to sound (Casper et al. 2012).

For some species of elasmobranchs, behavioral changes have been documented in response to the presence of sound. A study on southern stingrays in a very shallow (35–75 cm depth) ocean net pen (5x5 m), observed changes in swimming behavior in response of low-frequency tones (50–500 Hz) at 140 dB re 1 µPa in females, and 160 dB re 1 µPa in males (Mickle et al. 2020). Some species of sharks also temporarily changed their behavior in response to loud and high intensity sound sources (Klimley and Myrberg 1979; Myrberg et al. 1978) and in the presence of artificially generated sound (Chapuis et al. 2019). In a study off Australia, some acoustically tagged sharks displayed possible avoidance of seismic survey operations (i.e., changing their swimming speed during seismic survey operations or changing their diel movement patterns post-survey) but others moved in and out of the area and even into the seismic survey area (Bruce et al. 2018). Other studies show that some shark species are attracted to low-frequency pulsed sounds (Myrberg 2001). Pulsed sounds are not unlike the sound from airguns, and a review of sound effects on fishes concluded that the relative risk of elasmobranchs exhibiting a behavioral response, injury, or mortality to impulsive sound sources was low (Popper et al. 2014a).

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood; however, given the signal of the airgun sound and level of exposure to the signal, we do not expect a measureable response. The most likely response of ESA-listed elasmobranchs exposed to the airguns, if any, would be minor temporary behavioral changes in orientation to the sound source, none of which would be detectable outside of normal behavioral responses or result in adverse effects to the individual. Therefore, the potential effect of the airgun noise on ESA-listed elasmobranchs is considered insignificant. We conclude that noise from the airguns may affect, but is not likely to adversely affect ESA-listed elasmobranchs (giant manta ray and oceanic whitetip shark).

7.3 Hawksbill Sea Turtle

The ESA-listed hawksbill turtle may occur in the action area and may be affected by sound generated by the 2 GI airguns used in the seismic survey. The hawksbill turtle is generally found throughout the tropics and subtropics, including coastal and pelagic areas, in the Atlantic, Indian, and Pacific Oceans (NMFS 2013). Hawksbill turtles nest at low densities throughout the southern Gulf of Mexico (April–September; Cuevas et al. 2019) and wider Caribbean region (Piniak and Eckert 2011), with infrequent nesting in southern Texas (Eckert and Eckert 2019; Valverde and Holzwart 2017). Based on telemetry data compiled by The State of the World's Sea Turtles (SWOT 2022) and sightings recorded in the Ocean Biodiversity Information System Spatial Ecological analysis of Megavertebrate Populations (OBIS-SEAMAP) database, hawksbill turtles are rare in the northern Gulf of Mexico. For hawksbill turtles, the DOE effects determination was may affect, likely to adversely affect. However, based on the best available science, summarized above and in the DOE’s draft environmental assessment (DOE 2023), it is extremely unlikely that the proposed seismic survey will overlap with hawksbill turtles. In addition, the closest OBIS-SEAMAP record of a hawksbill turtle to the proposed survey area is ~200 km (~124 mi) south, off Corpus Christi, Texas, and only one other sighting has been made off Texas, in deep water (Halpin et al. 2009). Because of the low probability of occurrence of hawksbill turtles in the action area, the potential of exposure to effects from the airgun noise is extremely unlikely to occur and thus discountable. Therefore, we conclude that DOE and UT’s seismic survey may affect, but is not likely to adversely affect ESA-listed hawksbill turtles.

7.4 Designated Critical Habitat – Loggerhead Turtle Northwest Atlantic Ocean Distinct Population Segment

On July 10, 2014, NMFS and the U.S. Fish and Wildlife Service (USFWS) designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtles along the U.S. Atlantic and Gulf of Mexico coasts (79 FR 39856; Figure 2). The Final Rule designated 5 different units of critical habitat, each supporting PBFs for loggerhead turtles. These units include nearshore reproductive habitat, winter area, *Sargassum*, breeding areas, and migratory corridors. In total, the designated critical habitat is composed of 38 occupied marine areas and 1,102.4 km (685 mi) of nesting beaches. Loggerhead designated critical habitat occurs within the action area; however, only the *Sargassum* unit overlaps with the action area. PBFs for *Sargassum* habitat include: 1) areas where there are concentrated components of the *Sargassum* community in water temperatures suitable for optimal growth of *Sargassum* and loggerhead inhabitance; 2) *Sargassum* in concentrations that support adequate prey abundance and cover; 3) available prey and other material associated with *Sargassum* habitat; and 4) sufficient water depth and proximity to available currents for offshore transport, foraging, and cover for post-hatchling loggerheads.

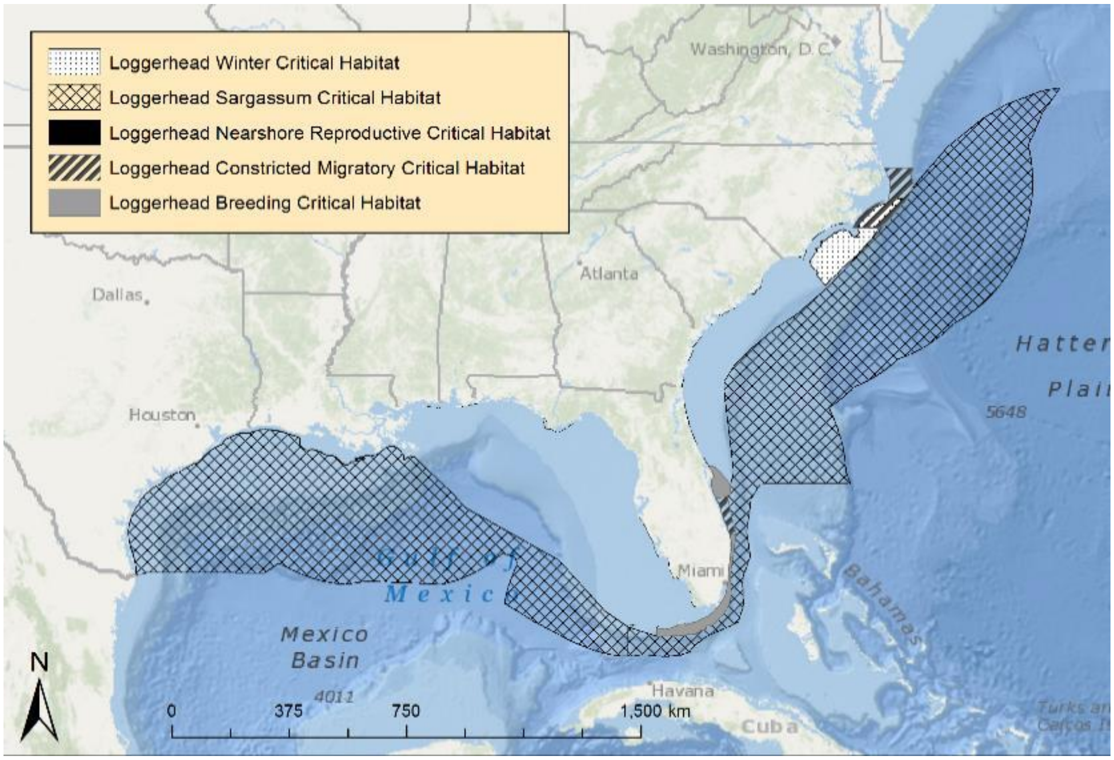

Figure 2. Designated critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of loggerhead sea turtles

The entire proposed survey area (222 km^2 or 85.7 mi^2) overlaps with *Sargassum* habitat. The proposed seismic survey may affect the third PBF of *Sargassum* habitat: available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods. We found very little information regarding airgun noise impacts on hydroids, although Solé et al. (2016) observed acoustic trauma in true jellyfish when exposed to low-frequency sounds. There was also little information on airgun noise effects on copepods in the action area; however, evidence indicates that seismic airguns may lead to a significant reduction in zooplankton (McCauley et al. 2017). McCauley et al. (2017) found that the use of a single airgun with a volume of 150 in^3 led to a decrease in zooplankton abundance by over 50% and a 2 to 3-fold increase in dead adult and larval zooplankton when compared to control scenarios. Copepods, an abundant zooplankton species, in particular experienced a 50% reduction in abundance around 509–658 m (1,670–2,159 ft) from the airgun (McCauley et al. 2017). However, Fields et al. (2019) observed limited effects on *Calanus spp.* (a genus of copepod) mortality within 10 m from an airgun source (4,260.6 cm^3 or 260 in^3), and no measureable effects at distances greater than 10 m. At distances within 5 m (16.4 ft) from the airguns, Fields et al. (2019) observed significantly higher immediate mortality (within 1 h after exposure) in copepods exposed to the airgun noise compared to the control. Mortality 1 week after exposure to the airguns was 9% higher than controls in copepods placed 10 m (32.8 ft) from the airgun blast but was not significantly different from the controls at a distance of 20 m (65.6 ft) from the airgun blast.

McCauley et al. (2017) noted that, for seismic activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question. In particular, 3-D seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, could be of concern McCauley et al. 2017. In part, this is because, for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton McCauley et al. 2017.

Given the results from each of these studies, it is difficult to assess the exact effect seismic airguns may have on the instantaneous or long-term survivability of hydroids or copepods that are exposed. The majority of copepod prey available to loggerhead sea turtles in *Sargassum* habitat are expected to be near the surface (Witherington et al. 2012), but the results of McCauley et al. (2017) provide little information on the effects to copepods at the surface because their analyses excluded zooplankton in the surface bubble layer. Nonetheless, given that airguns primarily transmit sound downward, and airguns associated with the proposed action will be towed at depths between 3–4 m (9.8–13.1 ft), we expect that sounds from seismic airguns will be relatively low at the surface and, as such, would affect copepod prey in *Sargassum* critical habitat less than that reported in McCauley et al. (2017). We also anticipate that seismic survey operators will actively avoid *Sargassum* patches within the action area because *Sargassum* may get tangled in the towed seismic equipment and propellers, and could damage the seismic equipment. Further, the proposed survey will be temporary (7 days of seismic acquisition), overlap a relatively small portion of *Sargassum* (222 km^2 or 85.7 mi^2) habitat, and is not likely to have significant effects on zooplankton given the high turnover rate of zooplankton.

In summary, while the proposed seismic survey may temporarily alter copepod abundance in designated loggerhead *Sargassum* critical habitat, we expect such effects to be insignificant because 1) most copepods will be near the surface where sound levels from seismic airguns are expected to be relatively low, 2) seismic survey operators will actively avoid *Sargassum* patches, and 3) the high turnover rate of zooplankton will minimize any effects. Therefore, we find that the proposed action may affect, but is not likely to adversely affect designated loggerhead *Sargassum* critical habitat.

8 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This section identifies and examines the status of ESA-listed sea turtles that are expected to be adversely affected by sound generated by the airguns from the proposed action's seismic survey activities. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on these NMFS websites: https://www.fisheries.noaa.gov/species-directory/threatened-endangered. One factor affecting the range-wide status of sea turtles and marine habitat at large is climate change. The localized effects of climate change in the action area are discussed in the Environmental Baseline (Section 9).

8.1 Green turtle – North Atlantic Distinct Population Segment

The green turtle was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green turtles as threatened or endangered under the ESA (81 FR 20057). The North Atlantic DPS of green turtle is listed as threatened. The North Atlantic DPS of green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 3).

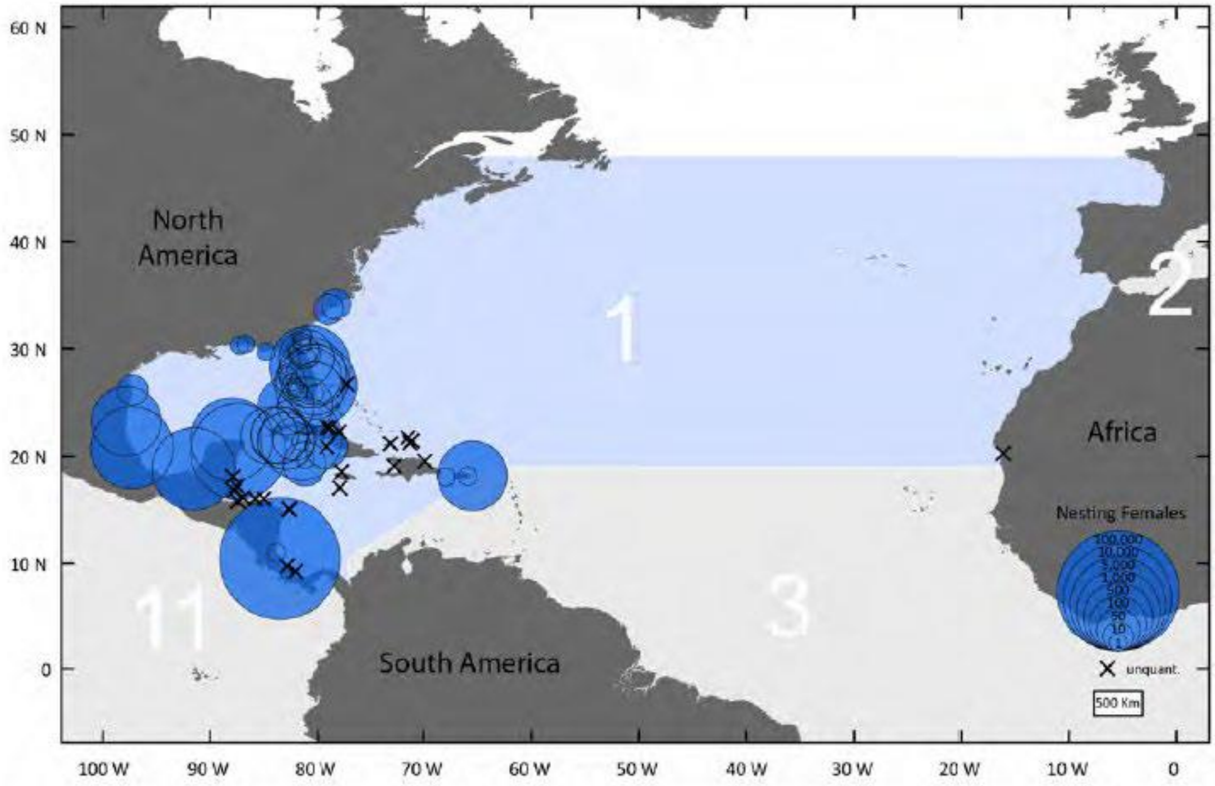

Figure 3. Map of geographic range of the North Atlantic distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015)

8.1.1 Life History

Green turtles have a circumglobal distribution, occurring throughout nearshore tropical, subtropical and, to a lesser extent, temperate waters. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. Mating occurs in waters off nesting beaches. Females are usually 20 to 40 years at first reproduction. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is 2–5 years for females. Males are known to reproduce every year (Balazs 1983). In the southeastern U.S., females generally nest between June through September, and peak nesting occurs in June through July (Witherington and Ehrhart 1989). During the nesting season, females nest at approximately 2-week intervals, laying an average of 3–4 clutches (Johnson and Ehrhart 1996) of approximately 110–115 eggs. Eggs incubate for approximately 2 months before hatching. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months.

After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. This early oceanic phase remains one of the mostly poorly understood aspects of the life history of green turtles (NMFS and USFWS 2007a). Green turtles exhibit particularly slow growth rates of about 1–5 cm (0.4–2 in) per year (Green 1993; McDonald-Dutton and Dutton 1998), which may be attributed to their largely herbivorous, low-net energy diet (Bjorndal 1982). At approximately 20–25 cm (8–10 in) carapace length, juveniles leave the pelagic environment and enter nearshore developmental habitats such as protected lagoons and open coastal areas rich in seagrass and marine algae. Growth studies using skeletochronology indicate that green turtles in the western Atlantic Ocean shift from the oceanic phase to nearshore developmental habitats after approximately 5–6 years (Bresette et al. 2006; Zug and Glor 1998). Within the developmental habitats, juveniles begin the switch to a more herbivorous diet, and by adulthood feed almost exclusively on seagrasses and algae (Rebel 1974), although some populations are known to also feed heavily on invertebrates (Carballo et al. 2002). Adult green turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey. Green turtles mature slowly, requiring 20 to 50 years to reach sexual maturity (Chaloupka and Musick 1997; Hirth and USFWS 1997).

8.1.2 Population Dynamics

Accurate population estimates for marine turtles do not exist because of the difficulty in sampling turtles over their geographic ranges and within their marine environments. Nonetheless, researchers have used nesting data to study trends in reproducing sea turtles over time. Worldwide, nesting data at 464 sites indicate that 563,826–564,464 female green turtles nest each year (Seminoff et al. 2015). A summary of nesting trends and nester abundance is provided in the most recent status review for the species (Seminoff et al. 2015), with information for the North Atlantic DPSs.

The range of the North Atlantic DPS extends from the boundary of South and Central America, north to Nova Scotia/Newfoundland, and east across the Atlantic Ocean to the western coasts of Africa and Europe (Figure 3). In the waters of the U.S. Atlantic Ocean and Gulf of Mexico, green turtles are distributed throughout inshore and nearshore waters from Texas to Massachusetts. Principal benthic foraging areas in the southeastern U.S. include Aransas Bay, Matagorda Bay, Laguna Madre, and the Gulf inlets of Texas (Doughty 1984; Hildebrand 1982; Shaver 1994), the Gulf of Mexico off Florida from Yankeetown to Tarpon Springs (Caldwell and Carr 1957; Carr 1984), Florida Bay and the Florida Keys (Schroeder and Foley 1995), the Indian River Lagoon system in Florida (Ehrhart 1983), and the Atlantic Ocean off Florida from Brevard through Broward Counties (Guseman and Ehrhart 1992; Wershoven and Wershoven 1992). The summer developmental habitat for green turtles also encompasses estuarine and coastal waters from North Carolina to as far north as Long Island Sound (Musick and Limpus 1997). Additional important foraging areas in the western Atlantic Ocean include the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean Sea coast of Panama, scattered areas along Colombia and Brazil (Hirth 1971), and the northwestern coast of the Yucatán Peninsula.

Compared to other DPSs, the North Atlantic DPS of green turtle exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites (Figure 3; Seminoff et al. 2015). Eight of the nesting sites have high levels of abundance (i.e., >1,000 nesters), located in Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, and Quintana Roo), U.S. (Florida), and Cuba (Seminoff et al. 2015). All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015).

Tortuguero, Costa Rica is by far the predominant nesting site, accounting for an estimated 79% of nesting for the DPS (Seminoff et al. 2015). Nesting at Tortuguero appears to have been increasing since the 1970’s, when monitoring began. For instance, from 1971–1975 there were approximately 41,250 average annual emergences documented and this number increased to an average of 72,200 emergences from 1992–1996 (Bjorndal et al. 1999). Troëng and Rankin (2005) collected nest counts from 1999–2003 and also reported increasing trends in the population consistent with the earlier studies, with nest count data suggesting 17,402–37,290 nesting females per year (NMFS and USFWS 2007a). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more resulted in an estimate of the Tortuguero, Costa Rica population’s growing at 4.9% annually.

In the U.S., green turtle nesting occurs along the Atlantic coast, primarily along the central and southeast coast of Florida (Meylan et al. 1994; Weishampel et al. 2003). Occasional nesting has also been documented along the Gulf Coast of Florida, Georgia, North Carolina, and Texas (Meylan et al. 1995). Modeling by Chaloupka et al. (2008) using data sets of 25 years or more resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9% at that time. Increases have been even more rapid in recent years. In Florida, index beaches were established to standardize data collection methods and effort on key nesting beaches. Since establishment of the index beaches in 1989, the pattern of green turtle nesting has generally shown biennial peaks in abundance with a positive trend during the 10 years of regular monitoring. According to data collected from Florida's index nesting beach survey from 1989–2022, green sea turtle nest counts across Florida have increased dramatically, from a low of 267 in the early 1990s to a high of 40,911 in 2019. Similar to the nesting trend found in Florida, in-water studies in Florida have also recorded increases in green turtle captures at the Indian River Lagoon site, with a 661% increase over 24 years (Ehrhart et al. 2007), and the St Lucie Power Plant site, with a significant increase in the annual rate of capture of immature green turtles (straight carapace length < 90 cm) from 1977 to 2002 (3,557 green turtles total; M. Bressette, Inwater Research Group, unpubl. data; Witherington et al. 2006).

Differences in DNA of green turtles from different nesting regions can indicate different genetic subpopulations (Bowen et al. 1992; Fitzsimmons et al. 2006). For example, the North Atlantic DPS of green turtle has a globally unique haplotype, which was a factor in defining the discreteness of this population. Evidence from mitochondrial DNA studies indicates that there are at least 4 independent nesting subpopulations in Florida, Cuba, Mexico, and Costa Rica (Seminoff et al. 2015). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin et al. 2016). Although green turtles may nest in different regions, individuals from separate nesting origins are commonly found mixed together on foraging grounds throughout the species' range. For example, in the South Atlantic DPS, genetic analysis of green turtles on the foraging grounds off Ubatuba and Almofala, Brazil show mixed stocks coming primarily from Ascension, Suriname and Trindade as a secondary source, but also Aves, and even sometimes Costa Rica (North Atlantic DPS) (Naro-Maciel et al. 2007; Naro-Maciel et al. 2012).

Within U.S. waters, individuals from both the North Atlantic DPS and South Atlantic DPS can be found on foraging grounds. While there are currently no in-depth studies available to determine the percent of North Atlantic DPS and South Atlantic DPS individuals in any given location two small-scale studies provide an insight into the degree of mixing on the foraging grounds. An analysis of cold-stunned green turtles in St. Joseph Bay, Florida (northeastern Gulf of Mexico; North Atlantic DPS) found approximately 4% of individuals came from nesting stocks in the South Atlantic DPS (specifically Suriname, Aves Island, Brazil, Ascension Island, and Guinea Bissau; Foley et al. 2007). On the Atlantic Ocean coast of Florida (North Atlantic DPS), a study on the foraging grounds off Hutchinson Island found that approximately 5% of the green turtles sampled came from the Aves Island/Suriname nesting assemblage, which is part of the South Atlantic DPS (Bass and Witzell 2000). All of the individuals in both studies were benthic juveniles. Available information on green turtle migratory behavior indicates that long distance dispersal is only seen for juvenile green turtles. This suggests that larger adult-sized green turtles return to forage within the region of their natal rookeries, thereby limiting the potential for gene flow across larger scales (Monzón-Argüello et al. 2010). Currently, there is no indication that South Atlantic DPS turtles occur off Texas (northwestern Gulf of Mexico).

8.1.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Bartol et al. 1999a; Lenhardt 1994, 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2016) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz–1,600 kHz (maximum sensitivity at 200–400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses of green turtles have been measured to hear in the 50 Hz–1.6 kHz 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 similarly found greatest sensitivities between 200–400 Hz for the green turtle with a range of 100–500 Hz (Bartol and Ketten 2006; Ridgway et al. 1969) and around 250 Hz or below for juveniles (Bartol et al. 1999a). However, Dow et al. (2008) found best sensitivity between 50–400 Hz.

These hearing sensitivities are similar to those reported for 2 terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 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 3–4 kHz (Patterson 1966).

In the French West Indies, a recent study recorded vocalizations of free-ranging juvenile green turtles (Charrier et al. 2022). Four main categories of vocalizations were recorded: pulses, low-amplitude calls, frequency-modulated calls, and squeaks. Pulses (mono, doublet, triplets, and multipulses consisting of an average of 5 pulses) had a main frequency around 1 kHz. Low-amplitude calls consisted of croaks and rumbles. The frequency range for croaks was 725 ± 330 Hz and the frequency range for rumbles was 323 ± 94 Hz. Frequency-modulated calls were either ascending, descending, or both, and ranged between 31–1,047 Hz. Squeaks were more than 3 kHz. Received levels of all vocalizations ranged between 102–124 dB re 1 μPa (rms).

8.1.4 Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation for food and other products. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Other threats include pollution, habitat loss through coastal development or stabilization, destruction of nesting habitat from storm events, artificial lighting, poaching, global climate change, natural predation, disease, cold-stunning events, and oil spills. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations. While the threats continue, the green turtle appears to be somewhat resilient to future perturbations.

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population’s decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green turtle generation, up to 50 years. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS of green turtle appears to be somewhat resilient to future perturbations.

8.1.5 Status in the Action Area

Green turtles nest throughout the Gulf of Mexico from May through September (Valverde and Holzwart 2017). In the Gulf of Mexico, major nesting beaches are located in Mexico and Florida, but there have been nesting females recorded on South Padre Island and Padre Island National Seashore off the southern tip of Texas (Eckert and Eckert 2019; Seminoff et al. 2015; SWOT 2022; Valverde and Holzwart 2017). Telemetry data on green turtles recorded animals in waters off Texas, as well as in the rest of the northern Gulf of Mexico; however, most records were in the southern portion of the Gulf of Mexico, which is outside of the action area (SWOT 2022). Dispersal modeling by Putman et al. (2020) indicates that hatchlings could occur throughout the Gulf of Mexico, including the proposed survey area. There is one OBIS-SEAMAP record from near the 20-m isobath more than 50 km southeast of the proposed survey area; this record is for February (Halpin et al. 2009).

8.2 Kemp’s ridley turtle

The Kemp’s ridley turtle is considered to be the most endangered sea turtle, internationally (Groombridge 1982; Zwinenberg 1977). Its range extends from the Gulf of Mexico to the Atlantic coast, with nesting beaches limited to a few sites in Mexico and Texas (Figure 4). Kemp’s ridley sea turtles have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomás and Raga 2008). Juvenile Kemp’s ridley turtles, possibly carried by oceanic currents, have been recorded as far north as Nova Scotia. The species was listed as endangered under the ESA since 1970.

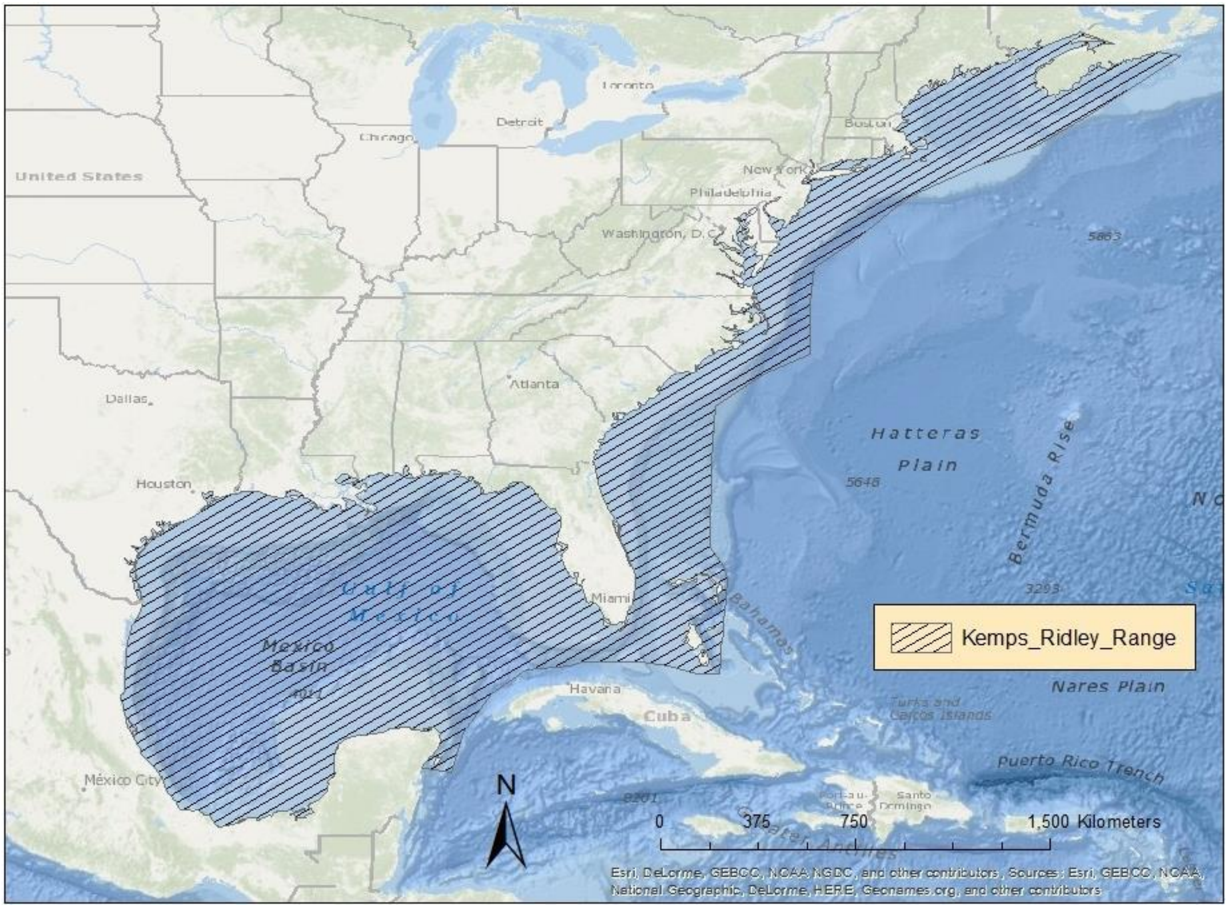

Figure 4. Map identifying the range of the endangered Kemp's ridley turtle off the U.S. coast

8.2.1 Life History

Kemp's ridley turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. After 45–58 days of embryonic development, the hatchlings emerge and swim offshore into deeper, oceanic waters where they feed and grow until returning at a larger size. Their return to nearshore coastal habitats typically occurs around 2 years of age (Ogren 1989), although the time spent in the oceanic habitat may vary from 1–4 years or perhaps more (TEWG 2000). Females generally reach maturity at 12 years of age, but may range from 5–16 years. The average remigration is 2 years, although some animals nest annually. Nesting occurs from April through July in arribadas (large aggregations) mainly on beaches in the Gulf of Mexico, but primarily at Rancho Nuevo, Mexico. Historic records indicate a nesting range from Mustang Island, Texas, in the north to Veracruz, Mexico, in the south. Kemp's ridley turtles have also recently been nesting along the Atlantic coast of the U.S., with nests recorded from beaches in Florida, Georgia, North Carolina, South Carolina, and Virginia.

Females lay an average of 2.5 clutches per season. The annual average clutch size is 97–100 eggs per nest. The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately 2 years before returning to nearshore coastal habitats. Juvenile Kemp’s ridley turtles use these nearshore coastal habitats from April through November, but move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water temperature drops. Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 37 m (120 ft) deep, although they can also be found in deeper offshore waters. As adults, Kemp’s ridley turtles forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS and USFWS 2011).

8.2.2 Population Dynamics

Of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. Nesting steadily increased through the 1990s, and then accelerated during the first decade of the 21st century. Following a significant, unexplained one-year decline in 2010, Kemp’s ridley turtle nests in Mexico reached a record high of 21,797 in 2012 (NPS 2013). In 2013, there was a second significant decline, with 16,385 nests recorded. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from 3 primary nesting beaches in Mexico (NMFS and USFWS 2015). The number of nests in Padre Island, Texas has increased over the past 2 decades, with 1 nest observed in 1985, 4 in 1995, 50 in 2005, 197 in 2009, and 119 in 2014 (NMFS and USFWS 2015). Gallaway et al. (2013) estimated the female population size for age 2 and older in 2012 to be 188,713 (SD = 32,529). If females comprise 76% of the population, the total population of age 2+ of Kemp’s ridley turtles was estimated to have been 248,307 in 2012 (Gallaway et al. 2013).

Kemp’s ridley turtle nesting population was exponentially increasing (NMFS et al. 2011c); however, since 2009 there has been concern over the slowing of recovery (Gallaway et al. 2016a; Gallaway et al. 2016b; Plotkin 2016). From 1980 through 2003, the number of nests at 3 primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15% annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2015). In fact, nest counts dropped by more than a third in 2010 and continue to remain below predictions (Caillouet et al. 2018).

Genetic variability in Kemp’s ridley turtles is considered to be high, as measured by heterozygosis at microsatellite loci (NMFS and USFWS 2011). Additional analysis of the mitochondrial DNA taken from samples of Kemp’s ridley turtles at Padre Island, Texas, showed 6 distinct haplotypes, with 1 found at both Padre Island and Rancho Nuevo (Dutton et al. 2006). Additionally, the genetic diversity of immature Kemp’s ridley turtles foraging in the northern Gulf of Mexico (along the Florida panhandle) closely correspond to that of nesting females in

Rancho Nuevo, Mexico (Lamont et al. 2021). Despite recent declines in Kemp's ridley turtle populations, a recent study found that genetic diversity, as assessed through the mitochondrial genome, has remained stable (Frandsen et al. 2020).

8.2.3 Vocalization and Hearing

As noted in Section 9.1.3, sea turtles are low frequency hearing specialists. Juvenile Kemp's ridley turtles can hear from 100–500 Hz, with a maximum sensitivity between 100–200 Hz at thresholds of 110 dB re 1 μPa (Bartol and Ketten 2006).

8.2.4 Status

Kemp's ridley turtles face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (plastics, petroleum products, petrochemicals, etc.), ecosystem alterations (nesting beach development, beach nourishment and shoreline stabilization, vegetation changes, etc.), poaching, global climate change, fisheries interactions, natural predation, and disease.

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances in Mexico prohibited the harvest of sea turtles from May through August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program has resulted in the re-establishment of nesting at Texan beaches. While fisheries bycatch remains a threat, the use of sea turtle excluder devices mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. The Deepwater Horizon oil spill event reduced nesting abundance and associated hatchling production as well as exposures to oil in the oceanic environment which has resulted in large losses of the population across various age classes, and likely had an important population-level effect on the species. We do not have an understanding of those impacts on the population trajectory for the species into the future. The species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

8.2.5 Status in the Action Area

In the northern Gulf of Mexico on the Texas coast, Kemp's ridley turtles primarily nest at Padre Island National Seashore, with a few hundred nesting attempts annually (Eckert and Eckert 2019; NMFS et al. 2011a; Piniak and Eckert 2011; Shaver and Caillouet Jr 1998; Shaver et al. 2016; SWOT 2022). Nesting has also been reported for the shoreline closest to the proposed survey area (Eckert and Eckert 2019; NMFS et al. 2011a; Seney and Landry Jr 2008; Shaver et al. 2016). According to the Turtle Island Restoration Network, in 2023, there were 256 Kemp's ridley turtle nests on the Texas coast: 217 on North and South Padre Island and Padre Island National Seashore, and 10 nests in the action area, between Freeport and Galveston (https://seaturtles.org/turtle-count-texas-coast/). The nesting season in the Gulf of Mexico is April–July (Valverde and Holzwart 2017).

Satellite-tagged adult female Kemp's ridley turtles from Padre Island National Seashore and Rancho Nuevo showed post-nesting movements to foraging sites along the coast of the northern Gulf of Mexico, including nearshore waters off Texas (Shaver et al. 2013). Foraging sites were observed in water less than 26 m deep, averaging 33.2 km from shore (Shaver et al. 2013). Similarly, Seney and Landry Jr 2008, 2011) noted that, during the nesting season, adult female turtles tagged at Texas beaches typically stayed in nearshore waters of Texas, with core areas of activity located within and near the proposed survey area; post-nesting turtles also spent time within and near the proposed survey area during summer, but mainly foraged on the shelf off Louisiana. Tagged juveniles showed a preference for tidal passes, bays, coastal lakes, and nearshore waters, in water <5 m deep, particularly during the warmer months of May–October (Seney and Landry Jr 2008; Valverde and Holzwart 2017). Tagged juveniles typically did not occur in the proposed survey area. Several of the tracked adult turtles nested multiple times on the coast of Texas in one season (Seney and Landry Jr 2008). Hart et al. (2018) also found that post-nesting adult females satellite-tagged in the Gulf of Mexico foraged near the proposed survey area off Texas, as well as most coastal waters along the northern and eastern Gulf of Mexico. Based on telemetry data compiled by SWOT (2022), Kemp's ridley turtle locations were reported along the entire northern coast of the Gulf of Mexico, including Texas. Dispersal modeling by Putman et al. (2020) indicated that hatchlings could also occur in the proposed survey areas. There are numerous sighting records in OBIS-SEAMAP of Kemp's ridley turtles in the proposed survey area (Halpin et al. 2009).

8.3 Leatherback turtle

The leatherback turtle ranges from tropical to subpolar latitudes, worldwide (Figure 5). It was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

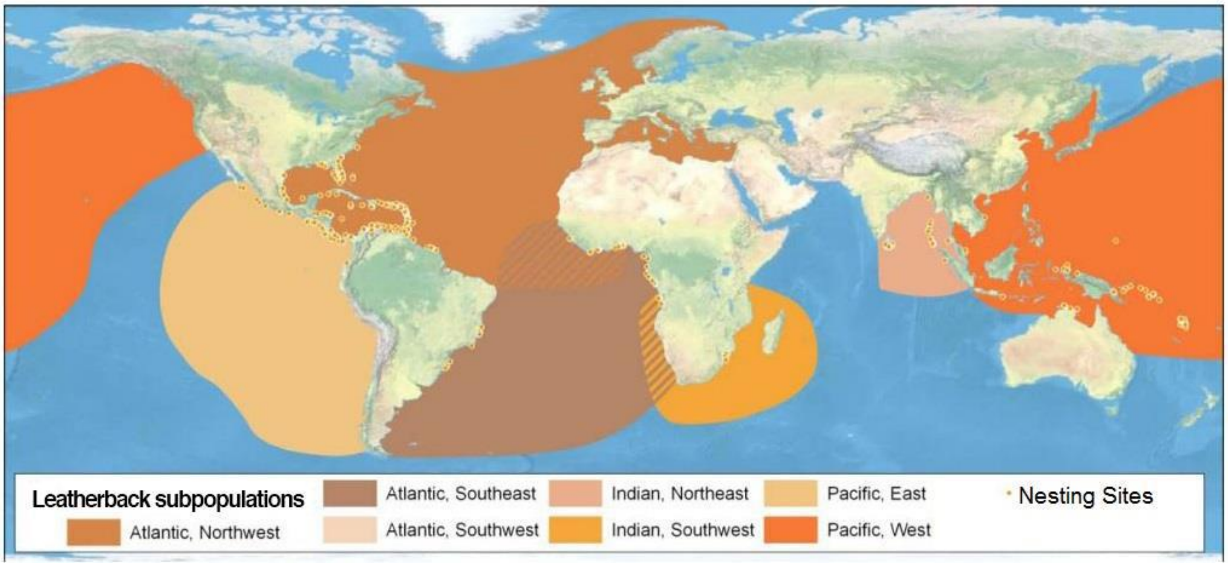

Figure 5. Map identifying the range of the endangered leatherback turtle. Adapted from Wallace et al. 2013

8.3.1 Life History

Leatherback turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. While a robust estimate of the life span does not exist, the current best estimate for the maximum age is 43 (Avens et al. 2009a). Age at maturity has been difficult to ascertain, with estimates ranging from 16–29 years (Avens et al. 2009b; Spotila et al. 1996). On average, they reach maturity at approximately 20 years (Jones et al. 2011).

Females usually lay up 5–7 clutches (7–15 days apart) per nesting season (3–6 months generally during the summer), with 20 to more than 100 eggs per clutch and eggs weighing greater than 80 g (0.17 lbs) (Eckert et al. 2012; Eckert et al. 2015; Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest onto the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012) and approximately 30% of the eggs may be infertile. Eggs hatch after about 2 months (60–65 days; Eckert et al. 2015). Females nest on sandy, tropical beaches at intervals of every 1–11 (average of 2–4) years (Eckert et al. 2015). Nesting females exhibit low site-fidelity to their natal beaches, returning to the same region, but not necessarily the same beach, to nest (Dutton et al. 1999; Dutton et al. 2007). Females have been observed with fertility spans as long as 25 years (Hughes 1996). Natal homing, at least within an ocean basin, results in reproductive isolation between 5 broad geographic regions: eastern and western Atlantic Ocean, Indian Ocean, and eastern and western Pacific Ocean.

In the Northwest Atlantic Ocean, the sex ratio appears to be skewed toward females. Hatchling sex ratios range from 30–100% females in Suriname, Tobago, Colombia, and Costa Rica (Dutton et al. 1985; Godfrey et al. 1996; Mickelson and Downie 2010; Mrosovsky 1994; Patino-Martinez et al. 2012). The proportion of females documented in foraging individuals and strandings ranges from 57–70% (James et al. 2007; Murphy et al. 2006; TEWG 2007), and the ratio of females to males during an individual breeding season is thought to be closer to 1:1 (Stewart and Dutton 2014). Reports of nearshore and onshore stranding data from the Atlantic Ocean and Gulf of Mexico coasts indicate that 60% of strandings were females (TEWG 2007). James et al. (2007) collected size and sex data from large subadult and adult leatherback turtles off Nova Scotia and also concluded a bias toward females at a ratio of 1.86:1.

Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005b; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon prey availability foraging success and duration (Hays 2000; Price et al. 2004).

Unlike other sea turtles, leatherback turtles have several unique traits that enable them to live in cold water. For example, leatherback turtles have a countercurrent circulatory system (Greer et al. 1973), a thick layer of insulating fat (Davenport et al. 1990a; Goff and Lien 1988), gigantothermy (Paladino et al. 1990), and they can increase their body temperature through increased metabolic activity (Bostrom and Jones 2007; Southwood et al. 2005). These adaptations allow leatherback turtles to be comfortable in a wide range of temperatures, which helps them travel further than any other sea turtle species (NMFS and USFWS 1995). For example, a leatherback turtle may swim more than 10,000 km (6,000 mi) in a single year (Benson et al. 2007a; Benson et al. 2011b; Eckert 2006a; Eckert et al. 2006). They search for food between latitudes 71°N and 47°S, in all oceans, and travel extensively to and from their tropical nesting beaches.

While leatherback turtles will look for food in coastal waters, they appear to prefer the open ocean at all life stages (Heppell et al. 2003b). Leatherback turtles have pointed tooth-like cusps and sharp-edged jaws that are adapted for a diet of soft-bodied prey such as jellyfish and salps. A leatherback turtle's mouth and throat also have backward-pointing spines that help retain jelly-like prey as water is expelled. Leatherback turtles favorite prey occur commonly in temperate and northern or subarctic latitudes and likely has a strong influence on their distribution in these areas (Plotkin 1995). Leatherback turtles are known to be deep divers, with recorded depths in excess of 1 km (3,280.8 ft) for almost 90 min, but they may also come into shallow waters to locate prey items. In the Atlantic Ocean, they are found as far north as the North Sea, Barents Sea, Newfoundland, and Labrador, and as far south as Argentina and the Cape of Good Hope, South Africa (NMFS USFWS 2013). In the U.S., important nesting areas include Florida, St.

Croix, and Puerto Rico. Other islands of the Caribbean Sea south to Brazil and Venezuela are also important nesting areas in the Western Atlantic Ocean (NMFS USFWS 2013).

The survival and mortality rates for leatherback turtles are difficult to estimate and vary by location. For example, the annual mortality rate for leatherback turtles that nested at Playa Grande, Costa Rica, was estimated to be 34.6% in 1993–1994 and 34% in 1994–1995 (Spotila et al. 2000b). In contrast, overall survival rates for nesting females is relatively high at 85% (Pfaller et al. 2018), with mean estimated annual survival rates of 70–99% in French Guiana (Rivalan et al. 2005), 89% in St. Croix (Dutton et al. 2005), and 89–96% on the coast of the Atlantic Ocean of Florida (Stewart et al. 2014), respectively. For the St. Croix population the average annual juvenile survival rate was estimated to be approximately 63% and the total survival rate from hatchling to first year of reproduction for a female was estimated to be between 0.4–2% (assuming age at first reproduction is between 9–13 years; Eguchi et al. 2006). Spotila et al. (1996)estimated first-year survival rates for leatherback turtles at 6.25%.

Migratory routes of leatherback turtles are not entirely known; however, information from satellite tags have documented long travels between nesting beaches and foraging areas in the Atlantic and Pacific Ocean basins (Benson et al. 2007a; Benson et al. 2011b; Eckert 2006a; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; James et al. 2005a). Leatherback turtles nesting in the northwest Atlantic Ocean move throughout most of the North Atlantic Ocean from the equator to about 50°N latitude. Leatherback turtles nesting in Central America and Mexico travel thousands of miles through tropical and temperate waters of the South Pacific Ocean (Eckert and Sarti 1997; Shillinger et al. 2008). Data from satellite tagged animals suggest that they may be traveling in search of seasonal aggregations of jellyfish (Benson et al. 2007b; Bowlby et al. 1994; Graham 2009; Shenker 1984; Starbird et al. 1993; Suchman and Brodeur 2005). Overall, 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. 2011a).

8.3.2 Population Dynamics

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Movements of adults and sub-adults span across all major ocean basins and range from equatorial waters to temperate high-latitude regions (Shillinger and Bailey 2015). Leatherback turtles originating from the same nesting beach may forage in diverse and geographically distant regions, with variance among individuals (Benson et al. 2011a; Eckert 2006b; Eckert et al. 2006; Hays et al. 2006; Namboothri et al. 2012; Witt et al. 2011). Conversely, leatherback turtles from different nesting beaches may move to the same foraging regions as adults (Fossette et al. 2014). Patterns of leatherback turtle movements between nesting beaches and foraging areas are complex, and appear to be linked to ocean currents that facilitate hatchling dispersal (Gaspar et al. 2012) or adult movements throughout the oceans (Lambardi et al. 2008). Adults are known to return to the same foraging areas after nesting (Seminoff et al. 2012), and hatchlings from different nesting beaches may reach the same foraging areas, creating a mosaic of overlapping population ranges. Wallace et al. (2010) identified 7 global regional management units (subpopulations) by reviewing the genetic data available and performing a spatial analysis of these genetic data combined with nesting, tagging, and tracking data, these include: northwest Atlantic Ocean, southwest Atlantic Ocean, southeast Atlantic Ocean, northeast Indian Ocean, west Pacific Ocean, and east Pacific Ocean.

Detailed population structure is unknown, but is likely dependent upon nesting beach location and influenced by physical barriers (i.e., land masses), current systems, and long migrations. The total index of nesting female abundance in the Northwest Atlantic Ocean is 20,659 females (NMFS 2020b). Based on estimates calculated from nesting data, there are approximately 18,700 (10,000–31,000 nesting females) total adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). The total index of nesting female abundance in the Southwest Atlantic Ocean is approximately 27 females (NMFS 2020b). The total index of nesting female abundance in the Southeast Atlantic Ocean is approximately 9,198 females (NMFS 2020). The total index of nesting female abundance in the Southwest Indian Ocean is approximately 149 females (NMFS 2020b). The total index of nesting female abundance in the Northeast Indian Ocean is approximately 109 females (NMFS 2020b). The total index of nesting female abundance in the West Pacific Ocean is approximately 1,277 females (NMFS 2020b). The total index of nesting female abundance in the East Pacific Ocean is approximately 755 females (NMFS 2020b). The total index of nesting female abundance is likely an underestimate because we did not have adequate data from many nesting beaches, which have the potential for being unmonitored or unidentified.

Declines in nesting can occur rapidly in populations of leatherback turtles. In the Pacific Ocean, nesting has declined precipitously in recent decades (Benson et al. 2015). Aerial surveys of nesting beaches in Mexico detected declines from 70,000 nesting females in 1982 to fewer than 250 in 1998, with an annual mortality rate of 22.7% (Spotila et al. 2000a). The Terengganu, Malaysia nesting population was reduced to less than 1% of its original size between the 1950s and 1995 (Chan and Liew 1996) and is now considered functionally extinct. Significant declines in nesting have been documented for other nesting aggregations, such as Gabon, French Guiana, and Indonesia.

Population growth rates for leatherback turtles vary by ocean basin. Leatherback turtles in the Northwest Atlantic Ocean exhibit a decreasing nest trend at nesting beaches with the greatest known nesting female abundance (NMFS 2020b). This decline has become more pronounced (2008 through 2017), and the available nest data reflect a steady decline for more than a decade (Eckert and Mitchell 2018a). Leatherback turtles in the Southwest Atlantic Ocean exhibit an increasing, although variable, nest trend (nearly 5% average annual increase, with the largest increase occurring in the past decade; NMFS 2020b). Leatherback turtles in the Southeast Atlantic Ocean of the coast of Gabon exhibit a declining nest trend (8.6% annually) at the largest nesting aggregation (NMFS 2020b). Leatherback turtles in the Southwestern Indian Ocean exhibit a slightly decreasing nest trend at monitored nesting beaches off the coast of South Africa

(NMFS 2020b). Leatherback turtles in the Northeast Indian Ocean exhibit a drastic population decline with extirpation of its largest nesting aggregation in Malaysia (NMFS 2020b). Leatherback turtles in the West Pacific Ocean exhibit low hatching success and a declining nest and population trend (NMFS 2020b). Leatherback turtles in the East Pacific Ocean exhibit a decreasing trend since monitoring began, with a 97.4% decline (depending on the nesting beach) since the 1980s or 1990s (Wallace et al. 2013). Despite intense conservation efforts, the decline in nesting has not been reversed as of 2011 (Benson et al. 2015).

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian Oceans suggest that each of the rookeries represent demographically independent populations (NMFS USFWS 2013).

Subpopulations are reproductively isolated with little to no gene flow connecting them. However, within some subpopulations there is fine-scale genetic structure. Genetic analyses using microsatellite data revealed fine-scale genetic differentiation among neighboring subpopulations in the Northwest Atlantic Ocean including: Trinidad, French Guiana/Suriname, Florida, Costa Rica, and St. Croix (Dutton and H. 2013). Tagging studies indicate individual movement and gene flow among nesting aggregations.

In the Atlantic Ocean, equatorial waters appear to be a barrier between breeding populations. In the northwestern Atlantic Ocean, post-nesting female migrations appear to be restricted to north of the equator but the migration routes vary (NMFS USFWS 2013). 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 (NMFS USFWS 2013).

8.3.3 Vocalization and Hearing

As noted in Section 9.1.3, sea turtles are low frequency hearing specialists. Dow Piniak et al. (2012a)measured hearing of leatherback turtle hatchlings in water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz–1.6 kHz in air, and between 50 Hz–1.2 kHz in water (lowest sensitivity recorded was 93 dB re 1 µPa at 300 Hz).

Leatherback eggs and hatchlings have been recorded producing sounds. Ferrara et al. (2014)recorded sounds including pulses, sounds with harmonic and nonharmonic frequency bands, sounds with frequency and amplitude modulation, and hybrid sounds with characteristics of pulsed and harmonic sounds. Pulses, sounds without harmonically related frequency bands, and sound with harmonic frequency bands were recorded in nests with both eggs and hatchlings. These were produced at a frequency range of about 187.5–1,343.8 Hz, 282.2–1,640.6 Hz, and 119–24,000 Hz, respectively. All sounds were less than 0.5 s. McKenna et al. (2019) also recorded sounds (no pulses) of leatherback turtle hatchlings. Sounds were produced at an average frequency range of 2.41 ± 3.02 kHz and average duration of 0.14 ± 0.13 s.

8.3.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The status of the subpopulations in the Atlantic, Indian, and Pacific Oceans are generally declining, except for the subpopulation in the Southwest Atlantic Ocean, which is slightly increasing. Leatherback turtles show a lesser degree of nest site fidelity than occurs with hardshell sea turtle species.

The primary threats to leatherback turtles include fisheries interactions (bycatch), harvest of nesting females, and egg harvesting (NMFS 2020b). Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, vegetation changes, sand extraction, beach nourishment, shoreline stabilization, and natural disasters (e.g., storm events and tsunamis) as well as cold-stunning, vessel interaction, pollution (contaminants, marine debris and plastics, petroleum products, petrochemicals), ghost fishing gear, natural predation, parasites, and disease (NMFS 2020b). Artificial lights on or adjacent to nesting beaches alter nesting adult female behavior and are often fatal to post-nesting females and emerging hatchlings as they are drawn to light sources and away from the sea. Ingestion of marine debris (plastic) is common in leatherback turtles and can block gastrointestinal tracts leading to death (NMFS 2020b). Climate change may alter sex ratios (as temperature determines hatchling sex) and nest success, range (through expansion of foraging habitat as well as alter spatial and temporal patterns), and habitat (through the loss of nesting beaches, because of sea-level rise and storms). Oceanographic regime shifts possibly impact foraging conditions that may affect nesting female size, clutch size, and egg size of populations. The species’ resilience to additional perturbation is low.

8.3.5 Status in the Action Area

Nesting by leatherbacks in the Gulf of Mexico is generally less frequent than that of other sea turtle species (Piniak and Eckert 2011). There is only occasional nesting in southern Texas at Padre Island National Seashore, with no recorded nests in 2023 according to the Turtle Island Restoration Network (Eckert and Eckert 2019; SWOT 2022; Valverde and Holzwart 2017). Leatherback sea turtles satellite tagged at Panama nesting beaches traveled through the Yucatán Channel into the Gulf of Mexico where they spent most of their time foraging, though there were no foraging hotspots identified within the proposed survey area (Aleksa et al. 2018). One satellite-tagged leatherback migrated adjacent to the proposed survey area, occupying coastal waters off Texas from Galveston to Matagorda Bay (Aleksa et al. 2018). Based on telemetry data compiled by SWOT (2022), leatherback turtle records were reported for waters off Louisiana, but not Texas. In the OBIS-SEAMAP database, there is one record near the 20-m isobath southeast of the proposed project area for August, and another record in shallow water <20 m deep off southern Texas (Halpin et al. 2009). Most other records are for deep offshore waters in depths >1000 m (Halpin et al. 2009).

8.4 Loggerhead turtle – Northwest Atlantic Ocean DPS

Loggerhead turtles are circumglobal, and are found in continental shelf and estuarine environments throughout the temperate and tropical regions of the Atlantic, Indian, and Pacific Oceans. The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated 9 DPSs of loggerhead turtles, with the Northwest Atlantic Ocean DPS listed as threatened (75 FR 12598). The Northwest Atlantic Ocean DPS of loggerhead turtles is found along eastern North America, Central America, and northern South America (Figure 6).

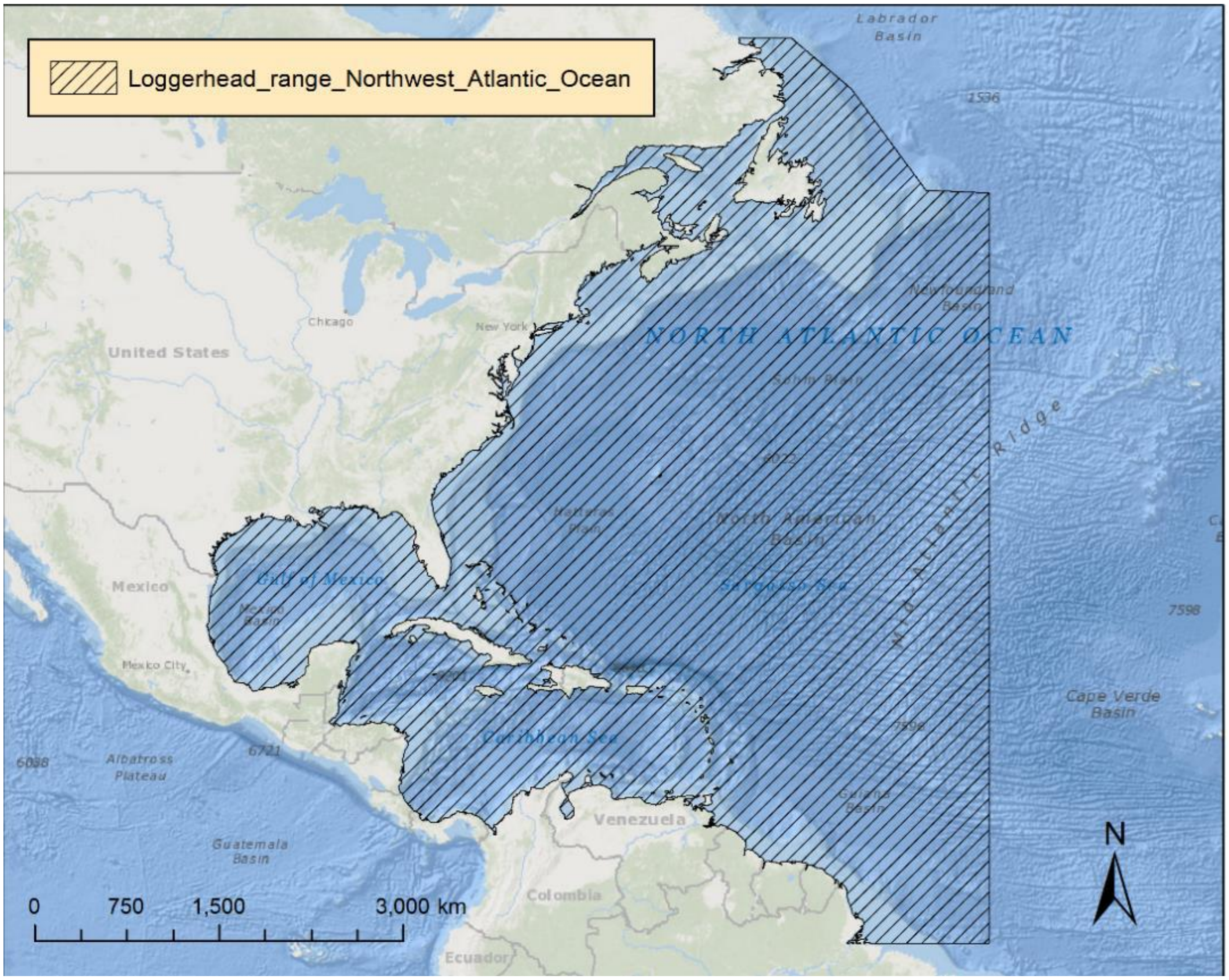

Figure 6. Map identifying the range of threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle

8.4.1 Life History

Loggerhead turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. The 8 stages of the life cycle and the ecosystems those stages generally use include: egg (terrestrial zone), hatchling (terrestrial zone), hatchling swim frenzy and transitional (neritic zone), juvenile (oceanic zone), juvenile (neritic zone), adult (oceanic zone), adult (neritic zone), nesting female (terrestrial zone) (NMFS and USFWS 2008b). Loggerhead turtles reach sexual maturity between 20–38 years of age, although this varies widely among populations (Frazer and Ehrhart 1985; NMFS 2001). Mean age at first reproduction for female loggerhead turtles is 30 years. The annual mating season occurs from late March through early June, and females lay eggs throughout the summer months. Females lay an average of 4 clutches per season (Murphy and Hopkins 1984), and an average remigration interval is 3.7 years (Tucker 2010). The annual average clutch size is 100–126 eggs per nest (Dodd 1988). Eggs incubate for 42–75 days before hatching (NMFS and USFWS 2008b). Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the loggerhead turtle during the middle of the incubation period.

The majority of nesting occurs at the western rims, concentrated in the north and south temperate zones and subtropics, of the Atlantic and Indian Oceans (NRC 1990). For the Northwest Atlantic Ocean DPS of loggerhead turtles, most nesting occurs along the East coast of the U.S., from southern Virginia to Alabama. Additional nesting occurs along the northern and western Gulf of Mexico, eastern Yucatán peninsula, at Cay Sal Bank in the eastern Bahamas (Addison 1997; Addison and Morford 1996), off the southwestern coast of Cuba (Gavilan 2001), and along the coasts of Central America, Colombia, Venezuela, and the eastern islands of the Caribbean Sea. Non-nesting, adult females are reported throughout the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Little is known about the distribution of adult males who are seasonally abundant near nesting beaches.

Habitat uses within continental shelf and estuarine environments vary by life stage. Loggerhead turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles. Neritic juvenile loggerhead turtles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the water's surface, whereas subadults and adults typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hardbottom habitats in coastal waters.

As post-hatchlings, loggerhead turtles hatched on beaches enter the "oceanic juvenile" life stage, migrating offshore and becoming associated with *Sargassum* habitats, driftlines, and other convergence zones (Carr 1986; Conant et al. 2009b; Witherington 2002). Oceanic juveniles grow at rates of 2.9–5.4 cm (1–2 in) per year (Bjorndal et al. 2003; Snover 2002) over a period as long as 7–12 years (Bolten et al. 1998) before moving to more coastal habitats. Studies have suggested that not all loggerhead turtles follow the model of circumnavigating the North Atlantic Gyre as pelagic juveniles, followed by permanent settlement into benthic environments (Bolten and Witherington 2003; Laurent et al. 1998). These studies suggest some animals may either remain in the oceanic habitat in the North Atlantic Ocean longer than hypothesized or they move back and forth between oceanic and coastal habitats interchangeably (Witzell 2002). When immature loggerhead turtles reach 40–60 cm (15–24 in), they begin to reside in coastal inshore waters of the continental shelf throughout the Atlantic Ocean and Gulf of Mexico (Witzell 2002).

After departing the oceanic zone, neritic juveniles in the Northwest Atlantic Ocean inhabit continental shelf waters from Cape Cod Bay, Massachusetts, south through Florida, the Bahamas, Cuba, and the Gulf of Mexico. Estuarine waters of the U.S., including areas such as Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River Lagoons, Biscayne Bay, Florida Bay, and numerous embayments fringing the Gulf of Mexico, comprise important inshore habitat. Along the shorelines of the Atlantic Ocean and Gulf of Mexico, essentially all shelf waters are inhabited by loggerhead turtles (Conant et al. 2009b).

Like juveniles, non-nesting adults also use the neritic zone. However, these adults do not use the relatively enclosed shallow-water estuarine habitats with limited ocean access as frequently as juveniles. Areas such as Pamlico Sound, North Carolina, and the Indian River Lagoon, Florida, are regularly used by juveniles but not by adults. Adults do tend to use estuarine areas with more access to the open ocean, such as the Chesapeake Bay in the mid-Atlantic Ocean. Shallow-water habitats with large expanses of access to the open ocean, such as Florida Bay, provide year-round resident foraging areas for significant numbers of female and male adults (Conant et al. 2009b).

Offshore, adults primarily inhabit continental shelf waters, from New York through Florida, the Bahamas, Cuba, and the Gulf of Mexico. Seasonal use of shelf waters in the mid-Atlantic Ocean, especially offshore of New Jersey, Delaware, and Virginia during summer months, and offshore shelf waters, such as Onslow Bay (off the North Carolina coast), during winter months has been documented (Hawkes et al. 2014; Hawkes et al. 2007). Satellite telemetry has identified the shelf waters along the west coast of Florida, the Bahamas, Cuba, and the Yucatán peninsula as important resident areas for adult females that nest in Florida (Foley et al. 2008; Girard et al. 2009; Hart et al. 2012). The southern edge of the Grand Bahama Bank is important habitat for nesting on the Cay Sal Bank in the Bahamas, but nesting females are also resident in the bights of Eleuthera, Long Island, and Ragged Islands. They also reside in Florida Bay. Moncada et al. (2010)report the recapture in Cuban waters of five adult females originally flipper-tagged in Quintana Roo, Mexico, indicating that Cuban shelf waters likely also provide foraging habitat for adult females that nest in Mexico.

8.4.2 Population Dynamics

It is difficult to estimate overall abundance for sea turtle populations because individuals spend most of their time in water, where they are difficult to count, especially considering their large range and use of many different and distant habitats. Females, however, converge on their natal beaches to lay eggs, and nests are easily counted. The total number of annual U.S. nest counts for the Northwest Atlantic DPS of loggerhead sea turtles is over 110,000 (NMFS and USFWS 2023).

In-water estimates of abundance include juvenile and adult life stages of loggerhead males and females are difficult to perform on a wide scale. In the summer of 2010, NMFS's Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) estimated the abundance of juvenile and adult loggerhead sea turtles along the continental shelf between Cape Canaveral, Florida and the mouth of the Gulf of St. Lawrence, Canada, based on Atlantic Marine Assessment Program for Protected Species (AMAPPS) aerial line-transect sighting survey and satellite tagged loggerheads (NMFS 2011). They provided a preliminary regional abundance estimate of 588,000 individuals (approximate inter-quartile range of 382,000–817,000) based on positively identified loggerhead sightings (NMFS 2011). A separate, smaller aerial survey, conducted in the southern portion of the Mid-Atlantic Bight and Chesapeake Bay in 2011 and 2012, demonstrated uncorrected loggerhead sea turtle abundance ranging from a spring high of 27,508 to a fall low of 3,005 loggerheads (NMFS and USFWS 2023). We are not aware of any current range-wide in-water estimates for the DPS.

Based on genetic analysis of subpopulations, the Northwest Atlantic Ocean DPS of loggerhead turtle is further categorized into 5 recovery units corresponding to nesting beaches. These are Northern Recovery Unit, Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit (Conant et al. 2009a). An analysis using expanded mitochondrial DNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct, and that rookeries from Mexico's Caribbean coast express high haplotype diversity (Shamblin et al. 2014). Furthermore, the results suggest that the Northwest Atlantic Ocean DPS of loggerhead turtle should be considered as 10 management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin et al. 2012).

The Northern Recovery Unit, from North Carolina to northeastern Florida, is the second largest nesting aggregation in the Northwest Atlantic Ocean DPS of loggerhead turtle, with an average of 5,215 nests from 1989 through 2008, and approximately 1,272 nesting females per year (NMFS and USFWS 2008c). The nesting trend from daily beach surveys showed a significant decline of 1.3% annually from 1989 through 2008. Aerial surveys of nests showed a 1.9% decline annually in nesting in South Carolina from 1980 through 2008. Overall, there is strong statistical data to suggest the Northern Recovery Unit has experienced a long-term decline over that period. Data since that analysis are showing improved nesting numbers and a departure from the declining trend. Nesting in Georgia has shown an increasing trend since comprehensive nesting surveys began in 1989. Nesting in North Carolina and South Carolina has begun to show a shift away from the declining trend of the past. Increases in nesting were seen from 2009 through 2012.

The Peninsular Florida Recovery Unit is the largest nesting aggregation in the Northwest Atlantic Ocean DPS of loggerhead turtle, with an average of 64,513 nests per year from 1989 through 2007, and approximately 15,735 nesting females per year (NMFS and USFWS 2008b). Following a 52% increase between 1989 through 1998, nest counts declined sharply (53%) from 1998 through 2007. However, annual nest counts showed a strong increase (65%) from 2007 through 2017 (FFWCC 2018). Index nesting beach surveys from 1989 through 2013 have identified 3 trends. From 1989 through 1998, a 30% increase was followed by a sharp decline over the subsequent decade. Large increases in nesting occurred since then. From 1989 through 2013, the decade-long decline had reversed and there was no longer a demonstrable trend. From 1989 through 2016, the Florida Fish and Wildlife Research Institute concluded that there was an overall positive change in the nest counts, but the change was not statistically significant.

The Dry Tortugas, Gulf of Mexico, and Greater Caribbean Recovery Units are much smaller nesting assemblages, but they are still considered essential to the continued existence of loggerhead turtles. The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. The only available data for the nesting subpopulation on Key West comes from a census conducted from 1995 through 2004 (excluding 2002), which provided a range of 168 to 270 (mean of 246) nests per year, or about 60 nesting females (NMFS and USFWS 2007b). There was no detectable trend during this period (NMFS and USFWS 2008b).

The Gulf of Mexico Recovery Unit has between 100 to 999 nesting females annually, and a mean of 910 nests per year. Analysis of a dataset from 1997 through 2008 of index nesting beaches in the northern Gulf of Mexico shows a declining trend of 4.7% annually. Index nesting beaches in the panhandle of Florida has shown a large increase in 2008, followed by a decline in 2009 through 2010 before an increase back to levels similar to 2003 through 2007 in 2011.

The Greater Caribbean Recovery Unit encompasses nesting subpopulations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán peninsula, in Quintana Roo, Mexico, with 903–2,331 nests annually (Zurita et al. 2003a). Other significant nesting sites are found throughout the Caribbean Sea, and including Cuba, with approximately 250–300 nests annually (Ehrhart et al. 2003), and over 100 nests annually in Cay Sal in the Bahamas (NMFS and USFWS 2008b). Survey effort at nesting beaches has been inconsistent, and not trend can be determined for this subpopulation (NMFS and USFWS 2008b). Zurita et al. (2003b) found an increase in the number of nests on 7 of the beaches on Quintana Roo, Mexico from 1987 through 2001, where survey effort was consistent during the period. Nonetheless, nesting has declined since 2001, and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008b).

8.4.3 Vocalization and Hearing

As noted in Section 9.1.3, sea turtles are low frequency hearing specialists. Bartol et al. (1999b) reported effective hearing range for juvenile loggerhead turtles is from at least 250–750 Hz. Both yearling and 2-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re 1 μPa and 2-year olds: about 86 dB re 1 μPa), with threshold increasing rapidly above and below that frequency (Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50–800 Hz and auditory evoked potential responses between

100–1,131 Hz in 1 adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re 1 μPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50–800 Hz while juveniles responded to sounds in the range of 50 Hz–1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

8.4.4 Status

Based on the currently available information, the overall nesting trend of the Northwest Atlantic DPS of loggerhead appears to be stable, neither increasing nor decreasing, for over 2 decades (NMFS and USFWS 2023). Destruction and modification of terrestrial and marine habitats threaten the Northwest Atlantic DPS of loggerhead. On beaches, threats that interfere with successful nesting, egg incubation, hatchling emergence, and transit to the sea include erosion, erosion control, coastal development, artificial lighting, beach use, and beach debris (NMFS and USFWS 2023). In the marine environment threats that interfere with foraging and movement include marine debris, oil spills and other pollutants, harmful algal blooms, and noise pollution (NMFS and USFWS 2023).

8.4.5 Status in the Action Area

Loggerhead nesting occurs along the coast of Texas, including <25 crawls (nesting crawls, including successful egg-laying and failed attempts, which can be 2 to 10 times higher than the number of actual nests) near the proposed survey area (Eckert and Eckert 2019; SWOT 2022). The nesting season for the Northwest Atlantic loggerhead DPS is from April through September (NMFS and USFWS 2008a). Post-nesting adult female loggerheads satellite-tagged in the Gulf of Mexico were found to forage near the proposed survey area off the coast of Texas, but most foraging occurred east of Texas (Hart et al. 2018; Hart et al. 2014). Similarly, no post-nesting movements of adult female loggerheads tagged off Florida were recorded off Texas, and most foraging occurred east of Texas, off Louisiana, Mississippi, and Alabama (Girard et al. 2009). According to the Turtle Island Restoration Network, no loggerhead turtle nests were recorded near the action area in 2023 (https://seaturtles.org/turtle-count-texas-coast/). Dispersal modeling by Putman et al. (2020)indicates that hatchlings could also occur in the proposed survey area, but the greatest concentrations are expected to occur in the eastern Gulf of Mexico. There are numerous loggerhead turtle records in the OBIS-SEAMAP database for waters <20 m deep in the northern Gulf of Mexico, including near but not within the proposed survey area; two of those records are for September and October (Halpin et al. 2009). In 2022, there was a record number (441) of loggerhead turtle strandings in Texas, including near the proposed survey area (see https://www.fws.gov/press-release/2022-09/sea-turtle-rehab-facilities-responding-loggerhead-strandings-texas-coast and https://coast.noaa.gov/states/stories/stranded-loggerheads.html). The cause of these strandings is unknown; however, NMFS noticed that turtles are in diminished nutritional condition.

9 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the ESA-listed species or its designated critical habitat in the action area, without the consequences to the ESA-listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02). In this section, we discuss the environmental baseline within the action area as it applies to species that are likely to be adversely affected by the proposed action.

A number of human activities have contributed to the status of populations of ESA-listed sea turtles (North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle) in the action area. Some human activities are ongoing and appear to continue to affect sea turtle populations in the action area for this consultation. The following discussion summarizes the impacts, which include climate change, sea turtle harvesting, vessel interactions (vessel strike), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, hydrocarbons, noise [vessel sound and commercial shipping, aircraft, seismic surveys, marine construction, active sonar, and military activities]), aquatic nuisance species, and scientific research activities.

Focusing on the impacts of the activities in the action area specifically allows us to assess the prior experience and state (or condition) of the threatened and endangered individuals that occur in the action area that will be exposed to effects from the proposed action under consultation. This is important because in some states or life history stages, or areas of their ranges, ESA-listed individuals will commonly exhibit, or be more susceptible to, adverse responses to stressors than they would be in other states, stages, or areas within their distributions. These localized stress responses or stressed baseline conditions may increase the severity of the adverse effects expected from the proposed action.

9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to affect ESA-listed species. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change in the action area.

The rising concentrations of greenhouse gases in the atmosphere, now higher than any period in the last 800,000 years, have warmed global ocean surface temperatures by 0.68–1.1°C between 1850–1900 and 2011–2020 (IPCC 2023). Over the last 100 years, sea surface temperatures have increased across much of the northwest Atlantic, consistent with the global trend of increasing sea surface temperature due to anthropogenic climate change (Beazley et al. 2021). Large-scale changes in the earth’s climate are in turn causing changes locally to the northwestern Gulf of Mexico’s climate and environment. Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution, warming surface temperatures) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of proposed and ESA-listed species including ESA-listed sea turtles in the action area. For example, ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs). Some studies in nutrient-rich regions have found that food supply may play a role in determining the resistance of some organisms to ocean acidification (Markon et al. 2018; Ramajo et al. 2016). Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, including prey for sea turtles.

In addition to impacts on prey species, higher trophic level marine species’ ranges in the action area are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions. For example, in the Gulf of Mexico, northward shifts in seagrass-associated fish species occurred over a period where air and sea surface temperatures increased more than 3°C (Fodrie et al. 2010). This northward shift has also been observed in cetacean and sea turtle species in the North Atlantic Ocean. Chavez-Rosales et al. (2022) identified a northward shift of an average of 178 km (~110.6 mi) when examining habitat suitability models for 16 cetacean species in the western North Atlantic Ocean. Record et al. (2019) also documented a shift in North Atlantic right whale distribution, based on a climate-driven shift in their main prey source. Based on climate, energetics, and habitat modeling, loggerhead and leatherback turtle distributions are expected to shift northward in the North Atlantic Ocean so that animals can stay within the environmental characteristics of suitable habitat (Dudley et al. 2016; McMahon and Hays 2006; Patel et al. 2021).

In addition to increased ocean warming and changes in species’ distribution, climate change is linked to increased extreme weather and climate events including, but not limited to, hurricanes, cyclones, tropical storms, heat waves, and droughts (IPCC 2023). Research from IPCC (2023) shows that it is likely extratropical storm tracks have shifted poleward in both the Northern and Southern Hemispheres, and heavy rainfalls and mean maximum wind speeds associated with hurricane events will increase with continued greenhouse gas warming. These extreme weather events have the potential to have adverse effects on ESA-listed sea turtles in the action area. For example, in 1999, off Florida, Hurricane Floyd washed out many loggerhead and green turtle nests, resulting in as many as 50,000–100,000 hatchling deaths (see https://conserveturtles.org/11665-2/). Hurricane Irma, also off Florida, washed more than half of green turtle nests out to sea at the Archie Carr National Wildlife Refuge, and rescuers during Hurricane Harvey dug up nests and incubated the eggs to save them from drowning (see https://usa.oceana.org/blog/simple-solution-can-save-thousands-sea-turtles/#:~:text=In%20Texas%2C%20hurricane%20Harvey%20forced,to%20save%20them%20from%20drowning.)

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change within the action area. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats, and may be exacerbated by additional threats in the action area.

9.2 Oceanic Temperature Regimes

Oceanographic conditions in the Atlantic can be altered due to periodic shifts in atmospheric patterns. In the Atlantic Ocean, this is caused by the Atlantic Multi-decadal Oscillation, or North Atlantic Oscillation. The North Atlantic Oscillation can alter habitat conditions and prey distribution for ESA-listed species in the action area.

The North Atlantic Oscillation is a large-scale, dynamic phenomenon that exemplifies the relationship between the atmosphere and the ocean. It is an alteration in the intensity of the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores Islands and the sub-polar low-pressure center over Iceland (Stenseth et al. 2002). Sea-level atmospheric pressure in the two regions tends to vary in a “see-saw” pattern – when the pressure increases in Iceland it decreases in the Azores and vice-versa (i.e., the two systems tend to intensify or weaken in synchrony). A positive phase occurs when there is high pressure over the Azores and low pressure over Iceland, and a negative phase occurs the difference in pressures weakens (Taylor et al. 1998). The North Atlantic oscillation is the dominant mode of decadal-scale variability in weather and climate in the North Atlantic Ocean region (Hurrell 1995). However, the North Atlantic Oscillation also has global significance, as it affects climate over Europe, North America, and even the Mediterranean Sea region, including sea surface temperatures, wind conditions, salinity, sea ice cover, mixed layer depth, and ocean circulation (Stenseth et al. 2002; Hurrell and Deser 2010; Curry and McCartney 2001; Greene and Pershing 2003; Pershing et al. 2001).

A strong association has been established between the variability of the North Atlantic Oscillation and changes affecting various trophic groups in North Atlantic marine ecosystems Drinkwater et al. 2003; Fromentin and Planque 1996. For example, the temporal and spatial patterns of *Calanus* copepods (zooplankton) were the first to be linked to the phases of the North Atlantic Oscillation Fromentin and Planque 1996; Stenseth et al. 2002. Such shifts in copepod patterns have a tremendous significance to upper-trophic-level species, including the North Atlantic right whale, which feeds principally on *Calanus finmarchicus* (Ganley et al. 2022;

Greene et al. 2003; Record et al. 2019). Decadal climatic regime shifts have also been related to changes in zooplankton in the North Atlantic Ocean Fromentin and Planque 1996, and decadal trends in the North Atlantic Oscillation Hurrell 1995 can affect the position of the Gulf Stream Taylor et al. 1998 and other circulation patterns in the North Atlantic Ocean that act as migratory pathways for various marine species, especially fish (Drinkwater et al. 2003). Shifts in the North Atlantic Oscillation have also been associated with shifts in the composition of fishery landings in the Gulf of Mexico (Karnauskas et al. 2015) and shifts in loggerhead turtle sightings in the eastern North Atlantic Ocean (Dellinger et al. 2022).

9.3 Sea Turtle Harvesting

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of several species, including the green turtle, Kemp's ridley turtle, leatherback turtle, and loggerhead turtle considered in this consultation. In the U.S., the harvest of nesting sea turtles and eggs is now illegal, and although there has been recent documented harvesting in the eastern Atlantic Ocean (see https://www.justice.gov/usao-sdfl/pr/poachers-93-protected-sea-turtle-eggs-sentenced-prison), there has been no documented harvesting in Texas.

9.4 Vessel Interactions

Within the action area, vessel interactions pose a threat to ESA-listed sea turtles. Overall, the action area has a great deal of vessel activity, from cargo and commercial shipping, to recreational vessels, and cruise ships. Vessel interactions can come in the form of vessel traffic (visual and auditory disturbance) and vessel strike.

Sea turtle vessel interactions are poorly studied compared to marine mammals; however, vessel strikes have the potential to be a significant threat to sea turtles given that they can results in serious injury and mortality (Work et al. 2010). Sea turtles can move somewhat rapidly but are not adept at avoiding vessels that are moving at more than 4 km/h (2.6 kts); most vessels move much faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007b; Work et al. 2010). All sea turtles must surface to breathe and several species are known to bask at the sea surface for long periods of time, potentially increasing the risk of vessel strike. Hazel et al. (2007b) documented live and dead sea turtles with deep cuts and fractures indicative of a vessel strike, and suggested that green turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to vessel strike or vessel speed increases. Stacy et al. (2020) analyzed Texas sea turtle stranding data for 2019, a year where sea turtle strandings were more than 2 times above average based on statewide stranding numbers for the previous 5 and 10 years, and analyzed causes of stranding by species and stranding zone. In the stranding zones that overlap the action area (zones 18 and 19), vessel strike-type injuries were the most common type of trauma observed in Kemp's ridley, green, and loggerhead turtles (Stacy et al. 2020). Approximately 71% of stranded green turtles and 61% of Kemp's ridley turtles studied had documented vessel strike injuries (Stacy et al. 2020).

9.5 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fishery interactions can adversely affect ESA-listed sea turtles. Direct effects of fisheries interactions on sea turtles include entanglement, tackle/gear injuries, and bycatch, which can lead to fitness consequences or mortality because of injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and habitat destruction. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by sea turtles.

Fishing gears that are known to interact with sea turtles include trawls, longlines, purse seines, gillnets, pound nets, dredges and to a lesser extent, pots and traps (Finkbeiner et al. 2011; Lewison et al. 2013). Within the action area, both recreational and commercial fisheries occur in Texas state waters. Lost traps and disposed monofilament and other fishing lines are a documented source of mortality in sea turtles due to entanglement that may anchor an animal to the bottom leading to death by drowning. Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual’s health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of ESA-species that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities.

Within the action area, fisheries-related injuries (hooking injuries, entanglement, and internal injuries resulting from ingestion of fishing gear) were the second-most documented injuries in sea turtles off Texas in 2019 (Stacy et al. 2020). Approximately 18% of green turtles and 22% of Kemp’s ridley turtles studied had documented fishing-related injuries (Stacy et al. 2020).

Regulations that went into effect in the early 1990’s require shrimp trawlers in the Atlantic and Gulf of Mexico to modify their gear with turtle excluder devices (TEDs), which are designed to allow turtles to escape trawl nets and avoid drowning. Analyses by Epperly and Teas (2002) indicated that, while early versions of TEDs were effective for some species, the minimum requirements for the escape opening dimension were too small for larger sea turtles, particularly loggerheads and leatherbacks. NMFS implemented revisions to the TED regulations in 2003 to address this issue (68 FR 8456; February 21, 2003). Revised TED regulations in 2014 were estimated to reduce shrimp trawl-related mortality by 94% for loggerheads and 97% for leatherbacks (NMFS 2014). In 2019, a final rule was published (84 FR 70048) requiring TEDs on skimmer trawls greater than 12.19 m (40 ft). The conservation benefit from the 2019 rule was estimated to prevent bycatch of up to 801–1,168 sea turtles in Southeastern U.S. shrimp fisheries. Furthermore, in 2021, NMFS introduced an advanced notice of a proposed rule to require TEDs on skimmer trawls less than 12.19 m (40 ft) operating in Southeast U.S. shrimp fisheries (86 FR 20475).

9.6 Pollution

Within the action area, pollution poses a threat to ESA-listed sea turtles. Pollution can come in the form of marine debris and plastics, pollutants and contaminants, and noise pollution from anthropogenic activities.

9.6.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrological transport of these materials from land-based sources or weather events (Gallo et al. 2018). Sea turtles within the action area may ingest marine debris, particularly plastics, which can cause intestinal blockage and internal injury, dietary dilution, malnutrition, and increased buoyancy. These can result in poor health, reduced fitness, growth rates, and reproduction, or even death (Nelms et al. 2016). Entanglement in plastic debris (including abandoned ‘ghost’ fishing gear) is known to cause lacerations, increased drag (thereby reducing the ability to forage effectively or avoid predators), and may lead to drowning or death by starvation. Leatherbacks appear to be most susceptible to ingesting marine debris, particularly plastic, which they misidentify as jellyfish, a primary food source (Mrosovsky et al. 2009; Schuyler et al. 2014). There are limited studies of debris ingestion in sea turtles within the action area; however, Plotkin et al. (1993) found that over half of the studied loggerhead turtles had anthropogenic debris, mainly pieces of plastic bags, present in digestive tract contents. Plotkin et al. (1993) attributed the deaths of 3 loggerhead turtles to debris ingestion, including 1 loggerhead turtle whose esophagus was perforated by a fishing hook, 1 loggerhead turtle whose stomach lining was perforated by a piece of glass, and 1 loggerhead turtle whose entire digestive tract was impacted by plastic trash bags. Along the Texas coast just south of the action area, Howell et al. (2016) found debris in over half of the stomach contents of juvenile green turtles. Elsewhere in the Gulf of Mexico, debris such as plastic, fishing gear, rubber, aluminum foil, and tar were found in green and loggerhead turtles (Bjorndal et al. 1994). At least 2 turtles died as a result of debris ingestion, although the volume of debris represented less than 10% of the volume of the turtle’s gut contents; therefore, even small quantities of debris can have severe health and fitness consequences (Bjorndal et al. 1994).

Sea turtles can also become entanglement in marine debris, namely fishing gear, which was discussed in Section 9.5.

9.6.2 Pollutants and Contaminants

Exposures to pollution and contaminants have the potential to cause adverse health effects in ESA-listed cetaceans and sea turtles. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are, therefore, difficult to identify and monitor (Grant and Ross 2002). Sources of pollution within or adjacent to the action area include agricultural and industrial runoff/dumping, and oil and gas exploration and extraction, each of which can degrade marine habitats used by sea turtles.

Agricultural and industrial runoff into rivers and canals empty into bays and the ocean (e.g., Mississippi River into the Gulf of Mexico). Such runoff, especially from agricultural sources, is nutrient-rich from fertilizers containing nitrogen and phosphorous, and can cause eutrophication. Eutrophication occurs when an environment becomes nutrient-loaded, stimulating plankton and algae growth. This can lead to algal blooms, which create hypoxic (low-oxygen) waters within which most marine life cannot survive (also called “dead zones”). In these hypoxic zones and adjacent waters, pelagic marine life are displaced and many benthic organisms are lost (Rabalais and Turner 2001). In the northern Gulf of Mexico, on the Louisiana and Texas continental shelf, one of the world’s largest dead zones is an annual occurrence from late-spring through late-summer (Rabalais et al. 2002), and could affect species and critical habitat in the action area. The U.S. Environmental Protection Agency’s (EPA) annual summer measurements of the dead zone were highest in 2002 and 2017, when the dead zone measured 8,494 mi^2 (~22,000 km^2) and 8,776 mi^2 (~22,729 km^2), respectively, which is larger than the state of Massachusetts (see https://www.epa.gov/ms-htf/northern-gulf-mexico-hypoxic-zone). The most recent 5-year average is 4,347 mi^2 (~11,259 km^2).

Dumping of waste and sewage from shipping and ships used for coastal construction can also contribute to nutrient-loading and coastal pollution. Adjacent to the action area, ships must pass through the Houston Ship Channel, spanning from the Gulf of Mexico through Galveston Bay, just north of the action area, to reach the Port of Houston. The Houston Ship Channel is the busiest waterway in the U.S., with more than 8,300 large ships, 231,000 commercial small craft, and 230 million tons of cargo a year (TDOT 2016). As a result, the action area contains major shipping routes, increasing the risk for pollutants to enter the marine environment.

Chemical pollutants (e.g., DDT, PCBs, polybrominated diphenyl ethers, perfluorinated compounds, and heavy metals) accumulate up trophic levels of the food chain, such that high trophic level species like sea turtles have higher levels of contaminants than lower trophic levels (Bucchia et al. 2015; D’ilio et al. 2011; Mattei et al. 2015). These pollutants can cause adverse effects including endocrine disruption, reproductive impairment or developmental effects, and immune dysfunction or disease susceptibility (Bucchia et al. 2015; Ley-Quiñónez et al. 2011). In sea turtles, maternal transfer of persistent organic pollutants threatens developing embryos with a pollution legacy and poses conservation concerns due to its potential adverse effects on subsequent generations (Muñoz and Vermeiren 2020). Although there is limited information on chemical pollutants in sea turtles in the action area, there are studies that have investigated heavy metals, brevetoxins, and persistent organic pollutants in some sea turtle species in other areas of the Gulf of Mexico and adjacent waters. Two studies have investigated heavy metals in Kemp’s ridley, loggerhead, hawksbill, and green turtles off eastern Texas and Louisiana (Kenyon et al. 2001; Presti et al. 2000). Heavy metal (mercury, copper, lead, silver, and zinc) concentrations in blood and scute (the scales on the shell, also known as carapace) samples increased with turtle size (Kenyon et al. 2001; Presti et al. 2000). After a red tide bloom near Florida's Big Bend, Perrault et al. (2017) found brevetoxins and heavy metals in Kemp's ridley and green turtles. Perrault et al. (2017) analyzed the turtles' health relative to the presence of brevetoxins and heavy metals, and found that the presence of toxic elements was related to oxidative stress, increased tumor growth, decreased body condition, inflammation, and disease progression.

Sea turtle tissues have been found to contain organochlorines and many other persistent organic pollutants. PCB concentrations in sea turtles are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (Davenport et al. 1990b; Orós et al. 2009). PCBs have been found in leatherback turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart et al. 2011). The contaminants (organochlorines) can cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007) and are known to depress immune function in loggerhead turtles (Keller et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation. Exposure to sewage effluent may also result in green turtle eggs harboring antibiotic resistant strains of bacteria (Al-Bahry et al. 2009).

Oil and gas exploration and extraction is of particular concern in the Gulf of Mexico, because it is an area of high-density offshore oil extraction. This results in an area with chronic, low-level spills and occasional massive spills (e.g., Deepwater Horizon oil spill event). Hydrocarbons that may pose a threat to ESA-listed sea turtles come from natural seeps, as well as oil spills. Hydrocarbons also have the potential to impact prey populations, and, therefore, may affect ESA-listed species indirectly by reducing food availability.

Natural seeps provide the largest petroleum input to the offshore Gulf of Mexico, about 95% of the total. Mitchell et al. (1999) estimated a range of 280,000–700,000 barrels per year (40,000–100,000 tonnes per year), with an average of 490,000 barrels (70,000 tonnes) for the northern Gulf of Mexico, excluding the Bay of Campeche. As seepage is a natural occurrence, the rate of approximately 980,000 barrels (140,000 tonnes) per year is expected to remain unchanged into the foreseeable future.

Oil spills are accidental and unpredictable events, but are a direct consequence of oil and gas development and production from oil and gas activities in the Gulf of Mexico, as well as from the use of vessels. Oil releases can occur at any number of points during the exploration, development, production, and transport of oil. Most instances of oil spill are generally small (less than 1,000 barrels), but larger spills occur. Large-scale and numerous small-scale (vessel) oil spills have occurred in the Gulf of Mexico.

A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton and Jin 2010). In this study, "vessel" included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of vessel types. Below we review the effects of oil spills on sea turtles more generally. Much of what is known comes from studies of large oil spills such as the Deepwater Horizon oil spill since no information exists on the effects of small-scale oil spills within the action area.

On April 20, 2010, while working on an exploratory well approximately 80.5 km (50 mi) offshore of Louisiana, the semi-submersible drilling rig Deepwater Horizon experienced an explosion and fire. The rig subsequently sank, and oil and natural gas began leaking into the Gulf of Mexico. Oil flowed for 86 days, until the well was capped on July 15, 2010. Millions of barrels of oil were released. Additionally, approximately 1.84 million gallons of chemical dispersant was applied both subsurface and on the surface to attempt to break down the oil. There is no question that the unprecedented Deepwater Horizon event and associated response activities (e.g., skimming, burning, and application of dispersants) have resulted in adverse effects on ESA-listed species and changed the environmental baseline for the Gulf of Mexico ecosystem. Berenshtein et al. (2020) used in situ observations and oil spill transport modeling to examine the full extent of the Deepwater Horizon spill, beyond the satellite footprint, that was at toxic concentrations to marine organisms.

The Deepwater Horizon oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of sea turtles to oil, causing restricted movement, exhaustion, vulnerability to predators, and ingestion of contaminated prey or water. The Deepwater Horizon oil spill also caused significant mortality; it is estimated that 4,900–7,600 large juvenile and adult sea turtles (Kemp’s ridley, loggerhead, and unidentified species), and between 55,000–160,000 small juvenile sea turtles (Kemp’s ridley, green turtles, loggerhead, hawksbill, and unidentified species) were killed by the Deepwater Horizon oil spill (Deepwater Horizon Trustees 2016). Nearly 35,000 hatchling sea turtles (loggerhead, Kemp’s ridley, and green turtles) were also injured by response activities. The Deepwater Horizon oil spill extensively oiled vital foraging, migratory, and breeding habitats of sea turtles throughout the northern Gulf of Mexico (Deepwater Horizon Trustees 2016). *Sargassum* habitats, benthic foraging habitats, surface and water column waters, and sea turtle nesting were all affected by the Deepwater Horizon oil spill. Sea turtles may have been exposed to Deepwater Horizon oil in contaminated habitats, through breathing oil droplets, oil vapor, and smoke, by ingesting oil-contaminated water and prey, and through maternal transfer of oil compounds to developing embryos. Translocation of eggs from the Gulf of Mexico to the Atlantic Ocean coast of Florida resulted in the loss of sea turtle hatchlings. Other response activities, including increased boat traffic, dredging, increased lighting on nesting beaches, and oil cleanup operations on nesting beaches, also contributed to sea turtle deaths.

Stacy et al. (2017) reported 319 live oiled sea turtles were rescued and showed disrupted metabolic and osmoregulatory functions, likely attributable to oil exposure, physical fouling and exhaustion, dehydration, capture, and transport. Accounting for sea turtles that are unobservable during the response efforts, high numbers of small oceanic and large sea turtles are estimated to have been exposed to oil resulting from the Deepwater Horizon event due to the duration and large footprint of the oil spill. Small juveniles were affected in the greatest numbers and suffered a higher mortality rate than large sea turtles. Leatherback turtle foraging and migratory habitat was also affected, and, though impacts to leatherback turtles were unquantified, it is likely some died as a result of the Deepwater Horizon oil spill and spill response (Deepwater Horizon NRDA Trustees 2016; NMFS and USFWS 2013).

Hatchlings from nesting beaches in the Gulf of Mexico were released in the Atlantic Ocean and not the Gulf of Mexico. Therefore, the hatchlings imprinted on the area of their release beach. It is thought that sea turtles use this imprinting information to return to the location of nesting beaches as adults. It is unknown whether these sea turtles will return to the Gulf of Mexico to nest; therefore, the damage assessment determined that the 14,796 hatchlings will be lost to the Gulf of Mexico breeding populations as a result of the Deepwater Horizon event. It is estimated that nearly 35,000 hatchling sea turtles (green, Kemp's ridley, and loggerhead turtles) were injured by response activities, and thousands more Kemp ridley and loggerhead turtle hatchlings were lost due to unrealized reproduction of adult sea turtles that were killed by the Deepwater Horizon event.

Green turtles made up 32.2% (154,000 animals) of all sea turtles exposed to oil from the Deepwater Horizon event with 57,300 juvenile mortalities out of the total exposed animals, which removed a large number of small juvenile green turtles from the population. A total of 4 nests (580 eggs) were relocated during response efforts. While green turtles regularly use the northern Gulf of Mexico, they have a widespread distribution throughout the entire Gulf of Mexico, Caribbean Sea, and Atlantic Ocean. Nesting is relatively rare on the northern Gulf of Mexico beaches. Although it is known that adverse impacts occurred and numbers of animals in the Gulf of Mexico were reduced as a result of the Deepwater Horizon event, the relative proportion of the population that is expected to have been exposed to and directly impacted by the Deepwater Horizon event is considered low, thus, a population-level impact to green turtles is not likely.

Kemp's ridley turtles were the most affected sea turtle species, accounting for 49% (239,000 animals) of all exposed sea turtles (478,900 animals) during the Deepwater Horizon event. Kemp's ridley turtles were the sea turtle species most impacted by the Deepwater Horizon event at a population level. The Deepwater Horizon damage assessment calculated the number of unrealized nests and hatchlings of Kemp's ridley turtles because all Kemp's ridley turtles nest in the Gulf of Mexico and belong to the same population (NMFS et al. 2011b). The total population abundance of Kemp's ridley turtles can be calculated based on numbers of hatchlings because all individuals are reasonably expected to inhabit the northern Gulf of Mexico throughout their lives. The loss of these reproductive-stage females will have contributed to some extent to the decline in total nesting abundance observed between 2011 and 2014. The estimated number of unrealized Kemp's ridley turtle nests is between 1,300–2,000, which translates to approximately 65,000–95,000 unrealized hatchlings. This is a minimum estimate because the sub-lethal effects of oil on sea turtles, their prey, and their habitats might have delayed or reduced reproduction in subsequent years, which may have contributed substantially to additional nesting deficits observed following the Deepwater Horizon event. These sub-lethal effects could have slowed growth and maturation rates, increased remigration intervals, and decreased clutch frequency (number of nests per female per nesting season). The impact of the Deepwater Horizon event on reduced Kemp's ridley turtle nesting abundance and associated hatchling production after 2010 requires further evaluation.

Loggerhead turtles made up 12.7% (60,800 animals) of the total sea turtle exposures (478,900 animals). A total of 14,300 loggerhead turtles died as a result of exposure to oil from the Deepwater Horizon event. Unlike Kemp's ridley turtles, the majority of nesting for the Northwest Atlantic Ocean DPS of loggerhead turtles occurs on the Atlantic coast, and thus nesting was impacted to a lesser degree for this species. It is likely that impacts to the Northern Gulf of Mexico Recovery Unit of the Northwest Atlantic Ocean DPS of loggerhead turtles would be proportionally much greater than the impacts occurring to the other recovery units, and likely included impacts to mating and nesting adults. Although the long-term effects remain unknown, the impacts from the Deepwater Horizon event to the Northern Gulf of Mexico Recovery Unit may include some nesting declines in the future due to a large reduction of oceanic age classes during the Deepwater Horizon event. However, the overall impact on the population recovery of the entire Northwest Atlantic Ocean DPS of loggerhead turtles is likely small.

Available information indicates hawksbill and leatherback turtles were least affected by the oil spill. Hawksbill turtles made up 1.8% (8,850 animals) of all sea turtle exposures. Although leatherback turtles were documented in the area of the oil spill, the number of affected leatherback turtles was not estimated due to a lack of information for leatherback turtles compared to other species of sea turtles. Potential Deepwater Horizon-related impacts to leatherback turtles include direct oiling or contact with dispersants, inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil and/or dispersants, and loss of foraging resources, which could lead to compromised growth and/or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred. Although adverse impacts likely occurred to hawksbill and leatherback turtles, the relative proportion of the populations of these species that are expected to have been exposed to and directly impacted by the Deepwater Horizon event is relatively low, thus a population-level impact is not believed to have occurred due to the widespread distribution and nesting locations outside of the Gulf of Mexico for both of these species of sea turtles.

The unprecedented Deepwater Horizon oil spill and associated response activities (e.g., skimming, burning, and application of dispersants) resulted in adverse effects on ESA-listed sea turtles. Despite natural weathering processes over the years since the Deepwater Horizon event, oil persists in some habitats where it continues to expose and impact resources in the northern Gulf of Mexico resulting in new environmental baseline conditions (BOEM 2016; Trustees 2016). The true impacts of offshore megafauna populations and their habitats may never be fully quantified, though it was necessary to characterize these impacts for response, damage assessment, and restoration activities (Frasier 2020). It is also unclear how restoration efforts have changed the environmental baseline relative to what it would be if those efforts had not happened.

In June of 1979, the catastrophic Ixtoc oil spill occurred in the Bay of Campeche, releasing approximately 3,000,000 barrels of oil into the Gulf of Mexico before it was capped in March of 1980. During this oil spill, prevailing northerly currents in the western Gulf of Mexico carried spilled oil toward the U.S. As a result, a 96.6 by 112.7 km (60 by 70 mi) patch of sheen containing a 91.4 by 152.4 m (300 by 500 ft) patch of heavy crude moved toward the coast of Texas. The heavy crude impacted a relatively small area and contributed to the sheen, tar balls, and other residuals through weathering. Tar balls from the oil spill impacted a 27.4 km (17 mi) stretch of beach in Texas.

9.6.3 Noise pollution

The ESA-listed sea turtles that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities (vessel sound and commercial shipping), aircraft, seismic surveys (exploration and research), and marine construction (dredging and pile-driving as well as the construction, operation, and decommissioning of offshore structures). These activities occur to varying degrees throughout the year. Anthropogenic noise is a known stressor that has the potential to affect sea turtles, although effects to sea turtles are not well understood. Within the action area, ESA-listed sea turtles may be impacted by anthropogenic sound in various ways. Responses to sound exposure may include lethal or nonlethal injury, permanent or temporary noise-induced hearing loss, behavioral harassment and stress, or no apparent response.

In the Gulf of Mexico, NOAA is working cooperatively with the ship-building industry to find technologically-based solutions to reduce the amount of sound produced by commercial vessels. Through ESA consultation with NMFS, Bureau of Ocean Energy Management (BOEM) and Bureau of Safety and Environmental Enforcement (BSEE) have implemented and periodically revised Gulf of Mexico-wide measures, such as BOEM Notice to Lessees and Operators (NTL) 2016-G02, to reduce the risk of harassment to sperm whales from sound produced by geological and geophysical surveying activities and explosive removal of offshore structures.

NOAA has also implemented the CetSound Ocean Sound Strategy (https://cetsound.noaa.gov/) that provides a better understanding of manmade sound impacts on cetacean species. CetSound produced modeled ambient sound maps for several sound source types in the Gulf of Mexico. Annual average ambient sound sums of the modeled source types including seismic airgun surveys at different frequencies and depths. Other modeled events that can be viewed on the CetSound website for the Gulf of Mexico include annual average ambient sound for only seismic airgun surveys, summed sound sources without airguns, and explosive severance of an oil platform during decommissioning. In addition, the Gulf of Mexico soundscape is being studied over the long-term by NOAA’s Sound Reference Station Network (https://www.pmel.noaa.gov/acoustics/noaanps-ocean-noise-reference-station-network; see also Haver et al. 2018). This network uses static passive acoustic monitoring (PAM) hydrophone (sound recorder) units to monitor trends and changes in the ambient sound field in U.S. federal waters.

Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of 10–50 Hz and range from 195 dB re 1 $\mu Pa^2/Hz$ at 1 m for fast-moving (greater than 37 km/h [20 kts]) supertankers to 140 dB re 1 $\mu Pa^2/Hz$ at 1 m for smaller vessels (NRC 2003b). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels about 2 kHz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15–20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

Much of the increase in sound in the ocean environment is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009b; McKenna et al. 2012; NRC 2003b, 2003c). Commercial shipping continues to be a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs. In the Gulf of Mexico, shipping noise dominates the low frequency soundscape (Snyder and Orlin 2007). As noted in Section 10.6.2, ships must pass through the Houston Ship Channel, spanning from the Gulf of Mexico through Galveston Bay, just north of the action area, to reach the Port of Houston. The Houston Ship Channel is the busiest waterway in the U.S., with more than 8,300 large ships, 231,000 commercial small craft, and 230 million tons of cargo a year (TDOT 2016), resulting in areas of high density vessel traffic adjacent to the action area.

Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kHz. The low frequency sounds from large vessels overlap with the estimated hearing ranges of sea turtles (approximately 50–1500 Hz; Dow Piniak et al. 2012b) and may affect their behavior and hearing. There is limited published information on how these sounds may affect important biological functions of sea turtles. Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

Sonar and Military Activities

Sonar systems are commonly used on commercial, recreational, and military vessels and may affect sea turtles. The action area may host many of these vessel types during any time of the year. Although little information is available on potential effects of multiple commercial and recreational sonars to ESA-listed sea turtles, the distribution of these sounds would be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al. 2007).

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and sound source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low-frequency for ≤ 1 kHz, mid-frequency for 1–10 kHz, high-frequency for 10–100 kHz; and very high-frequency for > 100 kHz (Hildebrand 2004). Low-frequency systems are designed for long-range detection (Popper et al. 2014b). The effective sound source level of a low-frequency airgun array, when viewed in the horizontal direction can be 235 dB re 1 µPa at 1 m or higher (Hildebrand 2004). Commercial sonars are designed for fish finding, depth sounds, and sub-bottom profiling. They typically generate sound at frequencies of 3–200 kHz, with sound source levels ranging from 150–235 dB re 1 µPa at 1 m (Hildebrand 2004). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments; however, fish finders are operated in both deep and shallow areas.

Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes or helicopters, to large commercial airliners. These aircraft produce a variety of sounds that can potentially impact sea turtles. While it is difficult to assess these impacts, and there is little data on sea turtle response to aircraft, several studies have documented what appear to be minor cetacean behavioral disturbances in response to aircraft presence (Nowacek et al. 2007). Erbe et al. (2018) recorded underwater noise from commercial airplanes reaching as high as 36 dB above ambient noise. Sound pressure levels received at depth were comparable to cargo and container ships traveling at distances of 1–3 km (0.5–1.6 NM) away, although the airplane noises ceased as soon as the airplanes left the area, which was relatively quick compared to a cargo vessel. Green and hawksbill turtles showed no response to drones flying at a minimum of 10 m away (Bevan et al. 2018). While such noise levels are relatively low and brief, they still have the potential to be heard by sea turtles at certain frequencies. Nevertheless, noise from aircraft is expected to be minimal due to the location of the action area, which is not located near an airport and has sparse aircraft traffic.

Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. Airgun surveys are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. 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 20066). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004). Seismic surveys dominated the northern Gulf of Mexico soundscape (Estabrook et al. 2016; Wiggins et al. 2016); thus, noise produced by the seismic survey activities could impact ESA-listed sea turtles within the action area.

These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of 10–20 s for extended periods (NRC 2003c). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235–240 dB at dominant frequencies of 5–300 Hz (NRC 2003a). Most of the sound energy is at frequencies below 500 Hz, which is within the hearing range of sea turtles (Dow Piniak et al. 2012b; Lavender et al. 2014). In the U.S., seismic surveys involving the use of airguns with the potential to take ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic waters, and the NSF and U.S. Geological Survey funds and/or conducts these seismic survey activities in domestic, international, and foreign waters. In doing so, these Federal agencies consult with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions (e.g., NMFS 2020a, 2023a, 2023b). For seismic surveys for oil and gas discovery, development and production in the Gulf of Mexico, required mitigation measures can be found in Bureau of Ocean Energy Management Notice to Lessees and Operators 2016-G02 “Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program” (https://www.boem.gov/sites/default/files/documents/oil-gas-energy/BOEM-NTL-No-2016-G02.pdf).

9.7 Aquatic Nuisance Species

Aquatic nuisance species are nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested waters, or any commercial, agricultural or recreational activities dependent on such waters. Aquatic nuisance species or invasive species include nonindigenous species that may occur within inland, estuarine, or marine waters and that presently or potentially threaten ecological processes and natural resources. Invasive species have been referred to as one of the top 4 threats to the world’s oceans (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, and shipping. Shipping is the main vector of aquatic nuisance species (species hitchhiking on vessel hulls and in ballast water) in aquatic ecosystems; globally, shipping has been found to be responsible for 69% of marine invasive species (e.g., Drake and Lodge 2007; Keller and Perrings 2011; Molnar et al. 2008).

Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). Shifts in the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002; Norse et al. 2005), potentially affecting prey availability and habitat suitability for ESA-listed species. They have been implicated in the endangerment of 48% of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on sea turtles in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed sea turtles is unknown.

Lionfish (*Pterois* sp.) have become a major invasive species in the western North Atlantic Ocean and have rapidly dispersed into the Caribbean Sea and Gulf of Mexico. Since lionfish were first captured in the northern Gulf of Mexico in 2010 and 2011, they have rapidly dispersed throughout the northern Gulf of Mexico, with the western most collection of lionfish off Texas (Fogg et al. 2013). Lionfish are voracious predators to native fishes having decimated native fish populations on Caribbean reefs, have a broad habitat distribution, with few natural predators in the region (Ingeman 2016; Mumby et al. 2011). It is unclear what impact lionfish will have on prey species in the action area. Although it is not possible to predict which aquatic nuisance species will arrive and thrive in the northwestern Gulf of Mexico, it is reasonably certain that they will be yet another facet of change and potential stress to native biota which may affect either the health or prey base of native fauna.

9.8 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the Atlantic Ocean, some of which extend into portions of the action area for the proposed action. Marine mammals and sea turtles have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of “take” of marine mammals and sea turtles in the action area from a variety of research activities.

Authorized research on ESA-listed sea turtles includes aerial and vessel surveys, close approaches, active acoustics, capture, handling, holding, restraint, and transportation, tagging, shell and chemical marking, biological sampling (i.e., biopsy, blood and tissue collection, tear, fecal and urine, and lavage), drilling, pills, imaging, ultrasound, antibiotic (tetracycline) injections, captive experiments, laparoscopy, and mortality. Most research activities involve authorized sub-lethal “takes,” with some resulting mortality.

There have been numerous research permits issued since 2009 under the provisions of both the Marine Mammal Protection Act and ESA authorizing scientific research on marine mammals and sea turtles all over the world, including for research activities in the action area. The consultations on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects on individuals or populations; and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

9.9 Impact of the Baseline on Endangered Species Act-Listed Species

Collectively, the baseline described above has had, and likely continues to have, lasting impacts on the ESA-listed species considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes and sea turtle harvesting), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., invasive species) impacts.

Assessing the aggregate impacts of these stressors on the species considered in this consultation is difficult. This difficulty is compounded by the fact that many of the species in this consultation are wide-ranging and subject to stressors in locations throughout and outside the action area.

We consider the best indicator of the aggregate impact of the Environmental Baseline section on ESA-listed resources to be the status and trends of those species. As noted in Section 9, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the Environmental Baseline section are impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the Environmental Baseline section. Therefore, while the stressors that affect the environmental baseline in the action area may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the Environmental Baseline section is preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical harvesting) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the Status of Species Likely to be Adversely Affected section (Section 9) of this consultation and what this means for the populations is discussed in the Integration and Synthesis section (Section 13).

10 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as all consequences to the ESA-listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.02).

This effects analyses section is organized following the stressor, exposure, response, risk assessment framework described in Section 2 above.

In this section, we further describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (give probable exposures) based on the available evidence. As described in Section 10.2, 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 will consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Associated with the Proposed Action

During consultation we determined that sound fields produced by the airguns may adversely affect ESA-listed species (North Atlantic DPS of green turtle, Kemp’s ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle) by introducing acoustic energy into the marine environment. This stressor and the likely effects on ESA-listed species are discussed starting in Section 10.2.

10.2 Exposure Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the action’s effects on the environment in space and time, and identify the nature of that co-occurrence. This section identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action’s effects and the population(s) or sub-population(s) those individuals represent. Although there are multiple stressors associated with the proposed action, the stressor of primary concern as the one that may adversely affect listed sea turtles in the action area is the acoustic impact of the airguns.

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the DOE and UT estimated exposure to the sounds from the airgun array that would result in ESA harassment of ESA-listed sea turtles.

Section 3 of the ESA defines take as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct” (16 U.S.C. §1532(19)). Harm is defined by regulation (50 C.F.R. §222.102) as “an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering.” NMFS does not have a regulatory definition of “harass.” However, on May 1, 2023, NMFS adopted, as final, the previous interim guidance on the term “harass,” defining it as to “create 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.”

Under the ESA, harassment resulting from seismic survey acoustic stressors may involve a wide range of behavioral responses of ESA-listed sea turtles including, but not limited to, avoidance, or disruption of feeding, migrating, or reproductive behaviors. In the following sections, we consider the best available scientific evidence to determine the likely nature of these responses and their potential fitness consequences in accordance with the definitions of “take” related to harm or harass under the ESA.

Our exposure analysis relies on 2 basic components: (1) information on species distribution (i.e., density or occurrence within the action area), and (2) information on the level of exposure to sound (i.e., acoustic thresholds) at which species are reasonably certain to be affected (i.e., exhibit some response). Using this information, and information on the seismic survey (e.g., sound source specifications, area or volume of water that would be ensonified at certain sound levels, trackline distances, days of operation, etc.), we then estimate the number of instances in which an ESA-listed species may be exposed to sound fields from the airgun array that are likely to result in adverse effects such as harm or harassment. In many cases, estimating the potential exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals; and proximity to and duration of exposure to the sound source. For these reasons and by regulation, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

10.2.1 Exposure Estimates of ESA-Listed Sea Turtles

As discussed in the Status of Species Likely to be Adversely Affected (Section 9), there are 4 ESA-listed sea turtle species that are likely to be adversely affected by the proposed action: the North Atlantic DPS of green turtle, Kemp’s ridley turtle, leatherback turtle, and the Northwest Atlantic Ocean DPS of loggerhead turtle.

The DOE and UT applied NMFS’s acoustic thresholds (NOAA 2018) to determine at what point during exposure to the airgun array sea turtles may be harmed or harassed. An estimate of the number of sea turtles that will be exposed to sounds from the airgun array is included in DOE’s draft environmental assessment (DOE 2023).

In this section, we describe the DOE and UT's analytical methods to estimate the number of ESA-listed sea turtle species that might be exposed to the airgun array's sound field.

ESA-Listed Sea Turtle Occurrence – Density Estimates

We reviewed available sea turtle densities with the DOE and UT, and agreed with them on which densities constituted the best available scientific information for each ESA-listed sea turtle species. We have adopted them for our ESA Exposure Analysis.

Estimates of sea turtle densities in the action area were utilized in the development of DOE and UT's draft environmental assessment (DOE 2023). The DOE and UT used habitat-based density estimates from Garrison et al. (2023). The habitat-based density models were produced from visual observations of sea turtles using line-transect survey methods aboard NOAA research vessels and aircraft in the Gulf of Mexico between 2003 and 2019 (as part of the Gulf of Mexico Marine Assessment Program for Protected Species, or GoMMAPPS). Only sea turtles greater than approximately 30–40 cm were recorded because smaller, post-hatchling turtles are difficult to observe from the aforementioned platforms (Rappucci et al. 2023). Therefore, the sea turtle densities in Garrison et al. (2023) represent the best available information regarding neritic-stage juvenile and adult sea turtle densities in the seismic survey area. Although we do not have current density information on post-hatchling turtles in the action area, we know that these sea turtle species are present in the region, and that there is a likelihood of exposure to the proposed seismic survey. In the absence of better information, we rely on a surrogate to estimate exposure of green, Kemp's ridley, leatherback, and loggerhead turtles, that is, the area within the 175 dB re 1 µPa (rms) isopleth is where sea turtles are likely to be adversely affected.

The habitat-based density models consisted of 40 km^2 hexagons (~3.9 km sides and ~7 km across) for each month across the entire Gulf of Mexico. Average densities in the cells for the seismic survey area (plus a 7 km [~4.3 mi] buffer to ensure that at least one full density hexagon cell immediately outside the seismic survey area in all directions was included) were calculated for each species and month. See Garrison et al. (2023) and Litz et al. (2022) for more details. The highest mean monthly density was chosen for each species from the months of September to December.

Data sources and density calculations are described in detail in DOE's draft environmental assessment (DOE 2023). There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some sea turtle species, the densities derived from past surveys may not be precisely representative of the densities that may be encountered during the seismic survey. Density estimates for each ESA-listed sea turtle likely to be adversely affected by the proposed action are found in Table 3. The approach used here is based on the best available data.

Table 3. Densities of Endangered Species Act-Listed Sea Turtles in the Action Area during the Department of Energy and University of Texas at Austin's Seismic Survey off Texas

Species	Season (Month of Highest Density between September–December)	Density (Individuals per km^2)
Green turtle – North Atlantic DPS	September	0.00276
Kemp's Ridley turtle	December	0.19854
Leatherback turtle	September	0.00017
Loggerhead turtle – Northwest Atlantic Ocean DPS	December	0.05006

km^2=square kilometers.

Total Ensonified Area for ESA-listed Sea Turtles

The number of sea turtles that can be exposed to the sounds from the airgun array on 1 or more occasions is estimated for the seismic survey area using expected seasonal density of animals in the area (Table 3). Summing exposures along the total distance of trackline yields the total exposures for each species for the proposed action of the 2 GI airguns for the seismic survey. As noted in Section 3, the seismic survey would consist of ~222 km (~138 mi) of trackline surveyed in one day, for a total of 1,704 km (~1,058.8 mi) of trackline (including endcaps of each trackline) over the 7-day seismic survey. DOE and UT's model to determine radial distances from the airguns to the 175 dB re 1 µPa [rms] behavioral disturbance threshold for sea turtles is shown in Table 4.

Table 4. Predicted Distances to Received Sound Level of 175 dB re 1 µPa (rms) from 2 GI Airguns for Sea Turtles during the Proposed Seismic Survey

Source	Volume (in^3)	Water Depth (m)	Distance to 175 dB re 1 µPa (rms) Threshold (m)
2 GI airguns	210	< 100 m	284

dB re 1 µPa=decibels referenced to a pressure of one microPascal; rms=root mean square; in^3=cubed inches; m=meters

The total ensonified area for the 175 dB re 1 µPa [rms] sea turtle behavioral disturbance threshold for the seismic survey tracklines is estimated to be approximately 1,263 km^2 (~487.6 mi^2). This area was calculated by using the radial distances from the airguns to the predicted isopleths corresponding to the 175 dB re 1 µPa (rms) threshold (Table 4), along both sides of a trackline that could be surveyed in 1 day (~222 km [~138 mi]), plus the endcaps to the start and end of the trackline (the area of a half circle). The daily ensonified area is multiplied by the total number of survey days (7 days). This provides an estimate of the total area (km^2) expected to be ensonified to the behavioral disturbance thresholds for sea turtles (Table 5).

Table 5. 175 dB re 1 µPa (rms) Harassment Isopleths, Trackline Distance, Ensonified Area, Number of Survey Days, and Total Ensonified Areas During the Department of Energy and University of Texas at Austin's Seismic Survey off Texas

Threshold	Source	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Total Ensonified Area (km^2)*
175 dB re 1 µPa (rms)	2 GI Airguns	222	126.3	7	884.1

km=kilometers, km^2=square kilometers; dB re 1 µPa=decibels referenced to a pressure of one microPascal; rms=root mean square; GI=generator injector

* Including endcaps and accounting for overlap

In addition to the ensonified area noted above, DOE assessed the predicted distances to PTS and TTS thresholds for sea turtles (Table 6). Based on the small anticipated isopleths for PTS (ESA harm) and TTS, and in consideration of the conservation measures (i.e., exclusion and buffer zones, shutdown procedures, ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, and additional conservation measures), we do not expect injury, PTS, or TTS of ESA-listed sea turtles.

Table 6. Predicted Distances for Sea Turtles to Noise-Induced Hearing Loss Thresholds for the Department of Energy and University of Texas at Austin's Seismic Survey off Texas

Threshold	Source	Distance to Threshold (m)
PTS: SPL_{peak} 232 dB	2 GI Airguns	1
TTS: SPL_{peak} 226 dB	2 GI Airguns	2

m=meters; SPL_{peak}=peak sound pressure level; dB=decibels; GI=generator injector

Sea Turtle Exposures as a Percentage of Population

Adult, juvenile, and post-hatchling North Atlantic DPS of green, Kemp's ridley, and Northwest Atlantic Ocean DPS of loggerhead, and adult and juvenile leatherback sea turtles are likely to be exposed during the seismic survey activities. Given that the seismic survey will be conducted in the fall, we expect that most animals would be foraging. All sea turtle species are expected to be feeding, traveling, or migrating in the action area but no females are expected to be nesting. Because the seismic survey will not occur during sea turtle nesting season, we assume that the sex distribution is even for the North Atlantic DPS of green, Kemp's ridley, leatherback, and Northwest Atlantic Ocean DPS of loggerhead sea turtles, and sexes are exposed at a relatively equal level.

Table 7. Calculated Exposures for Endangered Species Act-Listed Sea Turtles during the Department of Energy and University of Texas at Austin's Seismic Survey off Texas

Species	Density (Individuals per km^2)	Total Ensonified Area (km^2)*	Calculated Exposures to Harassment (Rounded Exposures)
Green turtle – North Atlantic DPS	0.00276	884.1	2.4 (2)
Kemp's Ridley turtle	0.19854	884.1	175.5 (176)
Leatherback turtle	0.00017	884.1	0.2 (0)*
Loggerhead turtle – Northwest Atlantic Ocean DPS	0.05006	884.1	44.3 (44)

km^2=square kilometers

* Although calculated exposure is more than 0 (i.e., not discountable), due to the low density in the action area, constant movement of the research vessel and animals, and the short duration of the seismic survey, we do not expect exposure will rise to 1 individual

The exposure numbers by ESA harassment (Table 7) are expected to be conservative for multiple reasons. The number of exposures presented above represent the estimated number of instantaneous moments in which an individual from each species will be exposed to sound fields from seismic survey activities at or above the behavioral disturbance threshold. While the exposures do not necessarily represent individual sea turtles, the overall exposure is relatively low compared to the abundance of each sea turtle population that may occur within the action area. Given this, we expect that most sea turtles will not be exposed more than once, meaning the exposure numbers likely represent individual animals. As for the duration of each instance of exposure estimated, we were unable to produce estimates specific to the proposed action due to the temporal and spatial uncertainty of the research vessel and sea turtles within the action area. However, all the exposures are expected to be less than a single day due to the movement of the research vessel and animals. Sea turtles are also expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures by ESA harassment. However, the extent to which sea turtles would move away from the sound source is difficult to quantify and is not accounted for in the exposure estimates. Finally, these exposure estimates do not account for conservation measures (i.e., exclusion and buffer zones, vessel-based visual monitoring, shutdown procedures) that will be implemented as part of the proposed action and may avoid or reduce exposure. Thus, exposure numbers are conservative estimates of the number of individuals that will be exposed.

Green Turtle – North Atlantic DPS – The estimated exposure of the regional population (a minimum of 167,424 nesting females for the North Atlantic DPS) of green turtle is a total of 2 individuals to behavioral harassment, which is approximately 0.00001% of the regional population.

Kemp's Ridley Turtle – The estimated exposure of Kemp's ridley turtles (regional population abundance unknown) is 176 individuals to behavioral harassment.

Leatherback Turtle – The estimated exposure of leatherback turtles (regional population abundance unknown) is 0 individuals to behavioral harassment.

Loggerhead Turtle – Northwest Atlantic Ocean DPS – The estimated exposure of the Northwest Atlantic Ocean DPS (population abundance unknown) of loggerhead turtle is 44 individuals to behavioral harassment.

10.3 Response Analysis

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, including ESA-listed sea turtles considered in this consultation. 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 effects on prey of ESA-listed sea turtles in the action area that would then affect the listed species.

As discussed in the Assessment Framework (Section 2) of this consultation, response analyses determine how ESA-listed resources are likely to respond after exposure to stressors from an action that causes changes to the environment or acts directly on ESA-listed species. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences.

During the proposed action, ESA-listed sea turtles may be exposed to sound from the airguns. The DOE and UT provided estimates of the expected number of ESA-listed sea turtles that could be exposed to received levels greater than or equal to 175 dB re 1 µPa (rms) from the airguns

(Section 10.2). Based on information presented in Sections 4.3 and 10.2, ESA-listed sea turtles exposed to these sound levels could be "taken" by ESA harassment.

10.3.1 Potential Response of Sea Turtles to Acoustic Sources

Acoustic Thresholds for Sea Turtles

If exposed to loud sounds, sea turtles may experience ESA harm and/or harrassment. For ESA harassment, NMFS has historically relied on a minimum acoustic threshold of 175 dB re 1 µPa (rms) for impulsive sound sources. These values are based on observations of behavioral disturbance in loggerhead and green sea turtles to seismic airguns (e.g., DeRuiter and Larbi Doukara 2012; McCauley et al. 2000b; O'hara and Wilcox 1990). For this action, we relied on this NMFS acoustic threshold to estimate the number of takes by behavioral harassment of ESA-listed sea turtles. Historically, we have considered TTS as a form of ESA harassment, whereas PTS is considered a form of ESA harm. The current TTS and PTS sea turtle thresholds use fish as a surrogate because few, if any, data are available to assess sea turtle hearing, let alone the precise sound levels that can result in TTS or PTS. The only study addressing sea turtle TTS was conducted by Moein et al. (1994) in which a loggerhead turtle experienced TTS upon multiple exposures to an airgun in a shallow water enclosure, but recovered full hearing sensitivity within 1 day. Salas et al. (2023) studied TTS in freshwater turtles in a tank, and found that turtles recovered between 1 h to 2 days.

We assume that sea turtles will not move towards a sound source that causes them stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sound sources (McCauley et al. 2000a; McCauley et al. 2000c; Moein et al. 1994; Nelms et al. 2016), 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 pulses from a seismic airgun array (Smultea and Holst 2003. For this reason, conservation measures will be implemented to limit sea turtle exposures to 100 m (~328 ft) or more from the sound source. Although the effectiveness of conservation measures is not fully understood, we do not expect any sea turtles present in the action area to be exposed to sound levels that will result in anything other than behavioral harassment. In addition, the constant movement of both the research vessel and the ESA-listed sea turtles in the action area (North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle), the short duration of exposure to loud sounds (because the research vessel is not expected to remain in any area where individual animals may concentrate for an extended period of time), and the small isopleths to PTS and TTS (1–2 m [3.3–6.6 ft]; Table 6), make TTS and PTS unlikely. Thus, we believe that take by ESA harassment via TTS and ESA harm (PTS) is unlikely and conclude that they will not occur.

Sea Turtles and Behavioral Responses

It is likely that sea turtles will experience behavioral responses in the form of avoidance. There is limited information available on sea turtle behavioral responses to airguns because of the difficulty in observing these responses in the wild; nevertheless, we present the best available information. Behavioral responses to human activity have been investigated in green and loggerhead (e.g., McCauley et al. 2000b; O'hara and Wilcox 1990), and leatherback, loggerhead, olive ridley, and 160 unidentified sea turtles hardshell species; Weir 2007. The work by O'Hara and Wilcox 1990 and McCauley et al. 2000b reported behavioral changes in sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re 1 µPa (rms) threshold for determining when sea turtles will be harassed due to sound exposure because, at and above this level, loggerhead turtles were observed exhibiting avoidance behavior, increased swimming speed, and erratic behavior. Loggerhead turtles have also been observed moving towards the surface upon exposure to an airgun Lenhardt 1994; Lenhardt et al. 1983. In contrast, loggerhead turtles resting at the ocean surface were observed to startle and dive as an active seismic source approached them, with the responses decreasing with increasing distance DeRuiter and Larbi Doukara 2012. However, some of these animals may have reacted to the vessel's presence rather than the sound source DeRuiter and Larbi Doukara 2012. Monitoring reports from seismic surveys show that some sea turtles move away from approaching airgun arrays, although sea turtles may approach active airgun arrays within 10 m (32.8 ft) with minor behavioral responses Holst et al. 2006; Holst and Smultea 2008; Holst et al. 2005; NMFS 2006, 2006h; Smultea et al. 2005.

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals, and that behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re 1 µPa (rms). If exposed at such sound levels, based on the available data, we anticipate some change in swimming patterns. Some sea turtles may approach the airguns, but we expect them to eventually turn away in order to avoid the active airgun array, or for shutdown procedures to take place if the turtle is within the exclusion zone. As such, we expect temporary displacement of exposed individuals from some portions of the action area during the seismic survey.

Sea Turtles and Masking

Relative to marine mammals, very little is known and there have been no quantitative data, on how masking affects sea turtles. Masking of sounds can interfere with important life functions such as finding prey, finding a mate, and avoiding predators. Nunny et al. (2005) suggested that sea turtles may use acoustic cues to identify appropriate nesting sites. Sea turtles hear best at low-frequencies (e.g., Dow Piniak et al. 2012b; Lavender et al. 2014); therefore, the potential masking noises fall within the turtles' hearing range. However, there are currently no data to show that sea turtles are affected by masking.

Sea Turtles and Physical or Physiological Effects

Direct evidence of seismic sound causing stress is lacking for sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a prey response Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Harris et al. 2018; Lima 1998; Romero 2004. As predators generally induce a stress response in their prey Dwyer 2004; Lopez 2001; Mateo 2007, we assume that sea turtles experience a stress response if exposed to loud sounds from airgun arrays. We expect that breeding adult females may experience a lower stress response. Female green, hawksbill, and loggerhead turtles appear to have a physiological mechanism to reduce or eliminate hormonal responses 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 approximately 175 dB re 1 µPa (rms), 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.

10.3.2 Potential Responses of Sea Turtle Prey to Acoustic Sources

Seismic surveys may have indirect, adverse effects on ESA-listed sea turtles by affecting their prey availability (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Prey includes fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, molluscs, and jellyfish. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed sea turtles. In a comprehensive review, Carroll et al. (2017) summarized the available information on the impacts seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed sea turtles is not available. Until more information specific to prey of the ESA-listed species considered in this opinion is available, we expect that prey (e.g., teleosts, zooplankton, cephalopods) of ESA-listed sea turtles considered in this consultation will react in manners similar to those fish and invertebrates described herein.

As for sea turtles, it is possible that seismic surveys can cause physical and physiological responses, including direct mortality, in fishes and invertebrates. In fishes, such responses appear to be highly variable and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Current data indicate that possible physical and physiological responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. For invertebrates, research is more limited, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality. In crustaceans and bivalves, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances. Furthermore, even within studies there may be differing results depending on what aspect of physiology one examines e.g., Fitzgibbon et al. 2017. In some cases, the discrepancies likely relate to differences in the contexts of the studies. For example, in a relatively uncontrolled field study, Parry et al. (2002) did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not. A more recent study by Day et al. (2017) found significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure. However, the increased mortality documented by Day et al. (2017) was not significantly different from the expected natural mortality. All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates that serve as prey may experience physical and physiological effects, including mortality, but, in most cases, such effects are only expected at relatively close distances to the sound source.

The prey of ESA-listed sea turtles may also exhibit behavioral responses if exposed to active seismic airguns. Based on the available data, as reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and others noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. Similarly, data on the behavioral response of invertebrates suggests some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. For example, a recent study by Charifi et al. (2017) found that oysters appear to close their valves in response to low frequency sinusoidal sounds. Day et al. (2017) recently found that, when exposed to seismic airgun array sounds, scallops exhibit behavioral responses such as flinching, but none of the observed behavioral responses were considered to be energetically costly. As with sea turtles, behavioral responses by fishes and invertebrates may also be associated with a stress response.

There has been research suggesting that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods (see Section 7.4). Given the results from the studies discussed in Section 7.4, it is difficult to assess the effects seismic airgun arrays may have on the instantaneous or long-term survivability of prey species that are exposed. However, the 1) small scale of the seismic survey relative to the Gulf of Mexico, 2) downward transmission of sound from the airguns towed at a depth of 6 m (19.7 ft), 3) the energy of the seismic survey (~3,441 cm^3 [210 in^3] versus 2,458.1 or 4,260.6 cm^3 [150–260 in^3]) proposed in this consultation, and 4) the depth at which the airguns will be towed (6 m or 19.7 ft) compared to the expected surface distribution of the prey species, suggests that any copepod directly exposed to the seismic airgun array would likely suffer less mortality than described by McCauley et al. 2017.

While the seismic survey may temporarily alter prey abundance in the action area, we expect such effects to be insignificant because of the high turnover rate of copepods and ocean circulation, which will minimize any effects.

Fish or invertebrate mortality may occur from exposure to airguns, but will be limited to close-range exposure to high amplitudes Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000c; McCauley et al. 2003b; 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. If fishes that are not within close range to the airgun array detect the sound and leave the area, it is because the sound is perceived as a threat or it causes some discomfort. We expect these fishes will return to the area once the disturbance abates. For example, a common response by fishes to airgun sound is a startle or distributional response, where fish react by changing orientation or swimming speed, or change their vertical distribution in the water column Davidsen et al. 2019; Fewtrell 2013a. During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper **(***Pagrus auratus*), and trevally (*Caranx ignobilis*) to generally exhibit startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures of the same individuals did not necessarily elicit a response Fewtrell 2013a. In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted that cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response; however, no behavioral startle response to the airgun was observed. Furthermore, both the Atlantic cod and saithe change swimming depth and horizontal position more frequently during airgun sound production Davidsen et al. 2019. We expect that, if fish detect a sound and perceive it as a threat or some other signal that induces them to leave the area, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort and will return to the area and be available as prey for sea turtles.

There are reports showing sub-lethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220–242 dB re 1 µPa) at close distances, with some cases of injury Booman et al. 1996; McCauley et al. 2003b. Effects from TTS were not found in whitefish at received levels of approximately 175 dB re 1 $\mu Pa^2 s$, but pike did show 10–15 dB of hearing loss with recovery within 1 day Popper et al. 2005. Caged pink snapper (*Pelates* spp.) have experienced PTS when exposed over 600 times to received sound levels of 165– 209 dB re 1 µPa peak-to-peak. Exposure to airguns at close range was found to produce balance issues in exposed fry Dalen and Knutsen 1986. Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups Payne 2009. Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re 1 µPa Falk and Lawrence 1973.

Startle responses were observed in rockfish at received airgun levels of 200 dB re 1 µPa 0-to-peak and alarm responses at greater than 177 dB re 1 µPa 0-to-peak Pearson et al. 1992. Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20–60 min after firing of the airgun ceased. A downward shift was also noted by Skalski et al. 1992 at received seismic sounds of 186–191 dB re 1 µPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days Skalski 1992. These fish also showed a startle response when the seismic survey vessel was as much as 2.5 km (1.3 NM) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about 2 h following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re 1 µPa 0-to-peak sound from airguns, but habituated to the sound after 1 h 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 sounds from airguns Dalen and Knutsen 1986. Hake (*Merluccius* spp.) may re-distribute downward La Bella et al. 1996. Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source Hassel et al. 2003; Hassel et al. 2004.

McCauley et al. 2000; 2000a found small 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 µPa (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 (*Pollachius* spp.) did not respond to sounds from airguns received at 195–218 dB re 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible Wardle et al. 2001. Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20–50 m (65.6–164 ft) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found Slotte et al. 2004. Startle responses were infrequently observed in salmonids receiving 142–186 dB re 1 µPa peak-to-peak sound levels from an airgun Thomsen 2002. Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) 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-to-peak 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 in fish, 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-to-peak 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. 1996 found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Squid are important prey for some sea turtle species. Squid responses to operating 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 µPa (rms) by first ejecting ink and then moving rapidly away from the area Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000c. 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 µPa (rms). Moriyasu et al. (2004) summarized published and unpublished data by Norris and Mohl (1983), which observed lethal effects in squid (*Loligo vulgaris*) at levels of

246–252 dB after 3–11 min. Andre et al. (2011) exposed 4 cephalopod species (*Loligo vulgaris, Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to 2 hours of continuous sound from 50–400 Hz at 157 ± 5 dB re 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ± 5 dB re 1 µPa, with peak levels at 175 dB re 1 µPa. Guerra et al. 2004 suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems up to 8 months post-exposure to airguns fired at 202–227 dB peak-to-peak pressure Christian 2013; Payne et al. 2013. However, feeding did increase for up to a month after exposure to the airguns Christian 2013; Payne et al. 2013.

In summary, the anticipated response of fishes and squids to sound from airguns is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. Based upon the best available information, prey species located within the sound fields corresponding to the approximate 175 dB re 1 µPa (rms) isopleth could vacate the area and/or dive to greater depths. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed sea turtles to reach a measurable level. Effects are likely to be temporary and, if displaced, both sea turtles and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

Based on the best available data, we anticipate seismic survey activities will result in temporary and minor reductions in the availability of prey for ESA-listed sea turtles near the airguns during and immediately following the use of active seismic sound sources. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. However, we do not expect this to have a meaningful impact on ESA-listed sea turtles in the action area. As described above, we believe that, in most cases, ESA-listed sea turtles will avoid closely approaching the airgun array when it is active, and will not likely be in areas where prey could be temporarily displaced or otherwise affected.

10.4 Summary of Effects

We expect up to 2 green turtles (North Atlantic DPS), 176 Kemp’s ridley turtles, and 44 Northwest Atlantic Ocean DPS of loggerhead turtles to be exposed to the airgun array within the 175 dB re 1 µPa (rms) ensonified areas during the seismic survey and exhibit responses in the form of ESA behavioral harassment.

Because of the nature of the seismic survey, as described above, we do not expect any injury or mortality to ESA-listed species from the exposure to the acoustic sources resulting from the proposed action. The proposed action will result in temporary effects including behavioral responses (e.g., avoidance, discomfort, and stress) to the exposed sea turtles (North Atlantic DPS of green turtle, Kemp’s ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle). Harassment is not expected to have more than short-term effects on individual ESA-listed sea turtles. Because of the large ranges of the affected ESA-listed sea turtles compared to the relatively small size of the portion of the action area where seismic surveys will occur, combined with the relatively short duration of the seismic survey activities, there may be multiple exposures of a small number of individuals in the action area.

The estimates of the number of individuals exhibiting measureable behavioral responses are considered conservative (i.e., they are likely higher than what the actual exposures would be and a lower number are likely to be harassed given the conservation measures that will be implemented).

11 CUMULATIVE EFFECTS

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

We expect that stressors described in the Environmental Baseline (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, sea turtle harvesting, fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, hydrocarbons, and anthropogenic sound), aquatic nuisance species, and scientific research activities to continue into the future for ESA-listed sea turtles. Many of these activities will require ESA consultation because they have a Federal nexus and are not part of our consideration of cumulative effects for this reason.

Because of recent trends and based on available information, we expect the amount and frequency of vessel activity to persist in the action area, and that ESA-listed sea turtles will continue to be affected. Different aspects of vessel activity can affect ESA-listed species, such as vessel noise, disturbance, and the risk of vessel strike causing injury or mortality. However, movement towards bycatch reduction and greater protections (e.g., use of TEDs) are generally occurring throughout the Gulf of Mexico and may continue to aid in abating the downward trajectory of some populations due to activities such as fishing in the action area.

During this consultation, we searched for information on future state, tribal, local or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area. We are not aware of any state, tribal, or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the Environmental Baseline of this consultation.

The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed sea turtles. Thus, this consultation assumed effects in the future would be similar to those in the past and are reflected in the anticipated trends described in the Status of the Species Likely to be Adversely Affected and Environmental Baseline, respectively.

12 INTEGRATION AND SYNTHESIS

The Integration and Synthesis is the final step in our assessment of the risk posed to species and their designated critical habitat because of implementing the proposed action. In this section, we add the Effects of the Action (Section 10) to the Environmental Baseline (Section 9) and the Cumulative Effects (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the Status of the Species Likely to be Adversely Affected (Section 8).

12.1 Jeopardy Analysis

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

Based on our effects analysis, adverse effects to ESA-listed sea turtles are likely to result from the proposed action. The following discussions summarize the probable risks that stressors resulting from the proposed action (specifically sound from seismic airguns) pose to ESA-listed sea turtles. These summaries integrate our exposure and response analyses from the Effects of the Actions (Section 10).

12.2 Green Turtle – North Atlantic Distinct Population Segment

Adult, juvenile, and post-hatchling North Atlantic DPS of green turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

Once abundant in tropical and subtropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation for food and other products. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, and trawl fisheries kill thousands of green turtles annually. Other threats include pollution, habitat loss through coastal development or stabilization, destruction of nesting habitat from storm events, artificial lighting, poaching, global climate change, natural predation, disease, cold-stunning events, and oil spills.

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population's decline. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS of green turtle appears to be somewhat resilient to future perturbations.

For the North Atlantic DPS of green turtle the available data indicate an increasing trend in nesting. There is no reliable estimates of population growth rate of the North Atlantic DPS as a whole, but estimates have been developed at a localized level. Apparent increases in nesting turtle abundance for the North Atlantic DPS of green turtle in recent years are encouraging, but must be viewed cautiously, as the datasets represent a fraction of green turtle generation, up to approximately 50 years.

No reduction in the distribution of North Atlantic DPS of green turtles from the Atlantic Ocean (northwestern Gulf of Mexico) is expected because of the DOE and UT's seismic survey.

No reduction in numbers is anticipated as part of the proposed action. Therefore, no reduction in reproduction is expected as a result of the proposed action. Non-lethal take of 2 individuals from the North Atlantic DPS of green turtles, which could be adults and/or juveniles, is expected as a result of the proposed seismic survey activities. Density data were not were not available to quantify the number of exposures for small sea turtles (< 30–40 cm [11.8–15.7 in]). Any small sea turtle found within an ensonified area of 884.1 km^2 (341.4 mi^2) is expected to be taken in the form of harassment. We anticipate temporary behavioral responses (e.g., temporary displacement and stress), and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction or the distribution of North Atlantic DPS of green turtles as a result of the proposed seismic survey, a reduction in the species' likelihood of survival is not expected.

The Recovery Plan for the U.S. Atlantic population of green turtle lists recovery objectives for the species (NMFS and USFWS 1991). The following recovery criteria and recovery actions are relevant to the impacts of the proposed actions:

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.
- Determine distribution and seasonal movements for all life stages in marine environment.
- Reduce threat to population and foraging habitat from marine pollution.

Because no mortalities or effects on the abundance, distribution, and reproduction of North Atlantic DPS of green turtle populations are expected, we do not anticipate that the proposed seismic survey will impede any recovery objectives for North Atlantic DPS of green turtles. In conclusion, we believe the effects associated with the proposed action are not expected to appreciably reduce the likelihood of survival and recovery of North Atlantic DPS of green turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

12.3 Kemp's Ridley Turtle

Adult, juvenile, and post-hatchling Kemp's ridley turtles are present in the action area and may be exposed and respond to noise from the seismic survey activities.

Kemp's ridley turtles face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (plastics, petroleum products, petrochemicals, etc.) ecosystem alterations (nesting beach development, beach nourishment and shoreline stabilization, vegetation changes, etc.), poaching, global climate change, fisheries interactions, natural predation, and disease.

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles from May through August, and, in 1990, the harvest of all sea turtles was prohibited by presidential decrees in Mexico. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program resulted in re-establishment of nesting on Texas beaches. While fisheries bycatch remains a threat, the use of sea turtle excluder devices mitigates take. Fishery interactions and strandings appear to be the main threats to the species. The Deepwater Horizon oil spill event reduced nesting abundance and associated hatchling production as well as exposures to oil in the oceanic environment which has resulted in large losses of the population across various age classes, and likely had an important population-level effect on the species. Kemp's ridley turtles in the area of the Deepwater Horizon oil spill event may also have been affected by prior environmental and prey conditions (e.g., Gallaway et al. 2016a; Gallaway et al. 2016b; Plotkin 2016). However, we do not have an understanding of those impacts on the population trajectory for the species into the future. The species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

Of the sea turtle species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) has fluctuated since the mid-1900's, from a low of approximately 300 nesting females in the mid-1980's to a high to 21,797 nesting females in 2012 (NPS 2013. The number of nests in Padre Island, Texas has increased over the past 2 decades, with 119 in 2014; however, recent increases in nest count are not expected to continue (NMFS and USFWS 2015).

No reduction in the distribution of Kemp's ridley turtles from the Atlantic Ocean (northwestern Gulf of Mexico) or changes to the geographic range of the species are expected because of the DOE and UT's seismic survey.

No reduction in numbers is anticipated as part of the proposed action. Therefore, no reduction in reproduction is expected because of the proposed action. Non-lethal take of 176 individuals, which could be adults and/or juveniles, is expected because of the seismic survey. Density data were not were not available to quantify the number of exposures for small sea turtles (< 30–40 cm [11.8–15.7 in]). Any small sea turtle found within an ensonified area of 884.1 km^2 (341.4 mi^2) are expected to be taken in the form of harassment. We anticipate ESA behavioral harassment, which will include temporary behavioral and physiological responses (e.g., temporary displacement and stress). We do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Kemp's ridley turtles or a change in their distribution due to the seismic survey, a reduction in the species' likelihood of survival is not expected.

The Bi-National (U.S. and Mexico) Recovery Plan for populations of Kemp's ridley turtle lists recovery objectives for the species (NMFS et al. 2011a). The following recovery criteria and recovery actions are relevant to the impacts of the proposed actions:

- Protect and manage populations in the marine environment.
- Maintain and develop local, state, and national government partnerships.

Because no mortalities or effects on the abundance, distribution, and reproduction of Kemp's ridley turtle populations are expected, we do not anticipate the seismic survey will impede any recovery objectives for Kemp's ridley turtles. In conclusion, we believe the non-lethal effects associated with the proposed action will not appreciably reduce the likelihood of survival and recovery of Kemp's ridley turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

12.4 Leatherback Turtle

Adult and juvenile leatherback turtles are present in the action area and may be exposed and respond to noise from the seismic survey. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The status of the subpopulations in the Atlantic, Indian, and Pacific Oceans are generally declining, except for the subpopulation in the Southwest Atlantic Ocean, which is slightly increasing. Leatherback turtles show a lesser degree of nest site fidelity than occurs with hardshell sea turtle species.

The primary threats to leatherback turtles include fisheries interactions (bycatch), harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, vegetation changes, sand extraction, beach nourishment, shoreline stabilization, and natural disasters (e.g., storm events and tsunamis) as well as cold-stunning, vessel interaction, pollution (contaminants, marine debris and plastics, petroleum products, petrochemicals), ghost fishing gear, natural predation, parasites, and disease. Artificial lights on or adjacent to nesting beaches alter nesting adult female behavior and are often fatal to post-nesting females and emerging hatchlings as they are drawn to light sources and away from the sea. Ingestion of marine debris (plastic) is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex) and nest success, range (through expansion of foraging habitat as well as alter spatial and temporal patterns), and habitat (through the loss of nesting beaches, because of sea-level rise and storms). Oceanographic regime shifts possibly impact foraging conditions that may affect nesting female size, clutch size, and egg size of populations. The species' resilience to additional perturbation is low.

Detailed population structure is unknown, but is likely dependent upon nesting beach location and influenced by physical barriers (i.e., landmasses), current systems, and long migrations. Based on estimates calculated from nesting data, there are approximately 20,659 total adult leatherback turtles in the Northwest Atlantic Ocean (NMFS 2020b). The North Atlantic estimate of nesting leatherback turtles is the most likely to represent the portion of the population with animals that could be exposed to the proposed seismic survey. The total index of nesting female abundance is likely an underestimate because we did not have adequate data from many nesting beaches, which have the potential for being unmonitored or unidentified.

Population growth rates for leatherback turtles vary by ocean basin. Leatherback turtles in the Northwest Atlantic Ocean exhibit a decreasing nest trend at nesting beaches with the greatest known nesting female abundance. This decline has become more pronounced (2008 through 2017), and the available nest data reflect a steady decline for more than a decade (Eckert and Mitchell 2018b). Despite intense conservation efforts, the decline in nesting has not been reversed as of 2011 (Benson et al. 2015).

No reduction in the distribution of leatherback turtles from the Atlantic Ocean (northwestern Gulf of Mexico) or changes to the geographic range of the species are expected because of the DOE and UT's seismic survey.

No reduction in numbers is anticipated as part of the proposed action. Therefore, no reduction in reproduction is expected because of the proposed action. Although leatherbacks could experience adverse affects (Section 10), due to the low estimated exposure (Table 7), the continuous movement of the research vessel and animals, and the short duration of the seismic survey (7 days), we do not believe that take by harassment is reasonably certain to occur. Therefore, non-lethal take of 0 individuals is expected because of the seismic survey activities. We do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of leatherback turtles or a change in distribution due to the seismic survey, a reduction in the species' likelihood of survival is not expected.

The Recovery Plan for the U.S. Caribbean, Atlantic, and Gulf of Mexico population of leatherback turtle lists recovery objectives for the species (NMFS and USFWS 1992). The following recovery criteria and recovery actions are relevant to the impacts of the proposed actions:

- Prevent degradation of coastal habitat from industrial and sewage effluents.
- Protect and manage populations in the marine environment.

Because no mortalities or effects on the abundance, distribution, and reproduction of leatherback turtle populations are expected because of the proposed action, we do not anticipate the seismic survey will impede any recovery objectives for leatherback turtles. In conclusion, we believe the non-lethal effects associated with the proposed action will not appreciably reduce the likelihood of survival and recovery of leatherback turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

12.5 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment

Adult, juvenile, and post-hatchling Northwest Atlantic Ocean DPS of loggerhead turtles are present in the action area and may be exposed and respond to noise from the seismic survey activities.

Based on the currently available information, NMFS categorizes the Northwest Atlantic Ocean DPS of loggerhead turtle population trend as being stable (NMFS 2017). Due to declines in nest counts at index beaches in the U.S. and Mexico, and continued mortality of juveniles and adults from fishery bycatch, the Northwest Atlantic Ocean DPS of loggerhead turtle is at risk and likely to decline in the foreseeable future (Conant et al. 2009a). Other threats include pollution (contaminants) and impacts from climate change (nesting beaches).

A number of stock assessment and similar reviews have examined the status of loggerhead turtles in the Atlantic Ocean, but none have developed a reliable estimate of absolute population size (Conant et al. 2009b; Heppell et al. 2003a; NMFS-SEFSC 2001, 2009; NMFS 2008; TEWG 1998, 2000, 2009). It is difficult to estimate overall abundance for sea turtle populations because individuals spend most of their time in water, where they are difficult to count, especially considering their large range and use of many different and distant habitats. Females, however, converge on their natal beaches to lay eggs, and nests are easily counted. The total number of annual U.S. nest counts for the Northwest Atlantic DPS of loggerhead sea turtles is over 110,000 (NMFS and USFWS 2023).

In-water estimates of abundance that include juvenile and adult life stages of loggerhead males and females are difficult to perform on a wide scale. In the summer of 2010, NMFS's NEFSC and SEFSC estimated the abundance of juvenile and adult loggerhead sea turtles along the continental shelf between Cape Canaveral, Florida and the mouth of the Gulf of St. Lawrence, Canada, based on AMAPPS aerial line-transect sighting survey and satellite tagged loggerheads (NMFS 2011). They provided a preliminary regional abundance estimate of 588,000 individuals (approximate inter-quartile range of 382,000–817,000) based on positively identified loggerhead sightings (NMFS 2011). A separate, smaller aerial survey, conducted in the southern portion of the Mid-Atlantic Bight and Chesapeake Bay in 2011 and 2012, demonstrated uncorrected loggerhead sea turtle abundance ranging from a spring high of 27,508 to a fall low of 3,005 loggerheads (NMFS and USFWS 2023). We are not aware of any current range-wide in-water estimates for the DPS.

No reduction in the distribution of Northwest Atlantic Ocean DPS of loggerhead turtles from the Northwest Atlantic Ocean (northwestern Gulf of Mexico) or changes to the geographic range of the species are expected because of the DOE and UT's seismic survey.

No reduction in numbers is anticipated as part of the proposed action. Therefore, no reduction in reproduction is expected because of the proposed action. Non-lethal take of 44 individuals, which could be adults and/or juveniles, is expected because of the seismic survey. Density data were not were not available to quantify the number of exposures for small sea turtles (< 30–40 cm [11.8–15.7 in]). Any small sea turtle found within an ensonified area of 884.1 km^2 (341.4 mi^2) are expected to be taken in the form of harassment. We anticipate ESA behavioral harassment, which will include temporary behavioral responses (e.g., temporary displacement and stress). We do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Northwest Atlantic Ocean DPS of loggerhead turtles or a change in distribution due to the seismic survey, a reduction in the species' likelihood of survival is not expected.

The Recovery Plan for the Northwest Atlantic population of loggerhead turtle lists recovery objectives for the species (NMFS and USFWS 2008a). The following recovery criteria and recovery actions are relevant to the impacts of the proposed actions:

- Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
- Manage sufficient feeding, migratory, and interesting marine habitats to ensure successful growth and reproduction.
- Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
- Minimize marine debris ingestion and entanglement.
- Minimize vessel strike mortality.

Because no mortalities or effects on the abundance, distribution, and reproduction of Northwest Atlantic Ocean DPS of loggerhead turtle populations are expected as a result of the proposed action, we do not anticipate the seismic survey will impede any recovery objectives for Northwest Atlantic Ocean DPS of loggerhead turtles. In conclusion, we believe the non-lethal effects associated with the proposed action will not appreciably reduce the likelihood of survival and recovery of Northwest Atlantic Ocean DPS Of loggerhead turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of the North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle.

It is also NMFS's biological opinion that the proposed action is not likely to adversely affect the hawksbill turtle, giant manta ray, oceanic whitetip shark, or the designated critical habitat of the Northwest Atlantic Ocean DPS of loggerhead turtle.

14 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of threatened and endangered species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). "Harm" is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102). NMFS has not defined "harass" under the ESA in regulation. On May 1, 2023, NMFS adopted, as final, the previous interim guidance on the term "harass," defining it as to "create 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." For purposes of this consultation, we relied on NMFS's definition of harassment to evaluate when the seismic survey activities are likely to harass ESA-listed sea turtles.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 CFR §402.02). Section 7(o)(2) provides that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

ESA section 9 take prohibitions do not apply to threatened species without ESA section 4(d) rules as specified in ESA section 9(a)(1)(g). The ESA does not prohibit the take of threatened species unless special regulations have been promulgated, pursuant to section 4(d), to promote the conservation of the species. ESA section 4(d) rules have been promulgated for the North Atlantic DPS of green turtles and Northwest Atlantic Ocean DPS of loggerhead turtles; therefore, section 9 take prohibitions apply to all ESA-listed sea turtles that are likely to be adversely affected by the proposed action.

14.1 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 specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR

26832). We anticipate the seismic survey off Texas is likely to result in the incidental take of ESA-listed sea turtles by harassment (Table 8); behavioral harassment is expected to occur at received levels at or above 175 dB re 1 µPa (rms) for airgun operations for ESA-listed sea turtles.

Table 8. Estimated Amount of Incidental Take of Endangered Species Act-Listed Sea Turtles Anticipated Because of the Proposed Action off Texas

Species	Anticipated Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities
Green Turtle – North Atlantic DPS	2
Kemp’s Ridley Turtle	176
Leatherback Turtle	0*
Loggerhead Turtle – Northwest Atlantic Ocean DPS	44

DPS=distinct population segment

* No take of a species means an ITS is not required, but, in an abundance of caution, we are providing one that notes no take is anticipated. Reasonable and prudent measures, and terms and conditions, do not apply here.

14.2 Reasonable and Prudent Measures

“Reasonable and prudent measures” are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 C.F.R. §402.02). These actions “cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes” (50 CFR 402.14(i)(2)). The measures described below must be undertaken by the DOE so that they become binding conditions 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 ESA-listed species, we will issue a statement that specifies the impact of any incidental taking of threatened or endangered species. To minimize such impacts, RPMs, and terms and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified RPMs and terms and conditions identified in the ITS are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

We believe the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The DOE must implement a program that should be coordinated with UT to minimize and report the potential effects of seismic survey activities, as well as the effectiveness of conservation measures for the incidental taking of sea turtles (North Atlantic DPS of

green turtles, Kemp's ridley turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles).

14.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the Federal action agency (i.e., DOE) must comply (or must ensure that any applicant complies) with the following terms and conditions. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)).

The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the NMFS ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey. Send report to nmfs.hq.esa.consultations@noaa.gov, with the subject line, "DOE Gulf of Mexico Seismic Survey Draft Report". The report should also demonstrate how effects were minimized during the seismic survey, including what conservation measures were implemented, whether there were any changes to the conservation measures in order to implement them, any information regarding whether implementation of conservation measures minimized effects based on sightings of animals prompting implementation of conservation measures, the effectiveness of conservation measures, and any observed effects on sea turtles (North Atlantic DPS of green turtles, Kemp's ridley turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles).
2. Any reports of injured or dead ESA-listed species must be provided by the DOE to the NMFS ESA Interagency Cooperation Division by email at nmfs.hq.esa.consultations@noaa.gov. The subject line of the e-mail should include "DOE Gulf of Mexico Seismic Survey: Dead/Injured ESA-listed Species Report".

15 CONSERVATION RECOMMENDATIONS

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

We make the following discretionary conservation recommendations that we believe are consistent with this obligation and may be considered by the DOE in relation to their 7(a)(1) responsibilities. These recommendations will provide information for future consultations involving seismic surveys that may affect ESA-listed species.

1. We recommend that the DOE promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle species and their prey.
2. We recommend that the DOE develop or support a more robust propagation model that incorporates environmental variables into estimates of how far sound levels from the airguns will reach.
3. We recommend that the DOE model potential impacts to ESA-listed species, validate assumptions used when modeling the ensonified area from the airguns and any effects to ESA-listed species, through refinements of current models and use of other relevant models, and seek information and high quality data for use in such efforts.
4. We recommend that the DOE require a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities and in future seismic survey efforts.
5. We recommend the DOE use clinometers or geometers, such as those described in Hansen et al. 2020, to accurately measure lateral distances from the research vessel to ESA-listed species for potential implementation of mitigation measures (e.g., shutdown procedure).
6. We recommend the DOE work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across PSO reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.
7. We recommend the DOE submit their monitoring data (i.e., visual sightings) from PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
8. We recommend the research vessel operator and other relevant vessel personnel (e.g., crewmembers) on the research vessel take the U.S. Navy’s marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to PSOs.
9. We recommend the DOE require the vessel operator attempt to maintain a distance of 45 m (147.6 ft) or greater whenever possible from the research vessel, when ESA-listed sea turtles are visually sighted, as a vessel strike avoidance measure.

10. We recommend the DOE seismic survey activities actively avoid *Sargassum* mats or patches in designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle.
11. We recommend the DOE coordinate with government agencies (e.g., Bureau of Ocean Energy Management, NMFS, Southeast Fisheries Science Center, U.S. Navy), academic institutions, and/or the private sector that may be conducting long-term PAM and/or tagging studies to potentially determine responses of protected species and their prey from the seismic survey activities in the action area.
12. We recommend the DOE measure ambient noise levels in the survey area to help better understand the total ensonified area from acoustic sources (e.g., vessel noise, airgun array operations) from the seismic survey to determine the extent of the action area in future ESA section 7 consultations.

In order to be informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the DOE and UT should notify us of any conservation recommendations they implement in their final action.

16 REINITIATION NOTICE

This concludes formal consultation for the DOE and UT marine seismic survey in the Gulf of Mexico off Texas. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if:

1. The amount or extent of taking specified in the ITS is exceeded;
2. New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered;
3. The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion; or
4. A new species is listed or critical habitat designated under the ESA that may be affected by the identified action.

If the total distance of tracklines, location of tracklines, acoustic characteristics of the airguns, timing of the seismic survey, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species may be greater than estimated in the ITS of this opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

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