UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
https://www.fisheries.noaa.gov/region/southeast

09/29/2023

F/SER31:AB
SERO-2022-00967

Angela Dunn
Chief, Environmental Branch
Jacksonville District Corps of Engineers
Department of the Army
701 San Marco Blvd
Jacksonville, FL 32207

Dear Ms. Dunn:

Please find enclosed the final Biological Opinion (Opinion) for the U.S. Army Corps of Engineers' (USACE) proposal to implement the Lake Okeechobee System Operation Manual (LOSOM). The Opinion was prepared by the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.). The Opinion is based on information provided by the USACE and the published literature cited within. The Opinion considers the effects of the U.S. Army Corps of Engineers' (USACE) proposal to implement LOSOM in south Florida on the following listed species:

> green sea turtle (North Atlantic DPS), hawksbill sea turtles, Kemp's ridley sea turtles, leatherback sea turtles, loggerhead sea turtles (Northwest Atlantic DPS), giant manta rays, Nassau grouper, smalltooth sawfish (United States DPS), boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, and staghorn coral; and critical habitats: loggerhead sea turtle, smalltooth sawfish, elkhorn and staghorn coral, and 5 Caribbean corals (boulder star, lobed star, mountainous star, pillar, and rough cactus corals).

The USACE also conferenced with NMFS under ESA section 7(a)(4) on effects to queen conch, which is proposed for listing, and Nassau grouper critical habitat, which is proposed for designation. The conference was conducted following the procedures for formal consultation, and the conclusions reached are reflected within this Opinion.

NMFS received the USACE's Biological Assessment (BA) and request for consultation on April 15, 2022. Following receipt, our respective agencies held a number of follow-up meetings to discuss project details, the USACE's project effect determinations, and the project's action area. The USACE provided supplemental information regarding harmful algal blooms on August 23, 2022, and an updated BA on October 17, 2022. The USACE provided updated BAs on January 27, and February 13, 2023. NMFS initiated formal consultation on March 1, 2023, and provided a draft Opinion for the USACE's review on June 1, 2023. USACE provided comments on the draft Opinion on June 15 and 27, 2023. NMFS edited the Opinion and provided text for USACE review on July 28, 2023. The USACE provided another supplemental document on September 15, 2023, to clarify their view on the environmental baseline and their discretion in implementing LOSOM. All information provided by the USACE was considered during the development of this final Opinion.

NMFS concludes that the proposed action will have no effect on boulder star coral, elkhorn coral, lobed star coral, pillar coral, rough cactus coral and staghorn coral. NMFS similarly concludes the proposed action will have no effect on the critical habitats for loggerhead sea turtles, elkhorn and staghorn corals, boulder star coral, lobed star coral, pillar coral and rough cactus coral. NMFS concludes that the proposed action is not likely to adversely affect hawksbill and leatherback sea turtles, giant manta rays, Nassau grouper, smalltooth sawfish, mountainous star coral, queen conch (proposed), and critical habitats for smalltooth sawfish, Nassau grouper (proposed), and mountainous star coral. NMFS concludes that the proposed action is likely to adversely affect, but is not likely to jeopardize the continued existence of, green (NA DPS), Kemp's ridley, and loggerhead (NWA DPS) sea turtles.

NMFS is providing an Incidental Take Statement with this Opinion. The Incidental Take Statement describes Reasonable and Prudent Measures that NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The Incidental Take Statement also specifies Terms and Conditions, including monitoring and reporting requirements with which the USACE must comply to carry out the Reasonable and Prudent Measures and to ensure that any takings of listed sea turtles are not considered prohibited takings, pursuant to ESA section 7(o)(2).

We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered marine species and critical habitat. If you have any questions regarding this consultation, please contact Adam Brame, Consultation Biologist, by phone at 727-209-5958, or by email at Adam.Brame@noaa.gov.

Sincerely,

STRELCHECK.ANDREW.JAMES.1365863152
Digitally signed by STRELCHECK.ANDREW.JAMES.1365863152
Date: 2023.09.29 16:16:38 -04'00'

Andrew J. Strelcheck
Regional Administrator

Enclosure (s): NMFS Biological Opinion SERO-2022-00967
File: 1514-22.f.4

cc: Jacob Thompson (Jacob.S.Thompson@usace.army.mil)
Gretchen Ehlinger (Gretchen.S.Ehlinger@usace.army.mil)
Andrew LoSchaivo (Andrew.J.Loschiavo@usace.army.mil)
Eric Summa (Eric.P.Summa@usace.army.mil)

Endangered Species Act - Section 7 Consultation
Biological Opinion

Action Agency:	United States Army Corps of Engineers
Applicant:	United States Army Corps of Engineers
Activity:	Implementation of the Lake Okeechobee System Operation Manual (LOSOM)
Location:	Florida
Consulting Agency:	National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida NMFS Tracking Number: SER-2022-00967

Approved by:

STRELCHECK.ANDREW.JAMES.1365863152

Digitally signed by STRELCHECK.ANDREW.JAMES.1365863152
Date: 2023.09.29 16:16:58 -04'00'

Andrew J. Strelcheck, Regional Administrator
NMFS, Southeast Regional Office
St. Petersburg, Florida

Date Issued: 09/29/2023

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

ac	acre(s)
°C	degrees Celsius
C&SF	Central and Southern Florida
CERP	Comprehensive Everglades Restoration Plan
cfs	Cubic feet per second
CRE	Caloosahatchee River Estuary
CFR	Code of Federal Regulations
cm	centimeter(s)
DPS	Distinct Population Segment
EAA	Everglades Agricultural Area
ECO	Environmental Consultation Organizer
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENP	Everglades National Park
ESA	Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.)
°F	degrees Fahrenheit
ft	foot/feet
FR	Federal Register
ft^2	square foot/feet
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Florida Fish and Wildlife Research Institute
HAB	Harmful Algal Bloom
HHD	Herbert Hoover Dike
in	inch(es)
IPCC	Intergovernmental Panel on Climate Change
km	kilometer(s)
lin ft	linear foot/feet
LOK	Lake Okeechobee
LORS08	Lake Okeechobee Regulation Schedule (implemented in 2008)
LOSOM	Lake Okeechobee System Operation Manual
LWL	Lake Worth Lagoon
m	meter(s)
mi	mile(s)
mi^2	square mile(s)
MMPA	Marine Mammal Protection Act
MMF	Marine Megafauna Foundation
MSA	Magnuson-Stevens Fishery Conservation and Management Act
N/A	not applicable
NAD 83	North American Datum of 1983
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
Opinion	Biological Opinion, Conference Biological Opinion, or Draft Biological Opinion
PBF	Physical and Biological Feature
Q90	90th percentile
RECOVER	Restoration Coordination and Verification

SAV	Submerged Aquatic Vegetation
SCL	Straight Carapace Length
SERO PRD	NMFS Southeast Regional Office, Protected Resources Division
SFWMD	South Florida Water Management District
SLE	St. Lucie River Estuary
SSRIT	Smalltooth Sawfish Recovery Implementation Team
STA	Stormwater Treatment Areas
STL	Stretched total length
STSSN	Sea Turtle Stranding and Salvage Network
TED	Turtle Excluder Device
U.S.	United States of America
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WSM	Water Shortage Management
WTA	Water Conservation Areas

1 INTRODUCTION

1.1 Overview

Section 7(a)(2) of the ESA, requires that each federal agency ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. In this context, "jeopardize" means either a direct or indirect action that one could reasonably expect to appreciably reduce "…the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR § 402.02). Similarly, "destruction or adverse modification of critical habitat" means "…a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species" (50 CFR § 402.02)." Section 7(a)(2) requires federal agencies to consult with the appropriate Secretary in carrying out these responsibilities. The NMFS and the USFWS share responsibilities for administering the ESA. Consultations on most ESA-listed marine species and their critical habitat are conducted between the federal action agency and NMFS (hereafter, may also be referred to as we, us or, our).

Consultation is required when a federal action agency determines that a proposed action "may affect" ESA-listed species or critical habitat and can be conducted informally or formally. Informal consultation is concluded after NMFS issues a Letter of Concurrence that concludes that the action is "not likely to adversely affect" ESA-listed species or critical habitat. Formal consultation is concluded after we issue a Biological Opinion (hereafter, referred to as an/the Opinion) that identifies whether a proposed action is "likely to jeopardize the continued existence of an ESA-listed species" or "destroy or adversely modify critical habitat," in which case Reasonable and Prudent Alternatives to the action as proposed must be identified to avoid these outcomes. An Opinion often states the amount or extent of anticipated incidental take of ESA-listed species that may occur, develops Reasonable and Prudent Measures necessary to minimize the impacts, i.e., amount or extent, of the anticipated incidental take, and lists the Terms and Conditions to implement those measures. An Opinion may also develop Conservation Recommendations that help benefit ESA-listed species. For species and critical habitat proposed for listing, each federal agency shall confer on any agency action that is likely to jeopardize the continued existence of any species proposed for listing or result in the destruction or adverse modification of proposed critical habitat (ESA section 7(a)(4)). Federal agencies may also request a conference on any proposed action that may affect proposed species or proposed critical habitat. Federal action agencies may request that the conference be conducted following the procedures for formal consultation and, subject to our agreement, the conference may be conducted formally.

A formal conference results in a Conference Biological Opinion in the same format and with the same content as a Biological Opinion. The Conference Biological Opinion may be adopted as the biological opinion when the species is listed or critical habitat is designated, but only if no significant new information is developed (including that developed during the rulemaking process on the proposed listing or critical habitat designation) and no significant changes to the Federal action are made that would alter the content of the opinion. An Incidental Take

Statement provided with a conference opinion does not become effective unless we adopt the Opinion once the listing is final (50 CFR 402.10(d)).

This document represents NMFS's Opinion based on our review of potential effects of the USACE's proposal to carry out the Lake Okeechobee System Operating Manual (LOSOM), which regulates the release of water from the lake to the St. Lucie River and Caloosahatchee River estuaries, on the following listed species and critical habitats: green sea turtles (NA DPS), hawksbill sea turtles, Kemp's ridley sea turtles, leatherback sea turtles, loggerhead sea turtles (NWA DPS), giant manta rays, Nassau grouper, smalltooth sawfish (U.S. DPS), boulder star coral, elkhorn coral, lobed star coral, mountainous star coral, pillar coral, rough cactus coral, staghorn coral and critical habitat for loggerhead sea turtles, smalltooth sawfish, and staghorn and elkhorn corals. The Opinion also considers effects to the proposed queen conch, Nassau grouper critical habitat, and 5 Caribbean corals critical habitat. Our Opinion is based on information provided by the USACE, Florida Fish and Wildlife Conservation Commission (FWC), and the published literature cited within.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 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 two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions 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.

1.2 Consultation History

The following is the consultation history for NMFS ECO tracking number SERO-2022-00967, Lake Okeechobee System Operations Manual.

We received your letter and the corresponding Biological Assessment (BA) requesting consultation on April 15, 2022. We requested additional information in May and June of 2022. The USACE provided a supplemental document regarding harmful algal blooms (HABs) on August 23, 2022. NMFS provided comments on the USACE's draft Environmental Impact Statement associated with the National Environmental Policy Act on September 9, 2022, which led to a necessary update to the BA. The USACE provided the updated BA on October 17, 2022. On November 9 and 21, 2022, NMFS emailed the USACE and expressed concern over the effect determinations and the supporting rationale for those determinations. A call was held December 12, 2022, to discuss effect determinations and rationale. NMFS sent an additional email request on January 23, 2023 and the USACE sent an updated BA on January 27, 2023 in response. On February 9, 2023, we held another call to discuss the BA and lingering concerns over the action area as defined in the document. The USACE sent a revised BA on February 13, 2023. An additional virtual meeting was held February 16 in which project details were discussed and further clarification was requested. The requested information was provided by email on February 22, 2023. A final call with both NMFS and USACE leadership was held on February 24, 2023, to discuss the consultation pathway and estimated timeframes for completion. On March 1, 2023, NMFS sent an email to the USACE indicating that formal consultation would be necessary and that consultation was underway.

On May 22, 2023, the USACE formally requested a draft Biological Opinion, acknowledging this would require extending the previously agreed upon completion date of early June. A new completion date of August 30, 2023 was mutually agreed upon. The draft Opinion was provided on June 1, 2023, along with a request to provide any comments on the draft by June 16th. The Jacksonville District provided written comments in response to the draft Opinion on June 15th. The USACE South Atlantic Division provided additional comments on June 27th. Staff for both NMFS and USACE met on July 10th and July 20th to discuss the comments and develop an approach for addressing them. Proposed edits were shared with USACE staff and engagement continued through August 2023. The USACE provided a supplemental document on September 15, 2023, to clarify their view on the environmental baseline and discretion in implementation of the proposed project.

1.3 USACE Authority and Project Oversight

USACE only considers water quality when making water management decisions to the extent consistent with existing authority and appropriations (Engineer Regulation 1100-2-8154, Water Quality Management, May 31, 2018). Water quality authority in Florida has been delegated to the State of Florida, where the Florida Department of Environmental Protection regulates nutrient restrictions. This delegation includes regulation of non-point-source nutrient runoff to surface water, point-source discharges of nutrients to surface water, and enforcement of water quality standards. For purposes of lake management, the USACE does not obtain discharge permits for LOK releases as water transfers are expressly excluded from regulation under the National Pollutant Discharge Elimination System (NPDES) program (40 C.F.R. Sec. 122.3(i)). Thus, water transfers are not subject to oversight by State water resource management agencies and LOK releases are not considered pollutant discharges under the CWA. In addition the USACE is not explicitly directed by congress to manage water for nutrient control. Therefore, while the USACE controls the infrastructure to hold and release water, they are not the agency responsible for regulating nutrient inputs into the lake or nutrient outputs from the lake. Nevertheless, the effects of nutrients on the downstream estuaries would not occur but for the water releases described in the proposed action.

The lack of direct regulatory control of nutrients makes it difficult for the USACE to address any take of protected species that may result from water releases. NMFS fully understands the limitations of USACE authority but nevertheless must account for the proposed action’s effects on listed species that may occur in the action area.

2 PROPOSED ACTION

2.1 Project Details

2.1.1 Project Description

The USACE (action agency) intends to implement a new water control plan for Lake Okeechobee (LOK) and the Everglades Agricultural Area (EAA), commonly referred to as "LOSOM." The new regulation schedule for LOK provides operational criteria for water control structures that account for the completion of the Herbert Hoover Dike (HHD) rehabilitation and considers completed or near-complete Comprehensive Everglades Restoration Plan (CERP) projects as well as non-CERP foundation activities (activities that predate CERP that also factor into Everglades restoration). The proposed action does not include new construction and is strictly operational in nature.

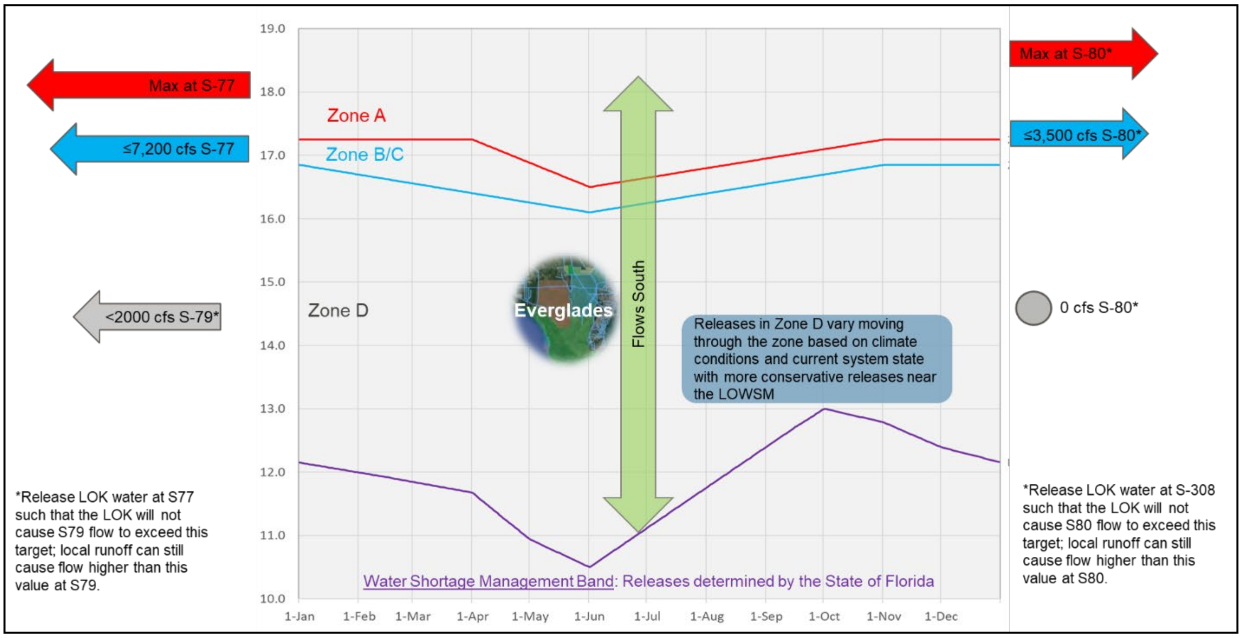
Since the development of structural works around LOK and within the EAA, the LOK stage and the quantity, timing, and duration of releases out of the lake have been heavily influenced by the active regulation schedule. The current Lake Okeechobee Regulation Schedule (LORS08) was completed in 2008 to improve lake and Northern Estuary (Caloosahatchee River and St. Lucie River estuaries) ecology and to reduce flood risk during rehabilitation of HHD. LOSOM is being developed to incorporate HHD rehabilitation and additional relevant projects since the last lake regulation schedule update.

The goal of LOSOM is to incorporate flexibility in LOK operations while balancing congressionally authorized project purposes, including flood control, water supply, navigation, enhancement of fish and wildlife resources, and recreation. The LOSOM project has four objectives:

1. Manage risk to public health and safety, life, and property, including risk associated with dam safety and algal blooms
2. Continue to meet authorized project purposes of navigation, recreation, and flood control
3. Improve water supply performance for the Seminole Tribe of Florida, Lake Okeechobee Service Area, and Lower East Coast Service Area
4. Enhance ecology in LOK, the Northern Estuaries and the South Florida ecosystem

There is a need to manage LOK stage and water releases to better balance achievement of LOSOM objectives and to incorporate critical flexibility into LOK operations. There is also a need to consider new science about the effects of water releases on downstream estuarine ecology and the effects of LOK stages on lake ecology. This new science will inform, for example, how LOSOM can achieve the project purpose of enhancement of fish and wildlife, and the study objective of managing risk to public health and safety, life, and property. In addition, there is a need to consider new Central and Southern Florida (C&SF) and state project features and updated technical information about the system's capability to send water south to the Stormwater Treatment Areas (STAs) and Water Conservation Areas (WCAs), as well as managing releases to the estuaries to better balance achievement of all project purposes and objectives.

LOSOM consists of four distinct operational zones that are based on lake stage (water level) and season (Figure 1). The schedule was modeled on two preferred alternatives (PA22 and PA25), the second of which accounts for the expected changes that will go into effect in 2025 when the C-43 reservoir becomes operational. Modelling considered water movement within Zone A, Zone BC, Zone D (modeled with 3 sub-zones), and the Water Shortage Management (WSM) Zone as shown in the figure 1 below. Additional details of LOSOM, beyond the discussion provided below, can be found in the Water Control Plan (https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/24343).



Releases in Zone D vary moving through the zone based on climate conditions and current system state with more conservative releases near the LOWSM

*Release LOK water at S77 such that the LOK will not cause S79 flow to exceed this target; local runoff can still cause flow higher than this value at S79.

*Release LOK water at S-308 such that the LOK will not cause S80 flow to exceed this target; local runoff can still cause flow higher than this value at S80.

Figure 1. Operational zones illustrated by lake stage (y-axis) and month (x-axis). Arrows on the right and left depict the direction and quantity of water releases to the east (via C-44 canal) and west (via the C-43 canal), respectively. The green arrow indicates water movement south to the Everglades.

The upper part of the LOSOM Regulation Schedule, Zones A and BC, represents the period where LOK releases are needed to lower lake stages to reduce HHD dam safety risk and reduce potential adverse impacts to the LOK littoral zone. Zone D is the largest zone in the LOSOM Regulation Schedule with a goal of optimizing beneficial uses of water across the system while minimizing the risk of entering the WSM Zone. The water management operations in Zone D are aimed at maintaining lake stages within Zone D and releases in this zone are primarily to supply desired releases from the lake, including up to 2,000 cubic feet per second (cfs) at S-79 and up to the maximum desirable south to the WCAs. The term “up to maximum desirable” is used to indicate the intent to send water south while acknowledging, and adjusting for, constraints and other needs within the system, such as local rainfall in the EAA, STA conditions as determined by South Florida Water Management District (SFWMD), regional water supply conditions, WCA conditions, downstream channel conditions, etc. The decisions on the quantity and timing of these Everglades-focused releases to the south will consider the current and projected water levels, climate forecasts, and conditions of the entire C&SF system to appropriately balance the entire system for all congressionally authorized project purposes. In the lower zone, the WSM

Zone, there are no defined releases from the lake, though SFWMD may request releases to allocate water supplies within the basin. The operational intent of this zone is to conserve water within LOK and release water as requested by SFWMD. The SFWMD manages water shortage restrictions in the LOK Region in accordance with the Water Shortage Plan as specified in Part III of Chapter 40E-22, Florida Administrative Code.

The determination of the operational zones relative to LOK stage is defined as a set of seasonally varying lines (i.e., “the schedule”) (Figure 1). When in Zone A, releases up to the maximum capacity will be made to the Caloosahatchee River Estuary [CRE] via C-43, the St. Lucie River Estuary [SLE] via C-44, the Lake Worth Lagoon [LWL] via C-51, and south to the WCAs to reduce lake stages as soon as practicable. When in Zone BC to reduce the risk of entering Zone A, releases to the estuaries could be up to 7,200 cfs to the CRE and up to 3,500 cfs to the SLE. Zone D does not send lake water to the SLE and limits flow rates to the CRE at up to 2,000 cfs as measured at S-79, below the stressful threshold of 2,100 cfs. Zone D allows for beneficial flows to the south and west along with beneficial flows to the LWL. There are no defined releases from the lake in the WSM Zone and District may request releases to meet water allocation needs.

As part of the proposed action, guidance for LOK Recovery Operations were developed. Recovery Operations can be utilized in Zone D to address ecological recovery from extreme high lake stages. The goal of lake recovery operations is to lower lake stages (referred to as a drawdown) to help expedite the reestablishment of submerged aquatic vegetation (SAV) within the lake. The desired result of Recovery Operations is to achieve a lake stage below 12.0 ft for 90 days (non-consecutive) between mid-April and mid-September or to recede below 11.5 ft for at least 60 days (non-consecutive) between May and August. This is based on the 2020 RECOVER criteria for returning to a normal ecological envelope. More detailed information about the LOK Recovery Operations can be found in the Final Water Control Plan (https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/24343).

Nutrient loads in LOK releases come from tributary flows and legacy nutrients in LOK. Regulation of nutrient input to LOK from the Kissimmee River and other tributaries including non-point source nutrient runoff and point source discharges of nutrients to surface waters, is the responsibility of the State of Florida. The USACE does not have general authority to implement pollution control measures for the C&SF Project, including LOK. Algal blooms in LOK are expected to continue until nutrient sources are reduced or eliminated. Even with a reduction of nutrient input into LOK, legacy nutrients within the lake sediment will continue to sustain algal blooms on LOK unless they are removed (Missimer et al. 2021).

In the Northern Estuaries (CRE and SLE), nutrient loading from upstream sources, including basin runoff and releases from LOK, may increase the risk of coastal algal bloom events, or play a role in the duration or severity of the events (Heil et al. 2014, Medina et al. 2020, Medina et al. 2022). In some cases, algae contain toxins that when released cause illness or mortality of fauna (Landsberg 2002). Red tide (*Karenia brevis*) is a toxic dinoflagellate that generally forms blooms offshore before prevailing wind and currents push these blooms to coastal areas (Steidinger and Haddad 1981, Weisberg et al. 2019). Red tide blooms are highly variable among and between years (Weisberg et al. 2019) but when pushed near shore land-based nutrients may further fuel bloom events. Releases from LOK can affect algal bloom risk in the Northern Estuaries by: 1) transporting a freshwater algal bloom from the lake through the structures and canals downstream to the estuary, 2) transporting additional nutrients and fresh water, some of the key components to an estuary bloom, via LOK releases; 3) changing salinity to make it more favorable to or discouraging freshwater algal species; and 4) creating stagnant water conditions and interfering with tidal flushing. While lake operational plans such as LOSOM cannot prevent algal blooms, USACE has several tools at its disposal to help manage algal blooms, including managing LOK stages and timing, volume, duration, and frequency of lake releases to the Northern Estuaries. Managing lake stages in advance of the summer months, when conditions are more favorable for algal blooms within the lake, can reduce the severity of algal blooms within LOK and reduce risk of algal mass delivery to the Northern Estuaries during summer months. However, lake stage also affects the authorized project purposes for LOK (flood control, water supply, navigation, enhancement of fish and wildlife, and recreation). Therefore, although USACE can consider water quality (including algal blooms) when making water management decisions, algal bloom risk cannot be the sole consideration because USACE must operate the project in accordance with its congressionally authorized purposes.

The USACE expects implementation of LOSOM will provide overall minor to moderate long-term beneficial effects to CRE and moderate to major long-term beneficial effects to SLE in terms of reducing algal bloom risk. The assumption is that reduced flows during peak algal bloom months from LOK to the Northern Estuaries will result in reduced transport of algal mass to the Northern Estuaries and improved salinity conditions less conducive for the occurrence of freshwater blooms. In addition, reduction in the number and duration of LOK releases at any time of the year results in a reduction of potential transport of the nutrients from LOK into the Northern Estuaries. The analysis of flows from LOK to the Northern Estuaries during peak algal bloom risk months for each estuary focuses on the potential to deliver algal mass to the estuaries.

LOSOM is expected to reduce mean annual lake releases to both the CRE and SLE as compared to the current operation schedule by 4% and 40%, respectively. During the summer months (June-August in CRE and May-August in SLE) when freshwater blooms are more likely, flows to CRE and SLE will be reduced by 23% and 65%, respectively. Reduction in the volume of LOK releases decreases the potential for freshwater algal bloom growth in the estuaries, particularly during peak algal bloom risk months. While minimizing lake releases to the Northern Estuaries, particularly during peak periods with high potential for lake algal blooms, would result in a corresponding reduction in direct nutrient loading from LOK, some nutrients will still enter the Northern Estuaries from the Lake and as a result of basin flow.

2.1.2 Mitigation Measures

While USACE does not have general authority to implement pollution control measures for the C&SF Project, it can incorporate operational methods to minimize nutrients and their effects on fish and wildlife. USACE can also consider water quality when making water management decisions. The USACE designed the Harmful Algal Bloom Operations decision process as a mitigation measure built into LOSOM to offset the potential impact of algal blooms in LOK on downstream water bodies. Through this decision process, the USACE will consider HABs and the risk of HABs in its operation of LOK within all zones of the schedule because HABs have become increasingly prevalent and intense in recent years in the lake and its outlets. The operation of LOK is the sole authority of USACE, but information and recommendations from federal and state agencies with water-quality regulation authority and expertise may make recommendations and supply information to help inform USACE decisions. The Florida Department of Environmental Protection (FDEP) provides a weekly update on freshwater algal blooms (https://floridadep.gov/AlgalBloomWeeklyUpdate) and also maintains an interactive map detailing sampling results (https://floridadep.gov/AlgalBloom). The Florida Wildlife Conservation Commission (FWCC) provides updates on saltwater algal blooms (https://myfwc.com/research/redtide/statewide/), while NOAA's Harmful Algal Bloom – Forecasting Branch monitors HABs via remote sensing technology (see Wynne et al. 2018). Water managers will consider all the available information on algal blooms in real time when determining when and how much to release from LOK, but USACE has operational flexibility to reduce or discontinue releases from LOK during HAB events. The decision to make or not make releases out of the lake based on HAB conditions is unique each time. USACE must weigh the risks of reducing or discontinuing releases against risks associated with HABs.

2.2 Action Area

The action area is defined by regulation as all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this federal action, the action area includes the entire C&SF watershed area from the headwaters of the Kissimmee River down to and through Florida Bay and the Keys, including LOK, the CRE, the SLE, LWL, the Greater Everglades, and Southern Coastal Systems (Florida Bay and Biscayne Bay). Water originates in the northern part of the watershed—which includes the Kissimmee Chain of Lakes, northern Kissimmee River, and Lake Istokpoga—and flows south into LOK primarily from the Kissimmee River, Fisheating Creek, the Istokpoga basin, and Taylor Creek and Nubbin Slough. Water is released from the lake east through the St. Lucie Canal (C-44) into the SLE, west through the Caloosahatchee River (C-43) into the CRE, and south through four major canals in the Everglades Agricultural Area (EAA) into LWL, WCAs, and ultimately to Everglades National Park (ENP), the Southern Estuaries (Florida Bay and Biscayne Bay), and the Lower East Coast. Therefore, the action area includes all of the aforementioned water bodies that water passes through after being released from LOK, which includes inshore and nearshore waters of CRE and SLE given the volume of water released in those watersheds (Figure 2).

The USACE did not provide a clearly defined action area illustrating how far seaward project effects may extend, thus complicating our assessment. Given our knowledge of indirect downstream effects associated with water releases we expect that mixing of waters may extend seaward from the primary estuaries to which LOK waters will be released. USACE did not model the movements of LOK waters and associated nutrients beyond the barrier islands associated with each estuary. Based on the limited modeling provided in the Biological Assessment, and the USACE's coral analysis that considered possible effects to the St. Lucie Reef located approximately 1 mile from the SLE, the action area includes all inshore waters and nearshore waters out to 1 mile from the two major estuaries (CRE and SLE). In the Biological Assessment, the USACE describes the LOSOM action area for turtles as including "…the Gulf beaches on the west side of Estero Island, Sanibel Island, Captiva Island, and Gasparilla Island, along Bunche Beach, the west side of Cayo Costa State Park, and the northern edge of Pine Island beach" for the CRE and "…the Atlantic beaches on the east side of the SIRL [South Indian River Lagoon], and on the east side of St. Lucie Inlet State Park and Hobe Sound National Wildlife Refuge" for the SLE. This description suggests potential offshore impacts from LOK releases near CRE from Estero Beach (26.4°N) to Gasparilla Island (26.8°N) and off SLE, from Hobe Sound (27.1°N) to SIRL (approximately 27.4°N). Thus, we establish those boundaries for the action area to the north and south on both coasts, out to 1 nautical mile from shore. This action area accounts for the variability of currents and circulation patterns within and at the mouth of each of the estuaries along with the potential of LOK nutrients to enhance existing nearshore red tide events, as discussed below. While areas like LWL, Biscayne Bay, and Florida Bay will also receive releases from LOK, the quantity will be less than that delivered to the two primary estuaries and thus effects are not anticipated offshore of these areas.

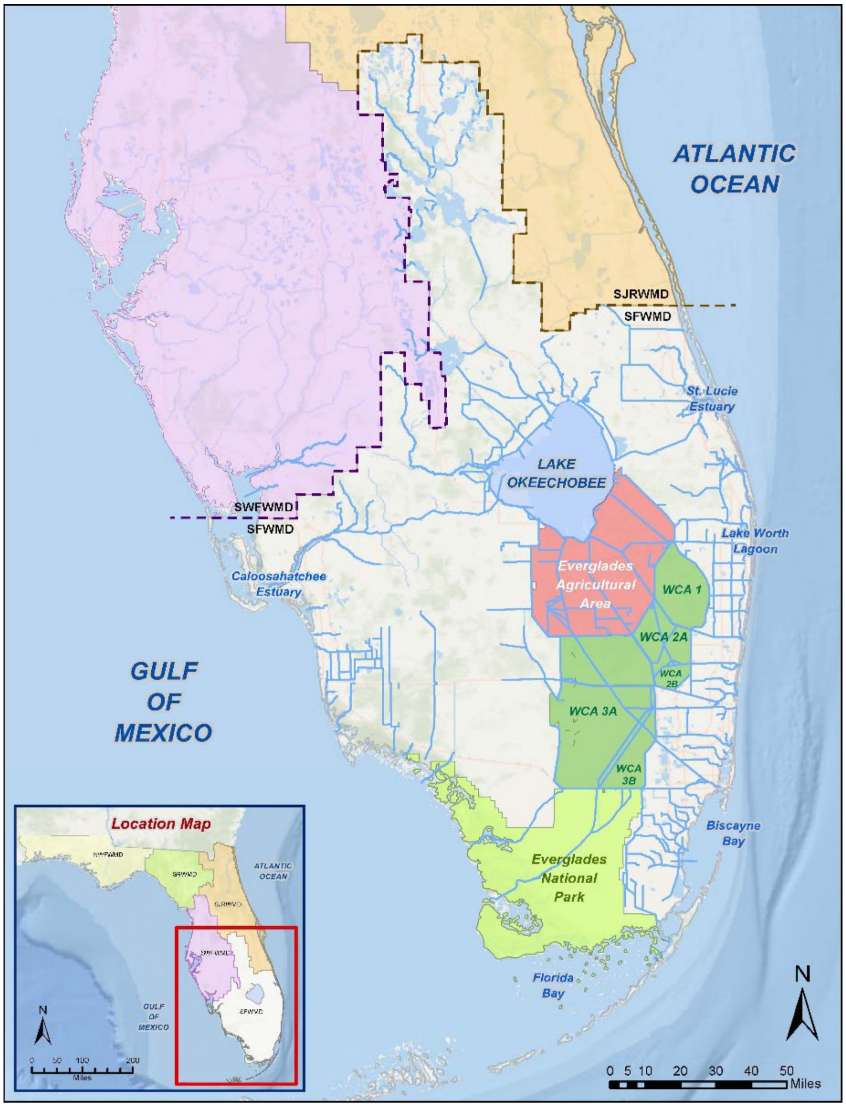


Figure 2. Image of the project location and surrounding area as provided by the USACE in Figure 3-1 of the Revised Biological Assessment

The action area is within the boundary of several critical habitat units as seen below in Section 3.2.

3 EFFECTS DETERMINATIONS

Please note the following abbreviations are only used in **Table 1** and **Table 2** and are not, therefore, included in the list of acronyms: E = endangered; T = threatened; P = proposed; LAA = likely to adversely affect; NLAA = may affect, not likely to adversely affect; NE = no effect.

3.1 Effects Determinations for ESA-Listed Species

3.1.1 Agency Effects Determinations

We have assessed the ESA-listed species that may be present in the action area and the USACE's and our determinations of the project's potential effects are shown in **Table 1** below.

Table 1. ESA-listed Species in the Action Area and Effect Determinations

Species (DPS)	ESA Listing Status	Listing Rule/Date	Most Recent Recovery Plan (or Outline) Date	USACE Effect Determination	NMFS Effect Determination
Sea Turtles					
Green sea turtle (NA DPS)	T	81 FR 20057/ April 6, 2016	October 1991	NLAA	LAA
Hawksbill sea turtle	E	35 FR 8491/ June 2, 1970	December 1993	NLAA	NLAA
Kemp's ridley sea turtle	E	35 FR 18319/ December 2, 1970	September 2011	NLAA	LAA
Leatherback sea turtle	E	35 FR 8491/ June 2, 1970	April 1992	NLAA	NLAA
Loggerhead sea turtle (NWA DPS)	T	76 FR 58868/ September 22, 2011	December 2008	NLAA	LAA
Fishes					
Giant manta ray	T	83 FR 2916/ January 22, 2018	2019 (Outline)	NLAA	NLAA
Nassau grouper	T	81 FR 42268/ June 29, 2016	2018 (Outline)	NE	NLAA
Smalltooth sawfish (U.S. DPS)	E	68 FR 15674/ April 1, 2003	January 2009	NLAA	NLAA
Invertebrates					

Species (DPS)	ESA Listing Status	Listing Rule/Date	Most Recent Recovery Plan (or Outline) Date	USACE Effect Determination	NMFS Effect Determination
Boulder star coral (*Orbicella franksi*)	T	79 FR 53852/ September 10, 2014	N/A	NLAA	NE
Elkhorn coral (*Acropora palmata*)	T	71 FR 26852/ May 9, 2006	March 2015	NLAA	NE
Lobed star coral (*Orbicella annularis*)	T	79 FR 53852/ September 10, 2014	N/A	NLAA	NE
Mountainous star coral (*Orbicella faveolata*)	T	79 FR 53852/ September 10, 2014	N/A	NLAA	NLAA
Pillar coral (*Dendrogyra cylindrus*)	T	79 FR 53852/ September 10, 2014	N/A	NLAA	NE
Rough cactus coral (*Mycetophyllia ferox*)	T	79 FR 53852/ September 10, 2014	N/A	NLAA	NE
Staghorn coral (*Acropora cervicornis*)	T	71 FR 26852/ May 9, 2006	March 2015	NLAA	NE
Proposed					
Queen conch (*Strombus gigas*)	PT	87 FR 55200/ September 8, 2022	N/A		NLAA

With the exception of mountainous star coral, we believe the proposed action will have no effect on listed corals, because these species are not generally present north of Palm Beach County, Florida.

3.1.2 Effects Analysis for ESA-Listed Species Not Likely to be Adversely Affected by the Proposed Action

We have determined that leatherback and hawksbill sea turtles, giant manta rays, Nassau grouper, smalltooth sawfish (U.S. DPS), mountainous star coral, and queen conch may be affected but are not likely to be adversely affected by the proposed action. Additional rationale to support this decision for each species is provided below.

Leatherback sea turtle

Leatherback sea turtles may be found along the periphery of the action area, particularly in the nearshore waters of southeastern Florida during nesting season, and therefore could be affected by the implementation of LOSOM. Freshwater released from LOK can affect salinity of, deliver additional nutrients to, and in some cases provide freshwater algae species to the downstream estuaries (SLE, CRE, LWL). Water quality changes to the estuaries and the nearshore areas associated with the estuaries could result in HABs (through algae and nutrient loading), decreased oxygen within the water (through nutrient cycling), and an altered forage community (plankton, fish, invertebrates, etc.). The primary route of effect that we believe could adversely affect sea turtles is HABs, specifically red tide (*Karenia brevis*). However, red tides that are generally responsible for sea turtle mortality mostly occur in the nearshore waters of Florida's west coast where leatherback sea turtles are less abundant. Although the species could interact with altered waters in the nearshore environment when coming ashore to nest, we believe the effect from HABs on leatherback sea turtles will be insignificant. First, we expect leatherback turtles to be rather rare in the action area, only entering during nesting season given their life history strategy that involves the species mostly using pelagic, deep-water habitat. Since 2008 there has only been 1 observed leatherback sea turtle stranding off the west coast of Florida (statistical zone 4) during a red tide event. Secondly, the species primarily feeds on jellyfish in offshore environments which are outside of the action area, so adverse effects associated with feeding are unlikely. Lastly, releases from LOK have been ongoing under LORS08 and we are not aware of any adverse effects of that action on leatherback turtles. Thus, the proposed action is not likely to adversely affect leatherback sea turtles.

Hawksbill sea turtle

Hawksbill sea turtles may be found in or near the action area, particularly along the reef tracts of southeastern Florida, and therefore could be affected by the implementation of LOSOM. Freshwater released from LOK can affect salinity of, deliver additional nutrients to, and in some cases provide freshwater algae species to the downstream estuaries (SLE, CRE, LWL). Water quality changes to the estuaries and the nearshore areas associated with the estuaries could result in HABs (through algae and nutrient loading), decreased oxygen within the water (through nutrient cycling), and an altered forage community (plankton, fish, invertebrates, etc.). The primary route of effect that we believe could adversely affect sea turtles is HABs, specifically red tide. However, red tides that are generally responsible for sea turtle mortality mostly occur in the nearshore waters of Florida's west coast where hawksbill sea turtles are less abundant. Although the species could interact with altered waters in the nearshore environment, we believe the effects from HABs on hawksbill sea turtles will be insignificant. In an analysis of sea turtles stranded in the action area during months of red tide between 2008 and 2022, we found very few hawksbill turtle records and the proportion of those stranded hawksbill turtles that could be attributed to LOK releases was significantly less than a single turtle. Though modified nearshore waters could affect hawksbill turtle feeding, we believe this effect will be insignificant given the species generally forages on sponges found along the reef tract which are far enough away from project impacts that any effects would be greatly reduced. Thus, the proposed action is not likely to adversely affect hawksbill sea turtles.

Giant manta ray

Giant manta rays may be found in the action area, particularly in the area of the St. Lucie Inlet along Florida's east coast. Therefore, the species could be subjected to any changes that may occur in its environment as a result of the proposed action. Releases from LOK can alter the salinity of, deliver additional nutrients to, and in some cases deliver freshwater algal blooms to, estuarine and nearshore waters. While these potential stressors are unlikely to directly affect giant manta rays, changes to the water could affect the zooplankton community that giant manta rays feed on; therefore resulting in giant manta rays shifting their feeding location or altering their diet. We believe this effect would be insignificant. Freshwater releases from LOK are ongoing and have been for many years with no documented effects on zooplankton abundance such that it adversely affected giant manta feeding. Further, only the delivery schedule (quantity and timing of water) is expected to change under LOSOM; therefore, we do not expect widespread changes to the zooplankton community. Thus, the proposed action is not likely to adversely affect giant manta rays.

Nassau grouper

Though not common, Nassau grouper may be occasionally found in the action area along the southeast coast of Florida, particularly along Florida's Reef Tract. When present, Nassau grouper could be affected by releases under the proposed action. Potential effects to the species could include a change in Nassau grouper distribution and behavior shifting away from the area affected by the release. This could be due to changes in salinity or other water quality parameters or changes in the forage fish community. We believe these effects will be insignificant for the following reasons: (1) freshwater releases are occurring under the current regulation schedule and there have been no reported effects to Nassau grouper, (2) the species is rare north of Government Cut, and (3) the expected extent of water quality effects seaward of the St. Lucie Inlet is limited. Thus, the proposed action is not likely to adversely affect Nassau grouper.

Smalltooth sawfish

The U.S. DPS of smalltooth sawfish is found in both the estuarine and nearshore waters of south Florida where the proposed action could affect the surrounding environment. Records indicate the species is found in both the St. Lucie and Caloosahatchee estuaries (U.S. Sawfish Recovery Database) of the action area, though abundance is greater in the latter as it provides vital nursery habitat. Juvenile sawfish have site fidelity to shallow, estuarine nursery habitat for up to 2 years and thus this life stage is more susceptible to environmental changes. Larger juveniles (<220 cm stretched total length [STL]) and adults have more variable habitat use and do not solely rely on inshore estuaries, therefore they are less likely to be adversely affected by changes to the estuarine environment.

Given the spatial overlap of this project with smalltooth sawfish distribution, we expect project effects could affect smalltooth sawfish, particularly juveniles under 220 cm STL. Freshwater releases from Lake Okeechobee could alter the salinity regime in both estuaries, supply additional nutrients that could affect the phytoplankton community, or introduce freshwater phytoplankton into the estuarine environment. Each of these stressors could modify the water quality of the estuaries and nearshore waters where smalltooth sawfish reside.

Water quality alterations could affect smalltooth sawfish directly through displacement caused by decreased salinity or dissolved oxygen—an effect of nutrient cycling of algal blooms. Further, if nutrients fuel algal blooms, such as red tides (a specific type of algal bloom consisting of the dinoflagellate species *K. brevis*) or cyanobacteria blooms (blue-green algae), sawfish could be adversely affected. Nutrients can result in bloom intensification, increased size, or prolonged duration and sawfish could be adversely affected by the brevetoxins released by red tide dinoflagellates or displaced from their preferred habitats due to the tainted water. The brevetoxin released by red tide cells affects the nervous system of fishes thereby restricting their ability to respire (Landsberg 2002). However, to date, researchers are unaware of any red tide related mortality of smalltooth sawfish (Brame et al. 2019) and any potential displacement effects are expected to be insignificant as we expect smalltooth sawfish to use similar suitable habitat nearby that is unaffected by the bloom. Given smalltooth sawfish have an affinity for salinities between 18 and 30 (Poulakis et al 2011, Simpfendorfer et al. 2011) and red tide requires salinity above 24 (Vargo 2009), at least a portion of juvenile sawfish habitat should remain available during any bloom events in the area. Similarly, researchers are unaware of any adverse effects of cyanobacteria blooms on sawfish. Cyanobacteria blooms are more common in lower salinity environments that may align with sawfish salinity preference, but these blooms occur more commonly on Florida's east coast where sawfish are less abundant. In addition, such blooms are generally much more geographically confined than red tide. Regardless, we believe any potential displacement effects from cyanobacteria blooms will also be insignificant, as we expect there to be similar suitable habitat nearby that is unaffected by a bloom. Any sawfish displaced by such blooms would only need to exert minimal effort to access the nearby habitat.

Water quality changes could also affect sawfish indirectly by altering the forage base upon which sawfish rely. Some prey fish are particularly susceptible to brevetoxicosis (brevetoxin poisoning) so prolonged bloom events could alter the forage fish community in sawfish habitats. We believe this effect will be insignificant as sawfish feed on a variety of prey fish and are mobile, thus likely to move to areas containing sufficient forage outside of blooms.

Thus, the proposed action is not likely to adversely affect smalltooth sawfish.

Mountainous star coral

Mountainous star coral can be found in the action area along the northern extent of the Florida Reef Tract and thus could be affected by the proposed action. Although the proposed action seeks to improve the health of estuarine habitats (the BA specifically mentions oysters and seagrasses), freshwater can result in coral stress, which can lead to slower growth rates (Banks et al. 2008). We believe the ongoing release of freshwater from the proposed action into the SLE, and its subsequent effect on water quality, will have an insignificant effect on mountainous star coral. Releases have been ongoing under the current regulation schedule and any corals within the action area would have acclimated to the current environment. The proposed action will reduce releases to the east coast of Florida via the St. Lucie River, so it is expected that water quality may be improved resulting in improved conditions for mountainous star coral in comparison to the current baseline. Based on our best judgment, we would not be able to meaningfully measure, detect, or evaluate the effects of the proposed action on mountainous star coral. Thus, the proposed action is not likely to adversely affect mountainous star coral.

Queen conch

The primary distribution of queen conch is found in the Caribbean, though the species is also found in portions of southeast Florida that may overlap with the action area. The proposed action could affect water quality of nearshore seagrass or reef habitat of queen conch. Altered water quality could affect macroalgae, subsurface diatom communities, and particulate organic material availability, which in turn could affect queen conch as this species relies on these for nutrition. However, we believe these effects will be insignificant. Releases have been ongoing under the current regulation schedule and established prevailing water quality in the action area that the current seagrass community has tolerated. The proposed action will reduce releases to the east coast of Florida via the St. Lucie River, so NMFS expects that water quality may be improved, resulting in improved habitat and nutrient conditions for queen conch in comparison to the current baseline. Thus, the proposed action is not likely to adversely affect queen conch.

3.1.3 ESA-Listed Species Likely to be Adversely Affected by the Proposed Action

We have determined that green (NA DPS), Kemp's ridley, and loggerhead sea turtles (NWA DPS) are likely to be adversely affected by the proposed action and thus require further analysis. We provide greater detail on the potential effects to these species from the proposed action in the Effects of the Action (Section 6.1) and whether those effects, when considered in the context of the Status of the Species (Section 4.1), the Environmental Baseline (Section 5), and the Cumulative Effects (Section 7), are likely to likely to jeopardize the continued existence of these ESA-listed species in the wild.

3.2 Effects Determinations for Critical Habitat

3.2.1 Agency Effects Determinations

We have assessed the critical habitats that overlap with the action area and our determinations of the project's potential effects is shown in **Table 2** below.

Table 2. Critical Habitat in the Action Area and Effect Determinations

Species (DPS)	Critical Habitat Unit in the Action Area	Critical Habitat Rule/Date	USACE Effect Determination	NMFS Effect Determination (Critical Habitat)
Sea Turtles				
Loggerhead sea turtle (NWA DPS)	LOGG-N-18 Reproductive and Migratory	79 FR 39856/ July 10, 2014	NLAA	NE
Fishes				
Smalltooth sawfish (U.S. DPS)	Charlotte Harbor Estuary Unit	74 FR 45353/ September 2, 2009	NLAA	NLAA
Invertebrates				

Species (DPS)	Critical Habitat Unit in the Action Area	Critical Habitat Rule/Date	USACE Effect Determination	NMFS Effect Determination (Critical Habitat)
Elkhorn coral	Florida Area	73 FR 72210/ November 26, 2008	NLAA	NE
Staghorn coral	Florida Area	73 FR 72210/ November 26, 2008	NLAA	NE
Proposed				
Fishes				
Nassau grouper	Florida Unit 1	87 FR 62930, October 17, 2022	NE	NLAA
Invertebrates				
Boulder star coral		85 FR 76302/ November 27, 2020	NLAA	NE
Lobed star coral		85 FR 76302/ November 27, 2020	NLAA	NE
Mountainous star coral		85 FR 76302/ November 27, 2020	NLAA	NLAA
Pillar coral		85 FR 76302/ November 27, 2020	NLAA	NE
Rough cactus coral		85 FR 76302/ November 27, 2020	NLAA	NE

Measureable impacts from the proposed action are not expected to overlap with elkhorn and staghorn coral designated critical habitat, nor the proposed critical habitat for boulder star coral, lobed star coral, pillar coral, and rough cactus coral. The northern boundary for elkhorn and staghorn coral designated critical habitat is Boynton Inlet (in Palm Beach County, south of the action area). The northern boundary for boulder star coral, lobed star coral, and pillar coral is

Lake Worth Inlet (in Palm Beach County, south of the action area), and the northern boundary for rough cactus coral is the Broward/Palm Beach County line (south of the action area). Because the action area does not overlap with the critical habitats of these coral species, we believe there are no routes by which the critical habitat could be affected and thus the proposed project will have no effect.

The proposed project is located within the boundaries of loggerhead sea turtle and smalltooth sawfish critical habitats. Additionally, the project is within the borders of proposed critical habitat for Nassau grouper and mountainous star coral. We will assess potential project effects on the physical and biological features (PBF) of each critical habitat unit below.

Loggerhead sea turtles (NWA DPS) critical habitat
Critical habitat for the NWA DPS of loggerhead sea turtles has been identified off the southeastern coast of Florida (Figure 3), thus overlapping with the action area of the proposed project. The migratory and nearshore reproductive categories of loggerhead critical habitat Unit 18 are present in the action area.

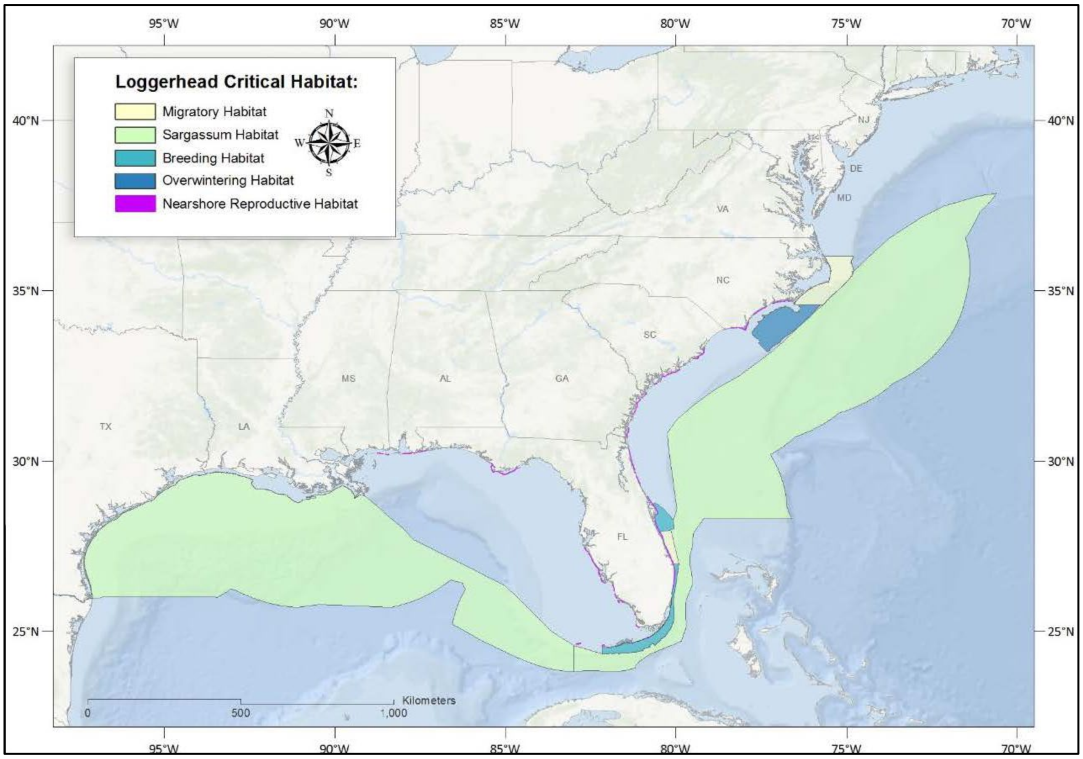


Figure 3. Map of loggerhead sea turtle critical habitat in the southeastern U.S.

The PBFs of nearshore reproductive habitat is the portion of the nearshore waters adjacent to nesting beaches that are used by hatchlings to egress to the open-water environment as well as by nesting females to transit between beach and open water during the nesting season. Primary constituent elements (PCE) that support the feature include: (1) nearshore waters directly off the highest density nesting beaches and their adjacent beaches to 1 mile offshore; (2) waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water, and (3) waters with minimal manmade structures that could promote predators, disrupt wave patterns necessary for orientation, and/or create excessive longshore currents.

The PBF of constricted migratory habitat is described as high use migratory corridors that are constricted (limited in width) by land on one side and the edge of the continental shelf and Gulf Stream on the other side. PCEs that support this habitat are: (1) constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways; and (2) passage conditions to allow for migration to and from nesting, breeding, and/or forage areas.

Although implementation of the proposed action may affect waters within the boundary of Unit 18 of the Northwest Atlantic DPS of loggerhead sea turtles, there are no routes of effect that will adversely affect any of the 3 PCEs for nearshore reproductive habitat or the 2 PCEs for constricted migratory habitat. Therefore, the project will have no effect on loggerhead sea turtle critical habitat.

3.2.2 Effects Analysis for Critical Habitat Not Likely to be Adversely Affected by the Proposed Action

Smalltooth sawfish (U.S. DPS) critical habitat
In 2009, NMFS designated critical habitat for the U.S. DPS of smalltooth sawfish in south and southwest Florida (Figure 4).

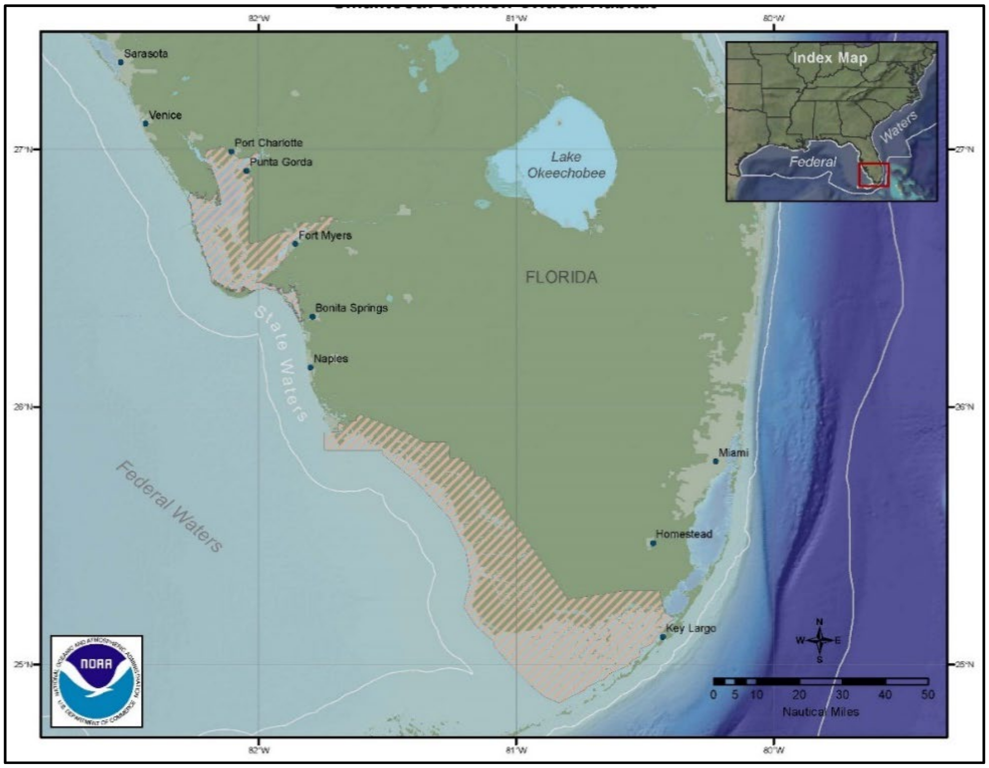
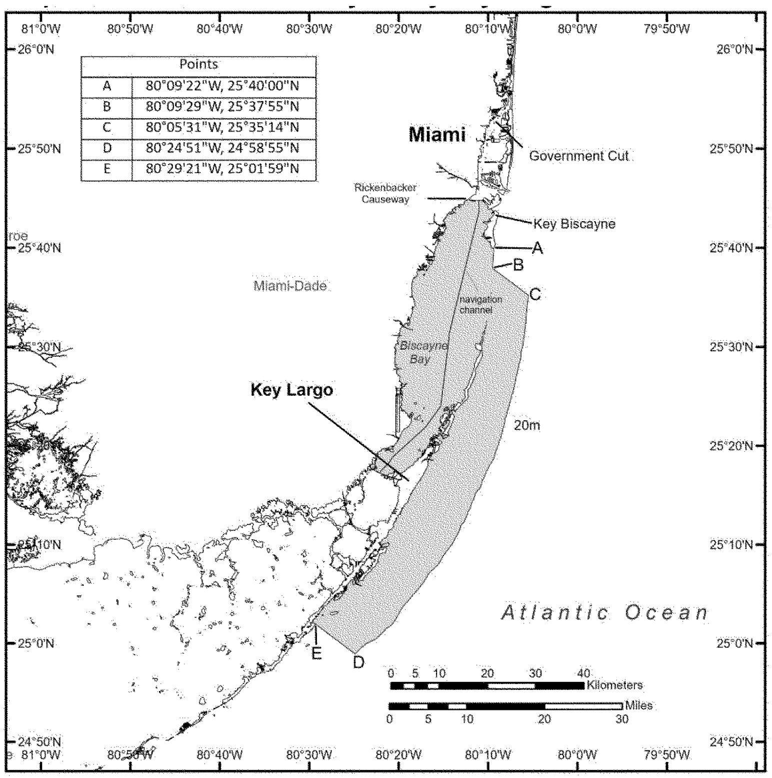


Figure 4. Smalltooth sawfish critical habitat located in southwestern Florida.

Smalltooth sawfish critical habitat was designated to support and facilitate juvenile survival and recruitment into the adult sawfish population. The features identified for this conservation purpose were (1) red mangroves, and (2) shallow, euryhaline waters characterized by depths between the mean high water line and 3 ft at mean lower low water. These features provide both refuge from predators and a supply of forage.

Releases from LOK have the potential to affect both essential features, largely through modifications of the salinity regime. Long-term changes in salinity could affect red mangrove growth and survival. Similarly, increased freshwater from LOK releases may affect the euryhaline waters feature of smalltooth sawfish critical habitat. Proposed changes to the release schedule that would alter the salinity pattern are expected to have insignificant effects on the essential features. LOK releases have been ongoing for years, establishing the prevailing salinity pattern that fluctuates with seasonal rainfall in addition to LOK releases, without any documented adverse effect on the essential features. Thus, the proposed action is not likely to adversely affect smalltooth sawfish critical habitat.

Nassau grouper proposed critical habitat
Proposed critical habitat for Nassau grouper includes the area of Biscayne Bay and adjacent waters off the southeast coast of Florida (Figure 5). This region overlaps with the action area of the proposed project.



Points	
A	80°09'22"W, 25°40'00"N
B	80°09'29"W, 25°37'55"N
C	80°05'31"W, 25°35'14"N
D	80°24'51"W, 24°58'55"N
E	80°29'21"W, 25°01'59"N

Figure 5. Map indicating the location of proposed Nassau grouper critical habitat in southeast Florida.

The proposed critical habitat rule identifies PBFs to support (1) adult reproduction at the spawning aggregations, and (2) settlement of larvae, and subsequent growth to maturity. The proposed rule identifies two essential features for the conservation of Nassau grouper: (1)

recruitment and developmental habitat and (2) spawning habitat. The first essential feature considers areas from nearshore to offshore that are necessary for recruitment, development, and growth of Nassau grouper. These areas contain a variety of benthic types that provide cover from predators and habitat for prey and consist of the following:

a. Nearshore shallow subtidal marine nursery areas with substrate that consists of unconsolidated calcareous medium to very coarse sediments (not fine sand) and shell and coral fragments and may also include cobble, boulders, whole corals and shells, or rubble mounds, to support larval settlement and provide shelter from predators during growth and habitat for prey.
b. Intermediate hardbottom and seagrass areas in close proximity to the nearshore shallow subtidal marine nursery areas that provide refuge and prey resources for juvenile fish. The areas include seagrass interspersed with areas of rubble, boulders, shell fragments, or other forms of cover; inshore patch and fore reefs that provide crevices and holes; or substrates interspersed with scattered sponges, octocorals, rock and macroalgal patches, or stony corals.
c. Offshore Linear and Patch Reefs in close proximity to intermediate hardbottom and seagrass areas that contain multiple benthic types, for example, coral reef, colonized hardbottom, sponge habitat, coral rubble, rocky outcrops, or ledges, to provide shelter from predation during maturation and habitat for prey.
d. Structures between the subtidal nearshore area and the intermediate hardbottom and seagrass area and the offshore reef area including overhangs, crevices, depressions, blowout ledges, holes, and other types of formations of varying sizes and complexity to support juveniles and adults as movement corridors that include temporary refuge that reduces predation risk as Nassau grouper move from nearshore to offshore habitats.

The proposed action will have no effect on spawning habitat as there is no identified spawning habitat within the action area. The proposed action could affect recruitment and developmental habitat located in the action area but the majority of these habitat types, as identified above, will not be affected by releases from LOK. The only potential route of effect to this essential feature could be changes in the seagrass community as a result of discharges changing water quality in the region of Biscayne Bay. We believe this effect will be insignificant. Though released water from LOK could contain algae and nutrients, the portion discharged south to the region of Biscayne Bay is expected to be minimal, as most of the released water will be moved to SLE and CRE. Further, releases have been ongoing under the current regulation schedule and set a baseline of water quality in Biscayne Bay, to which the seagrass community is currently acclimated, without any documented adverse effects specifically attributed to releases under LORS08. Thus, we conclude the proposed action is not likely to adversely affect Nassau grouper critical habitat.

Mountainous star coral proposed critical habitat
The action area includes proposed coral critical habitat for mountainous star coral (Figure 6).

We believe the proposed action, and its subsequent effect on the water quality essential feature, will be insignificant. LOK discharges into estuaries may be carried into coastal waters (thus, overlapping with proposed coral critical habitat). Freshwater discharges from LOK could introduce algae and nutrients that fuel algal blooms. We conservatively estimate nutrients in LOK releases may interact with nearshore waters out to 1 mile offshore from the SLE between 27° and 28°N. Increased microalgae in the water column (associated with LOK discharges) can reduce water transparency. However based on our best judgment, we would not be able to meaningfully measure, detect, or evaluate the effects of the proposed action on the water quality essential feature. Thus, we conclude the proposed action is not likely to adversely affect proposed coral critical habitat for mountainous star coral.

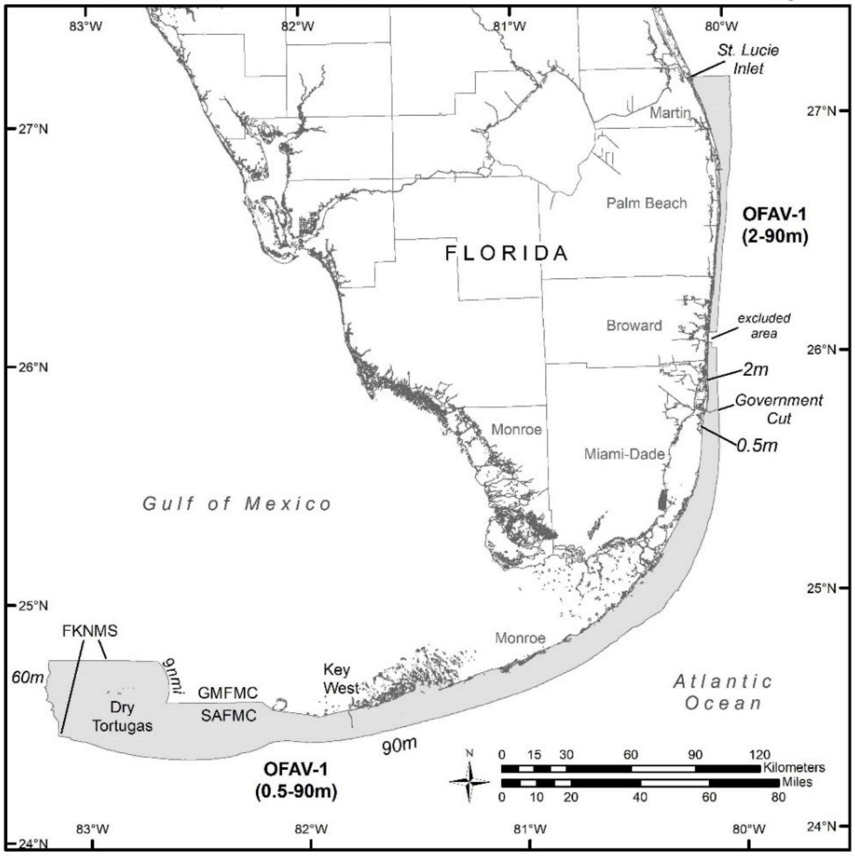


Figure 6. Map of proposed critical habitat for mountainous star coral in southeastern Florida.

4 STATUS OF ESA-LISTED SPECIES CONSIDERED FOR FURTHER ANALYSIS

4.1 Status of Sea Turtles Considered for Further Analysis

There are 5 species of sea turtles (green, hawksbill, Kemp's ridley, leatherback, and loggerhead) that travel widely throughout the South Atlantic, Gulf of Mexico and the Caribbean, only 3 of which are likely to be adversely effected by the proposed action. These species are highly migratory and therefore could occur within the action area. Section 4.2 will address the general threats that confront all sea turtle species. The remainder of Section 4 (Sections 4.3–4.6) will address information on the distribution, life history, population structure, abundance, population trends, and unique threats to each species of sea turtle.

4.2 General Threats Faced by all Sea Turtles

Sea turtles face numerous natural and man-made threats that shape their status and affect their ability to recover. Many of the threats are either the same or similar in nature for all listed sea turtle species. The threats identified in this section are discussed in a general sense for all sea turtles. Threat information specific to a particular species are then discussed in the corresponding status sections where appropriate.

Fisheries

Incidental bycatch in commercial fisheries is identified as a major contributor to past declines, and threat to future recovery, for all of the sea turtle species (NMFS and USFWS 1991; NMFS and USFWS 1992; NMFS and USFWS 1993; NMFS and USFWS 2008; NMFS et al. 2011). Domestic fisheries often capture, injure, and kill sea turtles at various life stages. Sea turtles in the pelagic environment are exposed to U.S. Atlantic pelagic longline and other fisheries. Sea turtles in the benthic environment in waters off the coastal United States are exposed to a suite of other fisheries in federal and state waters. These fishing methods include trawls, gillnets, purse seines, hook-and-line gear (including bottom longlines and vertical lines [e.g., bandit gear, handlines, and rod-reel], pound nets, and trap fisheries; refer to the Environmental Baseline section of this Opinion for more specific information regarding federal and state managed fisheries affecting sea turtles within the action area). The southeast U.S. shrimp fisheries have historically been the largest fishery threat to sea turtles in the southeastern United States, and continue to interact with and kill large numbers of sea turtles each year.

In addition to domestic fisheries, sea turtles are subject to direct as well as incidental capture in numerous foreign fisheries, further impeding the ability of sea turtles to survive and recover on a global scale. For example, pelagic stage sea turtles, especially loggerheads and leatherbacks, circumnavigating the Atlantic Ocean are susceptible to international longline fisheries including the Azorean, Spanish, and various other fleets (Aguilar et al. 1994; Bolten et al. 1994). Bottom longlines and gillnet fishing is known to occur in many foreign waters, including (but not limited to) the Northwest Atlantic, Western Mediterranean, South America, West Africa, Central America, and the Caribbean. Shrimp trawl fisheries are also occurring off the shores of numerous foreign countries and pose a significant threat to sea turtles similar to the impacts seen in U.S. waters. Many unreported captures or incomplete records by foreign fleets make it difficult to characterize the total impact that international fishing pressure is having on listed sea turtles. Nevertheless, international fisheries represent a continuing threat to sea turtle survival and recovery throughout their respective ranges.

Non-Fishery In-Water Activities

There are also many non-fishery impacts affecting the status of sea turtle species, both in the ocean and on land. In nearshore waters of the United States, the construction and maintenance of federal navigation channels has been identified as a source of sea turtle mortality. Hopper dredges, which are frequently used in ocean bar channels and sometimes in harbor channels and offshore borrow areas, move relatively rapidly and can entrain and kill sea turtles (NMFS 2020a). Sea turtles entering coastal or inshore areas have also been affected by entrainment in the cooling-water systems of electrical generating plants. Other nearshore threats include harassment and injury resulting from private and commercial vessel operations, military detonations and training exercises, in-water construction activities, and scientific research activities.

Coastal Development and Erosion Control

Coastal development can deter or interfere with nesting, affect nesting success, and degrade nesting habitats for sea turtles. Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and nourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). These factors may decrease the amount of nesting area available to females and change the natural behaviors of both adults and hatchlings, directly or indirectly, through loss of beach habitat or changing thermal profiles and increasing erosion, respectively (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). In addition, coastal development is usually accompanied by artificial lighting which can alter the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings that are drawn away from the water (Witherington and Bjorndal 1991). In-water erosion control structures such as breakwaters, groins, and jetties can impact nesting females and hatchlings as they approach and leave the surf zone or head out to sea by creating physical blockage, concentrating predators, creating longshore currents, and disrupting of wave patterns.

Environmental Contamination

Multiple municipal, industrial, and household sources, as well as atmospheric transport, introduce various pollutants such as pesticides, hydrocarbons, organochlorides (e.g., dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCB], and perfluorinated chemicals), and others that may cause adverse health effects to sea turtles (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata et al. 1993). Acute exposure to hydrocarbons from petroleum products released into the environment via oil spills and other discharges may directly injure individuals through skin contact with oils (Geraci 1990), inhalation at the water's surface and ingesting compounds while feeding (Matkin and Saulitis 1997). Hydrocarbons also have the potential to impact prey populations, and therefore may affect listed species indirectly by reducing food availability in the action area.

The April 20, 2010, explosion of the DEEPWATER HORIZON (DWH) oil rig affected sea turtles in the Gulf of Mexico. An assessment has been completed on the injury to Gulf of Mexico marine life, including sea turtles, resulting from the spill (DWH Trustees 2016). Following the spill, juvenile Kemp's ridley, green, and loggerhead sea turtles were found in *Sargassum* algae mats in the convergence zones, where currents meet and oil collected. Sea turtles found in these areas were often coated in oil or had ingested oil. The spill resulted in the direct mortality of many sea turtles and may have had sublethal effects or caused environmental damage that will impact other sea turtles into the future. Information on the spill impacts to individual sea turtle species is presented in the Status of the Species sections for each species.

Marine debris is a continuing problem for sea turtles. Sea turtles living in the pelagic environment commonly eat or become entangled in marine debris (e.g., tar balls, plastic bags/pellets, balloons, and lost, abandoned or discarded fishing gear) as they feed along oceanographic fronts where debris and their natural food items converge. Marine debris can cause significant habitat destruction from derelict vessels, further exacerbated by tropical storms moving debris and scouring and destroying corals and seagrass beds, for instance. Sea turtles that spend significant portions of their lives in the pelagic environment (i.e., juvenile loggerheads, and juvenile green turtles) are especially susceptible to threats from entanglement in marine debris when they return to coastal waters to breed and nest.

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. Some of the likely effects commonly mentioned are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. NOAA's climate information portal provides basic background information on these and other measured or anticipated effects (see http://www.climate.gov). The potential effects, and the expected related effects to ESA-listed species, stemming from climate change are the result of a slow and steady shift over a long time-period, and forecasting any specific critical threshold that may occur at some point in the future (e.g., several decades) is highly uncertain. Therefore, we review the effects of climate change on affected species over the course of the next few decades.

While we cannot currently predict impacts on sea turtles stemming from climate change with any degree of certainty, we are aware that significant impacts to the hatchling sex ratios of sea turtles may result (NMFS and USFWS 2007a). In sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range between 25 and 35°C (Ackerman 1997). Increases in global temperature over time could potentially skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007a).

The effects from increased temperatures may be intensified on developed nesting beaches where shoreline armoring and construction have denuded vegetation. Erosion control structures could potentially result in the permanent loss of nesting beach habitat or deter nesting females (NRC 1990). These impacts will be exacerbated by sea level rise. If females nest on the seaward side of the erosion control structures, nests may be exposed to repeated tidal overwash (NMFS and USFWS 2007b). Sea level rise from global climate change is also a potential problem for areas with low-lying beaches where sand depth is a limiting factor, as the sea may inundate nesting sites and decrease available nesting habitat (Baker et al. 2006; Daniels et al. 1993; Fish et al. 2005). The loss of habitat as a result of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

A combination of rising sea surface temperatures that could alter nesting behavior to more northern latitudes and sea level rise resulting in increased beach erosion north of Cape Hatteras, North Carolina (Sallenger et al. 2012) and reduced availability of existing beaches, could ultimately affect sea turtle nesting success in those areas. However, we expect those effects, should they occur, would likely occur over a fairly long time period encompassing several sea turtle generations, and not in the short term (e.g., over the next decade). Furthermore, modeled climate data from Van Houtan and Halley (2011) showed a future positive trend for loggerhead nesting in Florida, by far the species' most important nesting area in the Atlantic, with increases through 2040 as a result of the Atlantic Multidecadal Oscillation signal. A more recent study by

Arendt et al. (2013), which is a follow up review and critique of the Van Houtan and Halley (2011) analysis, suggested the mechanistic underpinning between climate and loggerhead nesting rates on Florida beaches was primarily acting on the mature adult females as opposed to the hatchlings. Nonetheless, Arendt et al. (2013) suggest that the population of loggerheads nesting in Florida could attain the demographic criteria for recovery by 2027 if annual nest counts from 2013 to 2019 are comparable to what were seen from 2008 to 2012. Since loggerhead sea turtles are known to nest on Florida beaches in large numbers (and likely will continue to do so in the short-term future), we believe that any impacts of the sea level rise described in Sallenger et al. (2012) are likely to be offset by increased nesting in Florida over the next few decades.
Other changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen [DO] levels, nutrient distribution, etc.) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish, etc.) which could ultimately affect the primary foraging areas of sea turtles.

Other Threats
Predation by various land predators is a threat to developing nests and emerging hatchlings. The major natural predators of sea turtle nests are mammals, including raccoons, dogs, pigs, skunks, and badgers. Emergent hatchlings are preyed upon by these mammals, as well as ghost crabs, laughing gulls, and the exotic South American fire ant (*Solenopsis invicta*). In addition to natural predation, direct harvest of eggs and adults from beaches in foreign countries continues to be a problem for various sea turtle species throughout their ranges (NMFS and USFWS 2008).

Diseases, toxic blooms from algae and other microorganisms, and cold stunning events are additional sources of mortality that can range from local and limited to wide-scale and impacting hundreds or thousands of animals.

4.3 Green Sea Turtle

The green sea turtle was originally listed as threatened under the ESA on July 28, 1978, except for the Florida and Pacific coast of Mexico breeding populations, which were listed as endangered. On April 6, 2016, the original listing was replaced with the listing of 11 DPSs (81 FR 20057 2016) (Figure 7). The Mediterranean, Central West Pacific, and Central South Pacific DPSs were listed as endangered. The North Atlantic, South Atlantic, Southwest Indian, North Indian, East Indian-West Pacific, Southwest Pacific, Central North Pacific, and East Pacific DPSs were listed as threatened. For the purposes of this consultation, only the North Atlantic DPS (NA DPS) will be considered, as it is the only DPS with individuals occurring in the Atlantic and Gulf of Mexico waters of the United States.

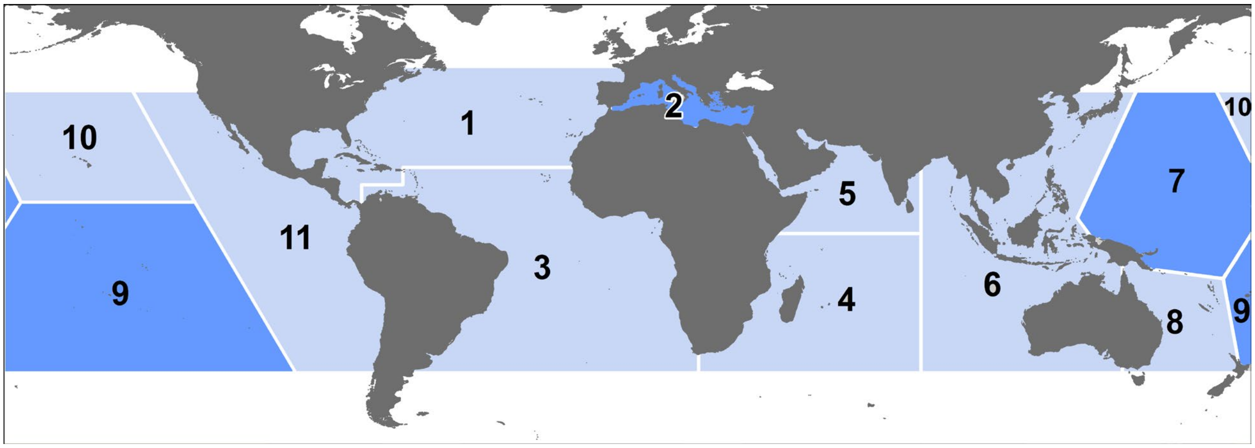


Figure 7. Threatened (light) and endangered (dark) green turtle DPSs.
Key: 1. North Atlantic (NA); 2. Mediterranean; 3. South Atlantic (SA); 4. Southwest Indian; 5. North Indian; 6. East Indian-West Pacific; 7. Central West Pacific; 8. Southwest Pacific; 9. Central South Pacific; 10. Central North Pacific; and 11. East Pacific.

Species Description and Distribution

The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 pounds (lb) (159 kilograms [kg]) with a straight carapace length (SCL) of greater than 3.3 ft (1 m). Green sea turtles have a smooth carapace with 4 pairs of lateral (or costal) scutes and a single pair of elongated prefrontal scales between the eyes. They typically have a black dorsal surface and a white ventral surface, although the carapace of green sea turtles in the Atlantic Ocean has been known to change in color from solid black to a variety of shades of grey, green, or brown and black in starburst or irregular patterns (Lagueux 2001).

With the exception of post-hatchlings, green sea turtles live in nearshore tropical and subtropical waters where they generally feed on marine algae and seagrasses. They have specific foraging grounds and may make large migrations between these forage sites and natal beaches for nesting (Hays et al. 2001). Green sea turtles nest on sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands in more than 80 countries worldwide (Hirth 1997). The 2 largest nesting populations are found at Tortuguero, on the Caribbean coast of Costa Rica (part of the NA DPS), and Raine Island, on the Pacific coast of Australia along the Great Barrier Reef.

Differences in mitochondrial deoxyribonucleic acid (DNA) properties of green sea turtles from different nesting regions indicate there are genetic subpopulations (Bowen et al. 1992; FitzSimmons et al. 2006). Despite the genetic differences, sea turtles from separate nesting origins are commonly found mixed together on foraging grounds throughout the species' range. Limited early information indicated that within U.S. waters benthic juveniles from both the North Atlantic and South Atlantic DPSs may be found on foraging grounds. Two small-scale studies provided an insight into the possible degree of mixing on the foraging grounds. An analysis of cold-stunned green turtles in St. Joseph Bay, Florida (northern Gulf of Mexico) found approximately 4% of individuals came from nesting stocks in the SA DPS (specifically Suriname, Aves Island, Brazil, Ascension Island, and Guinea Bissau) (Foley et al. 2007). On the Atlantic coast of Florida, a study on the foraging grounds off Hutchinson Island found that approximately 5% of the turtles sampled came from the Aves Island/Suriname nesting assemblage, which is part of the SA DPS (Bass and Witzell 2000). Available information on green turtle migratory behavior indicates that long distance dispersal is only seen for juvenile turtles. This suggests that larger adult-sized 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). However, with additional research it has been determined that South Atlantic juveniles are not likely to be occurring in U.S. mainland coastal waters in anything more than negligible numbers. Jensen et al. (2013) indicated that the earlier studies might represent a statistical artifact as they lack sufficient precision, with error intervals that span zero. More recent studies with better rookery baseline representation found negligible (<1%) contributions from the South Atlantic DPS among Texas and Florida GoM juvenile green turtle assemblages (Shamblin et al. 2016, 2018). Finally, an as-yet published genetic analysis of samples from various coastal areas in the Gulf of Mexico and Atlantic has now solidified the conclusion that South Atlantic juveniles represent at best a negligible number of individuals in mainland United States waters (Peter Dutton, SWFSC, pers. comm. April 2022). Therefore, we will not consider South Atlantic DPS individuals when conducting consultations for projects in the waters off the mainland United States.

The NA DPS boundary is illustrated in Figure 7. Four regions support nesting concentrations of particular interest in the NA DPS: Costa Rica (Tortuguero), Mexico (Campeche, Yucatan, and Quintana Roo), U.S. (Florida), and Cuba. By far the most important nesting concentration for green turtles in this DPS is Tortuguero, Costa Rica. Nesting also occurs in the Bahamas, Belize, Cayman Islands, Dominican Republic, Haiti, Honduras, Jamaica, Nicaragua, Panama, Puerto Rico, Turks and Caicos Islands, and North Carolina, South Carolina, Georgia, and Texas, U.S.A. In the eastern North Atlantic, nesting has been reported in Mauritania (Fretey 2001).

The complete nesting range of NA DPS green sea turtles within the southeastern United States includes sandy beaches between Texas and North Carolina, as well as Puerto Rico (Dow et al. 2007; NMFS and USFWS 1991). The vast majority of green sea turtle nesting within the southeastern United States occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Principal U.S. nesting areas for green sea turtles are in eastern Florida, predominantly Brevard south through Broward counties.

In U.S. Atlantic and Gulf of Mexico waters, green sea turtles are distributed throughout inshore and nearshore waters from Texas to Massachusetts. Principal benthic foraging areas in the southeastern United States 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), 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 sea 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 include the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean coast of Panama, scattered areas along Colombia and Brazil (Hirth 1971), and the northwestern coast of the Yucatán Peninsula.

Life History Information

Green sea turtles reproduce sexually, and mating occurs in the waters off nesting beaches and along migratory routes. Mature females return to their natal beaches (i.e., the same beaches where they were born) to lay eggs (Balazs 1982; Frazer and Ehrhart 1985) every 2 to 4 years while males are known to reproduce every year (Balazs 1983). In the southeastern United States, females generally nest between June and September, and peak nesting occurs in June and July (Witherington and Ehrhart 1989b). During the nesting season, females nest at approximately 2-week intervals, laying an average of 3-4 clutches (Johnson and Ehrhart 1996). Clutch size often varies among subpopulations, but mean clutch size is approximately 110-115 eggs. In Florida, green sea turtle nests contain an average of 136 eggs (Witherington and Ehrhart 1989b). Eggs incubate for approximately 2 months before hatching. Hatchling green sea turtles are approximately 2 in (5 cm) in length and weigh approximately 0.9 ounces (oz). Survivorship at any particular nesting site is greatly influenced by the level of man-made stressors, with the more pristine and less disturbed nesting sites (e.g., along the Great Barrier Reef in Australia) showing higher survivorship values than nesting sites known to be highly disturbed (e.g., Nicaragua) (Campell and Lagueux 2005; Chaloupka and Limpus 2005).

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 sea 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 most poorly understood aspects of green sea turtle life history (NMFS and USFWS 2007c). Green sea turtles exhibit particularly slow growth rates of about 0.4 to 2 in (1-5 cm) per year (Green 1993), which may be attributed to their largely herbivorous, low-net energy diet (Bjorndal 1982). At approximately 8 to 10 in (20 to 25 cm) carapace length, juveniles leave the pelagic environment and enter nearshore developmental habitats such as protected lagoons and open coastal areas rich in sea grass and marine algae. Growth studies using skeletochronology indicate that green sea turtles in the western Atlantic shift from the oceanic phase to nearshore developmental habitats after approximately 5 to 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). Green sea turtles mature slowly, requiring 20 to 50 years to reach sexual maturity (Chaloupka and Musick 1997; Hirth 1997).

While in coastal habitats, green sea turtles exhibit site fidelity to specific foraging and nesting grounds, and it is clear they are capable of "homing in" on these sites if displaced (McMichael et al. 2003). Reproductive migrations of Florida green sea turtles have been identified through flipper tagging and satellite telemetry. Based on these studies, the majority of adult female Florida green sea turtles are believed to reside in nearshore foraging areas throughout the Florida Keys and in the waters southwest of Cape Sable, and some post-nesting turtles also reside in Bahamian waters as well (NMFS and USFWS 2007c).

Status and 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. 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 each of the DPSs.

The NA DPS is the largest of the 11 green turtle DPSs, with an estimated nester abundance of over 167,000 adult females from 73 nesting sites. Overall this DPS is also the most data rich. Eight of the sites have high levels of abundance (i.e., <1000 nesters), located in Costa Rica, Cuba, Mexico, and Florida. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015).

Quintana Roo, Mexico, accounts for approximately 11% of nesting for the DPS (Seminoff et al. 2015). In the early 1980s, approximately 875 nests/year were deposited, but by 2000 this increased to over 1,500 nests/year (NMFS and USFWS 2007c). By 2012, more than 26,000 nests were counted in Quintana Roo (J. Zurita, CIQROO, unpublished data, 2013, in 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 to 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 to 37,290 nesting females per year (NMFS and USFWS 2007c). 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 continental United States, green sea 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 (Meylan et al. 1995). Green sea turtle nesting is documented annually on beaches of North Carolina, South Carolina, and Georgia, though nesting is found in low quantities (up to tens of nests) (nesting databases maintained on www.seaturtle.org).

Florida accounts for approximately 5% of nesting for this DPS (Seminoff et al. 2015). 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 sea turtle nesting has generally shown biennial peaks in abundance with a positive trend during the 10 years of regular monitoring (Figure 8). According to data collected from Florida's index nesting beach survey from 1989-2021, 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. Two consecutive years of nesting declines in 2008 and 2009 caused some concern, but this was followed by increases in 2010 and 2011. The pattern departed from the low lows and high peaks in 2020 and 2021 as well, when 2020 nesting only dropped by half from the 2019 high, while 2021 nesting only increased by a small amount over the 2020 nesting, with another increase in 2022 still well below the 2019 high (Figure 8). While nesting in Florida has shown dramatic increases over the past decade, individuals from the Tortuguero, the Florida, and the other Caribbean and Gulf of

Mexico populations in the North Atlantic DPS intermix and share developmental habitat. Therefore, threats that have affected the Tortuguero population as described previously, may ultimately influence the other population trajectories, including Florida. Given the large size of the Tortuguero nesting population, which is currently in decline, its status and trend largely drives the status of North Atlantic DPS.

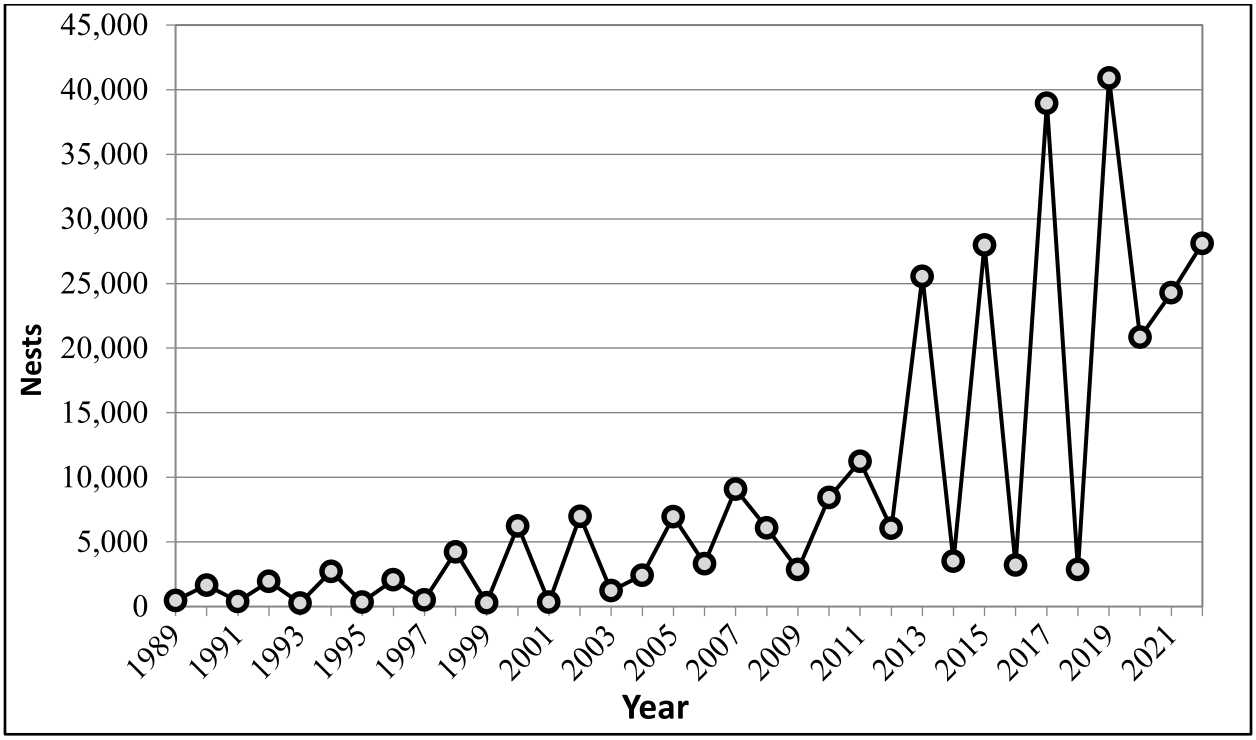


Figure 8. Green sea turtle nesting at Florida index beaches since 1989.

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 (SCL<90 cm) from 1977 to 2002 or 26 years (3,557 green turtles total; M. Bressette, Inwater Research Group, unpubl. data; (Witherington et al. 2006).

Threats

The principal cause of past declines and extirpations of green sea turtle assemblages has been the overexploitation of the species for food and other products. Although intentional take of green sea turtles and their eggs is not extensive within the southeastern United States, green sea turtles that nest and forage in the region may spend large portions of their life history outside the region and outside U.S. jurisdiction, where exploitation is still a threat. Green sea turtles also 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 (e.g., plastics, petroleum products, petrochemicals), ecosystem alterations (e.g., nesting beach development, beach nourishment and shoreline stabilization, vegetation changes), poaching, global climate change, fisheries interactions, natural predation, and disease. A discussion on general sea turtle threats can be found in Section 3.2.1.

In addition to general threats, green sea turtles are susceptible to natural mortality from Fibropapillomatosis (FP) disease. FP results in the growth of tumors on soft external tissues (flippers, neck, tail, etc.), the carapace, the eyes, the mouth, and internal organs (gastrointestinal tract, heart, lungs, etc.) of turtles (Aguirre et al. 2002; Herbst 1994; Jacobson et al. 1989). These tumors range in size from 0.04 in (0.1 cm) to greater than 11.81 in (30 cm) in diameter and may affect swimming, vision, feeding, and organ function (Aguirre et al. 2002; Herbst 1994; Jacobson et al. 1989). Presently, scientists are unsure of the exact mechanism causing this disease, though it is believed to be related to both an infectious agent, such as a virus (Herbst et al. 1995), and environmental conditions (e.g., habitat degradation, pollution, low wave energy, and shallow water (Foley et al. 2005). FP is cosmopolitan, but it has been found to affect large numbers of animals in specific areas, including Hawaii and Florida (Herbst 1994; Jacobson 1990; Jacobson et al. 1991).

Cold-stunning is another natural threat to green sea turtles. Although it is not considered a major source of mortality in most cases, as temperatures fall below 46.4°-50°F (8°-10°C) turtles may lose their ability to swim and dive, often floating to the surface. The rate of cooling that precipitates cold-stunning appears to be the primary threat, rather than the water temperature itself (Milton and Lutz 2003). Sea turtles that overwinter in inshore waters are most susceptible to cold-stunning because temperature changes are most rapid in shallow water (Witherington and Ehrhart 1989a). During January 2010, an unusually large cold-stunning event in the southeastern United States resulted in around 4,600 sea turtles, mostly greens, found cold-stunned, and hundreds found dead or dying. A large cold-stunning event occurred in the western Gulf of Mexico in February 2011, resulting in approximately 1,650 green sea turtles found cold-stunned in Texas. Of these, approximately 620 were found dead or died after stranding, while approximately 1,030 turtles were rehabilitated and released. During this same time frame, approximately 340 green sea turtles were found cold-stunned in Mexico, though approximately 300 of those were subsequently rehabilitated and released.

Whereas oil spill impacts are discussed generally for all species in Section 4.1.1, specific impacts of the DWH spill on green sea turtles are considered here. Impacts to green sea turtles occurred to offshore small juveniles only. A total of 154,000 small juvenile greens (36.6% of the total small juvenile sea turtle exposures to oil from the spill) were estimated to have been exposed to oil. A large number of small juveniles were removed from the population, as 57,300 small juveniles greens are estimated to have died as a result of the exposure. A total of 4 nests (580 eggs) were also translocated during response efforts, with 455 hatchlings released (the fate of which is unknown) (DWH Trustees 2016). Additional unquantified effects may have included inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil or dispersants, and loss of foraging resources, which could lead to compromised growth and reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred.

While green turtles regularly use the northern Gulf of Mexico, they have a widespread distribution throughout the entire Gulf of Mexico, Caribbean, and Atlantic, and the proportion of the population using the northern Gulf of Mexico at any given time is relatively low. Although it is known that adverse impacts occurred and numbers of animals in the Gulf of Mexico were reduced as a result of the DWH oil spill of 2010, the relative proportion of the population that is expected to have been exposed to and directly impacted by the DWH event, as well as the impacts being primarily to smaller juveniles (lower reproductive value than adults and large juveniles), reduces the impact to the overall population. It is unclear what impact these losses may have caused on a population level, but it is not expected to have had a large impact on the population trajectory moving forward. However, recovery of green turtle numbers equivalent to what was lost in the northern Gulf of Mexico as a result of the spill will likely take decades of sustained efforts to reduce the existing threats and enhance survivorship of multiple life stages (DWH Trustees 2016).

4.4 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle was listed as endangered on December 2, 1970, under the Endangered Species Conservation Act of 1969, a precursor to the ESA. Internationally, the Kemp's ridley is considered the most endangered sea turtle (Groombridge 1982; TEWG 2000; Zwinenberg 1977).

Species Description and Distribution

The Kemp's ridley sea turtle is the smallest of all sea turtles. Adults generally weigh less than 100 lb (45 kg) and have a carapace length of around 2.1 ft (65 cm). Adult Kemp's ridley shells are almost as wide as they are long. Coloration changes significantly during development from the grey-black dorsum and plastron of hatchlings, a grey-black dorsum with a yellowish-white plastron as post-pelagic juveniles, and then to the lighter grey-olive carapace and cream-white or yellowish plastron of adults. There are 2 pairs of prefrontal scales on the head, 5 vertebral scutes, usually 5 pairs of costal scutes, and generally 12 pairs of marginal scutes on the carapace. In each bridge adjoining the plastron to the carapace, there are 4 scutes, each of which is perforated by a pore.

Kemp's ridley habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 120 ft (37 m) deep, although they can also be found in deeper offshore waters. These areas support the primary prey species of the Kemp's ridley sea turtle, which consist of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

The primary range of Kemp's ridley sea turtles is within the Gulf of Mexico basin, though they also occur in coastal and offshore waters of the U.S. Atlantic Ocean. Juvenile Kemp's ridley sea turtles, possibly carried by oceanic currents, have been recorded as far north as Nova Scotia. Historic records indicate a nesting range from Mustang Island, Texas, in the north to Veracruz, Mexico, in the south. Kemp's ridley sea turtles have recently been nesting along the Atlantic Coast of the United States, with nests recorded from beaches in Florida, Georgia, and the Carolinas. In 2012, the first Kemp's ridley sea turtle nest was recorded in Virginia. The Kemp's ridley nesting population had been exponentially increasing prior to the recent low nesting years, which may indicate that the population had been experiencing a similar increase. Additional nesting data in the coming years will be required to determine what the recent nesting decline means for the population trajectory.

Life History Information

Kemp's ridley sea 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 to 58 days of embryonic development, the hatchlings emerge and swim offshore into deeper, ocean water where they feed and grow until returning at a larger size. Hatchlings generally range from 1.65 to 1.89 in (42 to 48 mm) straight carapace length (SCL), 1.26 to 1.73 in (32 to 44 mm) in width, and 0.3 to 0.4 lb (15 to 20 g) in weight. Their return to nearshore coastal habitats typically occurs around 2 years of age (Ogren 1989), although the time spent in the oceanic zone may vary from 1 to 4 years or perhaps more (TEWG 2000). Juvenile Kemp's ridley sea turtles use these nearshore coastal habitats from April through November, but they move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water temperature drops.

The average rates of growth may vary by location, but generally fall within 2.2 to 2.9 ± 2.4 in per year (5.5 to 7.5 ± 6.2 cm/year) (Schmid and Barichivich 2006; Schmid and Woodhead 2000). Age to sexual maturity ranges greatly from 5 to 16 years, though NMFS et al. (2011) determined the best estimate of age to maturity for Kemp's ridley sea turtles was 12 years. It is unlikely that most adults grow very much after maturity. While some sea turtles nest annually, the weighted mean remigration rate for Kemp's ridley sea turtles is approximately 2 years. Nesting generally occurs from April to July. Females lay approximately 2.5 nests per season with each nest containing approximately 100 eggs (Márquez M. 1994).

Population Dynamics

Of the 7 species of sea turtles in the world, the Kemp's ridley has declined to the lowest population level. Most of the population of adult females nest on the beaches of Rancho Nuevo, Mexico (Pritchard 1969). When nesting aggregations at Rancho Nuevo were discovered in 1947, adult female populations were estimated to be in excess of 40,000 individuals (Hildebrand 1963). By the mid-1980s, however, nesting numbers from Rancho Nuevo and adjacent Mexican beaches were below 1,000, with a low of 702 nests in 1985. Yet, nesting steadily increased through the 1990s, and then accelerated during the first decade of the twenty-first century (Figure 9), which indicates the species is recovering.

It is worth noting that when the Bi-National Kemp's Ridley Sea Turtle Population Restoration Project was initiated in 1978, only Rancho Nuevo nests were recorded. In 1988, nesting data from southern beaches at Playa Dos and Barra del Tordo were added. In 1989, data from the northern beaches of Barra Ostionales and Tepehuajes were added, and most recently in 1996, data from La Pesca and Altamira beaches were recorded. Currently, nesting at Rancho Nuevo accounts for just over 81% of all recorded Kemp's ridley nests in Mexico. Nesting data show a long term population increase from 1989 to 2009. Since that period the population of nesting females has fluctuated with high nest counts in 2011, 2012, 2017, and 2020 but low nest counts in 2010, 2014, 2015 and 2019. Record high nesting was observed in 2017, with 24,570 nests recorded (J. Pena, pers. comm., August 31, 2017), but nesting for 2018 declined to 17,945, with another steep drop to 11,090 nests in 2019 (Gladys Porter Zoo data, 2019). Nesting numbers rebounded in 2020 (18,068 nests), 2021 (17,671 nests), and 2022 (17,418) (CONAMP data, 2022).At this time, it is unclear whether the increases and declines in nesting seen over the past decade-and-a-half represents a population oscillating around an equilibrium point, if the recent three years (2020-2022) of relatively steady nesting indicates that equilibrium point, or if nesting will decline or increase in the future. Therefore, we can only conclude that the population has dramatically rebounded from the lows seen in the 80's and 90's, but we cannot ascertain a current population trend or trajectory.

A small nesting population is also emerging in the United States, primarily in Texas, rising from 6 nests in 1996 to 42 in 2004, to a record high of 353 nests in 2017 (National Park Service [NPS] data). It is worth noting that nesting in Texas has somewhat paralleled the trends observed in Mexico, characterized by a significant decline in 2010, but record nesting in 2017. More recently we've observed biennial fluctuations in nest counts, with 190 nests in 2019, 262 nests in 2020, 195 nests in 2021, and 284 nests in 2022 (NPS data, https://www.nps.gov/pais/learn/nature/current-nesting-season.htm, accessed April 4, 2023).

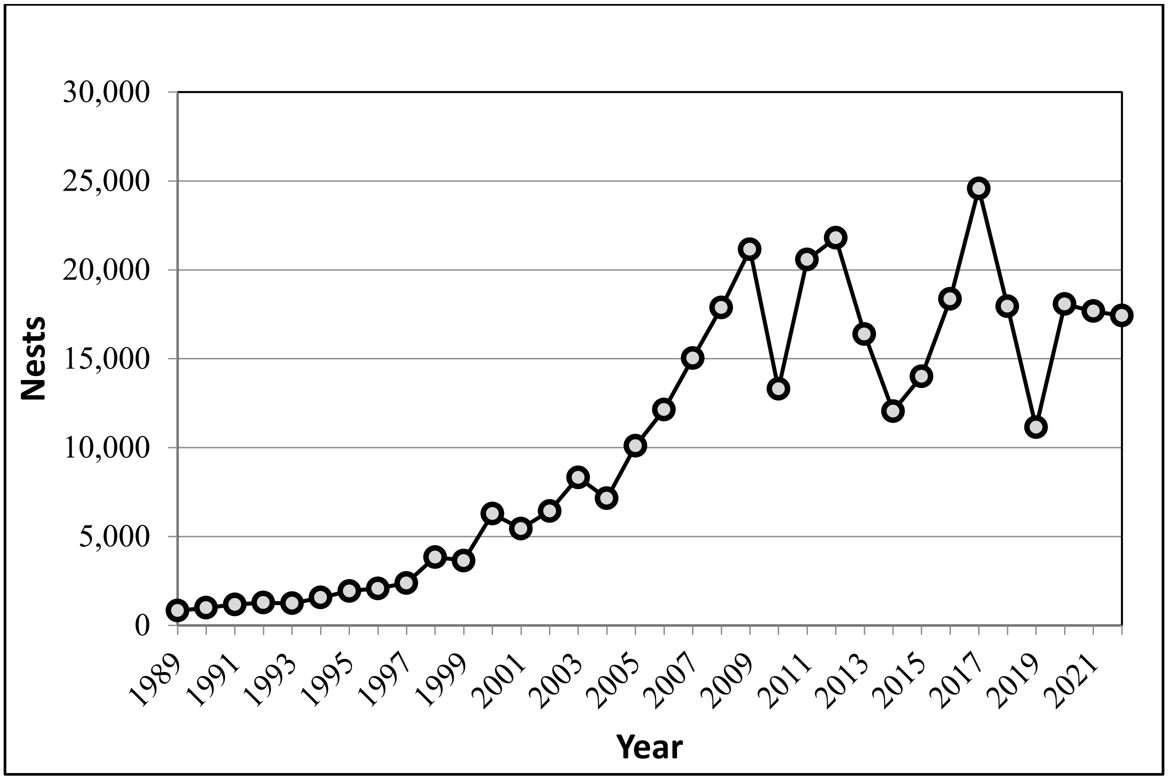


Figure 9. Kemp's ridley nest totals from Mexican beaches (Gladys Porter Zoo nesting database 2019 and CONAMP data 2020-2022).

Through modelling, Heppell et al. (2005) predicted the population is expected to increase at least 12 to 16% per year and could reach at least 10,000 females nesting on Mexico beaches by 2015. NMFS et al. (2011) produced an updated model that predicted the population to increase 19% per year and to attain at least 10,000 females nesting on Mexico beaches by 2011. Approximately 25,000 nests would be needed for an estimate of 10,000 nesters on the beach, based on an average 2.5 nests/nesting female. While counts did not reach 25,000 nests by 2015, it is clear that the population has increased over the long term. The increases in Kemp's ridley sea turtle nesting over the last 2 decades is likely due to a combination of management measures including elimination of direct harvest, nest protection, the use of turtle excluder devices (TEDs), reduced trawling effort in Mexico and the United States, and possibly other changes in vital rates (TEWG 1998; TEWG 2000). While these results are encouraging, the species' limited range as well as low global abundance makes it particularly vulnerable to new sources of mortality as well as demographic and environmental randomness, all factors which are often difficult to predict with any certainty. Additionally, the significant nesting declines observed in 2010 and 2013 to 2014 potentially indicate a serious population-level impact, and there is cause for concern regarding the ongoing recovery trajectory.

Threats

Kemp's ridley sea 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. A discussion on general sea turtle threats can be found in Section 4.1.1; the remainder of this section will expand on a few of the aforementioned threats and how they may specifically impact Kemp's ridley sea turtles.

As Kemp's ridley sea turtles continue to recover and nesting *arribadas*[1] are increasingly established, bacterial and fungal pathogens in nests are also likely to increase. Bacterial and fungal pathogen impacts have been well documented in the large arribadas of the olive ridley at Nancite in Costa Rica (Mo 1988). In some years, and on some sections of the beach, the hatching success can be as low as 5% (Mo 1988). As the Kemp's ridley nest density at Rancho Nuevo and adjacent beaches continues to increase, appropriate monitoring of emergence success will be necessary to determine if there are any density-dependent effects.

Since 2010, we have documented (via the Sea Turtle Stranding and Salvage Network [STSSN] data, https://www.fisheries.noaa.gov/national/marine-life-distress/sea-turtle-stranding-and-salvage-network) elevated sea turtle strandings in the Northern Gulf of Mexico, particularly throughout the Mississippi Sound area. For example, in the first 3 weeks of June 2010, over 120 sea turtle strandings were reported from Mississippi and Alabama waters, none of which exhibited any signs of external oiling to indicate effects associated with the DWH oil spill event. A total of 644 sea turtle strandings were reported in 2010 from Louisiana, Mississippi, and Alabama waters, 561 (87%) of which were Kemp's ridley sea turtles. During March through May of 2011, 267 sea turtle strandings were reported from Mississippi and Alabama waters alone. A total of 525 sea turtle strandings were reported in 2011 from Louisiana, Mississippi, and Alabama waters, with the majority (455) having occurred from March through July, 390 (86%) of which were Kemp's ridley sea turtles. During 2012, a total of 384 sea turtles were reported from Louisiana, Mississippi, and Alabama waters. Of these reported strandings, 343 (89%) were Kemp's ridley sea turtles. During 2014, a total of 285 sea turtles were reported from Louisiana, Mississippi, and Alabama waters, though the data is incomplete. Of these reported strandings, 229 (80%) were Kemp's ridley sea turtles. These stranding numbers are significantly greater than reported in past years; Louisiana, Mississippi, and Alabama waters reported 42 and 73 sea turtle

---

[1] *Arribada* is the Spanish word for "arrival" and is the term used for massive synchronized nesting within the genus *Lepidochelys.*

strandings for 2008 and 2009, respectively. It should be noted that stranding coverage has increased considerably due to the DWH oil spill event.

Nonetheless, considering that strandings typically represent only a small fraction of actual mortality, these stranding events potentially represent a serious impact to the recovery and survival of the local sea turtle populations. While a definitive cause for these strandings has not been identified, necropsy results indicate a significant number of stranded turtles from these events likely perished due to forced submergence, which is commonly associated with fishery interactions (B. Stacy, NMFS, pers. comm. to M. Barnette, NMFS PRD, March 2012). Yet, available information indicates fishery effort was extremely limited during the stranding events. The fact that 80% or more of all Louisiana, Mississippi, and Alabama stranded sea turtles in the past 5 years were Kemp's ridleys is notable; however, this could simply be a function of the species' preference for shallow, inshore waters coupled with increased population abundance, as reflected in recent Kemp's ridley nesting increases.

In response to these strandings, and due to speculation that fishery interactions may be the cause, fishery observer effort was shifted to evaluate the inshore skimmer trawl fisheries beginning in 2012. During May to July of that year, observers reported 24 sea turtle interactions in the skimmer trawl fisheries. All but a single sea turtle were identified as Kemp's ridleys (1 sea turtle was an unidentified hardshell turtle). Encountered sea turtles were all very small juvenile specimens, ranging from 7.6 to 19.0 in (19.4 to 48.3 cm) curved carapace length (CCL). Subsequent years of observation noted additional captures in the skimmer trawl fisheries, including some mortalities. The small average size of encountered Kemp's ridleys introduces a potential conservation issue, as over 50% of these reported sea turtles could potentially pass through the maximum 4-in bar spacing of TEDs currently required in the shrimp fisheries. Due to this issue, a proposed 2012 rule to require 4-in bar spacing TEDs in the skimmer trawl fisheries (77 FR 27411) was not implemented. Following additional gear testing, however, we proposed a new rule in 2016 (81 FR 91097) to require TEDs with 3-in bar spacing for all vessels using skimmer trawls, pusher-head trawls, or wing nets. Ultimately, we published a final rule on December 20, 2019 (84 FR 70048), that requires all skimmer trawl vessels 40 ft and greater in length to use TEDs designed to exclude small sea turtles in their nets effective April 1, 2021. As we previously noted, we delayed the effective date of this final rule until August 1, 2021, due to safety and travel restrictions related to the COVID-19 pandemic that prevented necessary training and outreach for fishers. Given the nesting trends and habitat utilization of Kemp's ridley sea turtles, it is likely that fishery interactions in the Northern Gulf of Mexico may continue to be an issue of concern for the species, and one that may potentially slow the rate of recovery for Kemp's ridley sea turtles.

While oil spill impacts are discussed generally for all species in Section 4.1.1, specific impacts of the DWH oil spill event on Kemp's ridley sea turtles are considered here. Kemp's ridleys experienced the greatest negative impact stemming from the DWH oil spill event of any sea turtle species. Impacts to Kemp's ridley sea turtles occurred to offshore small juveniles, as well as large juveniles and adults. Loss of hatchling production resulting from injury to adult turtles was also estimated for this species. Injuries to adult turtles of other species, such as loggerheads, certainly would have resulted in unrealized nests and hatchlings to those species as well. Yet, the calculation of unrealized nests and hatchlings was limited to Kemp's ridleys for several reasons.

All Kemp's ridleys in the Gulf belong to the same population (NMFS et al. 2011), so total population abundance could be calculated based on numbers of hatchlings because all individuals that enter the population could reasonably be expected to inhabit the northern Gulf of Mexico throughout their lives (DWH Trustees 2016).

A total of 217,000 small juvenile Kemp's ridleys (51.5% of the total small juvenile sea turtle exposures to oil from the spill) were estimated to have been exposed to oil. That means approximately half of all small juvenile Kemp's ridleys from the total population estimate of 430,000 oceanic small juveniles were exposed to oil. Furthermore, a large number of small juveniles were removed from the population, as up to 90,300 small juveniles Kemp's ridleys are estimated to have died as a direct result of the exposure. Therefore, as much as 20% of the small oceanic juveniles of this species were killed during that year. Impacts to large juveniles (>3 years old) and adults were also high. An estimated 21,990 such individuals were exposed to oil (about 22% of the total estimated population for those age classes); of those, 3,110 mortalities were estimated (or 3% of the population for those age classes). The loss of near-reproductive and reproductive-stage females would 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 nests is between 1,300 and 2,000, which translates to between approximately 65,000 and 95,000 unrealized hatchlings (DWH Trustees 2016). This is a minimum estimate, however, because the sublethal effects of the DWH oil spill event on 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 DWH oil spill event. These sublethal effects could have slowed growth and maturation rates, increased remigration intervals, and decreased clutch frequency (number of nests per female per nesting season). The nature of the DWH oil spill event effect on reduced Kemp's ridley nesting abundance and associated hatchling production after 2010 requires further evaluation. It is clear that the DWH oil spill event resulted in large losses to the Kemp's ridley population across various age classes, and likely had an important population-level effect on the species. Still, we do not have a clear understanding of those impacts on the population trajectory for the species into the future.

4.5 Loggerhead Sea Turtle (NWA DPS)

The loggerhead sea turtle was listed as a threatened species throughout its global range on July 28, 1978. We, along with USFWS, published a final rule on September 22, 2011, which designated 9 DPSs for loggerhead sea turtles (76 FR 58868, effective October 24, 2011). This rule listed the following DPSs: 1) NWA (threatened); 2) Northeast Atlantic Ocean (endangered); 3) South Atlantic Ocean (threatened); 4) Mediterranean Sea (endangered); 5) North Pacific Ocean (endangered); 6) South Pacific Ocean (endangered); 7) North Indian Ocean (endangered); 8) Southeast Indo-Pacific Ocean (endangered); and 9) Southwest Indian Ocean (threatened). The NWA DPS is the only one that occurs within the action area, and therefore it is the only one considered in this Opinion.

Species Description and Distribution

Loggerheads are large sea turtles. Adults in the southeast United States average about 3 ft (92 cm) SCL, and weigh approximately 255 lb (116 kg) (Ehrhart and Yoder 1978). Adult and subadult loggerhead sea turtles typically have a light yellow plastron and a reddish brown carapace covered by non-overlapping scutes that meet along seam lines. They typically have 11 or 12 pairs of marginal scutes, 5 pairs of costals, 5 vertebrals, and a nuchal (precentral) scute that is in contact with the first pair of costal scutes (Dodd Jr. 1988).

The loggerhead sea turtle inhabits continental shelf and estuarine environments throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd Jr. 1988). Habitat use within these areas vary by life stage. Juveniles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd Jr. 1988). Subadult and adult loggerheads are primarily found in coastal waters and eat benthic invertebrates such as mollusks and decapod crustaceans in hard bottom habitats.

The majority of loggerhead nesting occurs at the western rims of the Atlantic and Indian Oceans concentrated in the north and south temperate zones and subtropics (NRC 1990). For the NWA DPS, most nesting occurs along the coast of the United States, from southern Virginia to Alabama. Additional nesting beaches for this DPS are found 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 Caribbean Islands.

Non-nesting, adult female loggerheads are reported throughout the U.S. Atlantic, Gulf of Mexico, and Caribbean Sea. Little is known about the distribution of adult males who are seasonally abundant near nesting beaches. Aerial surveys suggest that loggerheads as a whole are distributed in U.S. waters as follows: 54% off the southeast U.S. coast, 29% off the northeast U.S. coast, 12% in the eastern Gulf of Mexico, and 5% in the western Gulf of Mexico (TEWG 1998).

Within the NWA DPS, most loggerhead sea turtles nest from North Carolina to Florida and along the Gulf Coast of Florida. Previous Section 7 analyses have recognized at least 5 western Atlantic subpopulations, divided geographically as follows: 1) a Northern nesting subpopulation, occurring from North Carolina to northeast Florida at about 29ºN; 2) a South Florida nesting subpopulation, occurring from 29°N on the east coast of the state to Sarasota on the west coast; 3) a Florida Panhandle nesting subpopulation, occurring at Eglin Air Force Base and the beaches near Panama City, Florida; 4) a Yucatán nesting subpopulation, occurring on the eastern Yucatán Peninsula, Mexico (Márquez M. 1990; TEWG 2000); and 5) a Dry Tortugas nesting subpopulation, occurring in the islands of the Dry Tortugas, near Key West, Florida (NMFS 2001).

The recovery plan for the Northwest Atlantic population of loggerhead sea turtles concluded that there is no genetic distinction between loggerheads nesting on adjacent beaches along the Florida Peninsula. It also concluded that specific boundaries for subpopulations could not be designated based on genetic differences alone. Thus, the recovery plan uses a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to identify recovery units. The recovery units are as follows: 1) the Northern Recovery Unit (Florida/Georgia border north through southern Virginia); 2) the Peninsular Florida Recovery Unit (Florida/Georgia border through Pinellas County, Florida); 3) the Dry Tortugas Recovery Unit (islands located west of Key West, Florida); 4) the Northern

Gulf of Mexico Recovery Unit (Franklin County, Florida, through Texas); and 5) the Greater Caribbean Recovery Unit (Mexico through French Guiana, the Bahamas, Lesser Antilles, and Greater Antilles) (NMFS and USFWS 2008). The recovery plan concluded that all recovery units are essential to the recovery of the species. Although the recovery plan was written prior to the listing of the NWA DPS, the recovery units for what was then termed the Northwest Atlantic population apply to the NWA DPS.

Life History Information

The Northwest Atlantic Loggerhead Recovery Team defined the following 8 life stages for the loggerhead life cycle, which include the ecosystems those stages generally use: 1) egg (terrestrial zone); 2) hatchling stage (terrestrial zone); 3) hatchling swim frenzy and transitional stage (neritic zone[2]); 4) juvenile stage (oceanic zone); 5) juvenile stage (neritic zone); 6) adult stage (oceanic zone); 7) adult stage (neritic zone); and 8) nesting female (terrestrial zone) (NMFS and USFWS 2008). Loggerheads are long-lived animals. They reach sexual maturity between 20-38 years of age, although age of maturity varies widely among populations (Frazer and Ehrhart 1985; NMFS 2001). The annual mating season occurs from late March to early June, and female turtles lay eggs throughout the summer months. Females deposit an average of 4.1 nests within a nesting season (Murphy and Hopkins 1984), but an individual female only nests every 3.7 years on average (Tucker 2010). Each nest contains an average of 100-126 eggs (Dodd Jr. 1988) which incubate for 42-75 days before hatching (NMFS and USFWS 2008). Loggerhead hatchlings are 1.5-2 in long and weigh about 0.7 oz (20 g).

As post-hatchlings, loggerheads hatched on U.S. 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. 2009; Witherington 2002). Oceanic juveniles grow at rates of 1-2 in (2.9-5.4 cm) 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 sea 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 turtles may either remain in the oceanic habitat in the North Atlantic longer than hypothesized, or they move back and forth between oceanic and coastal habitats interchangeably (Witzell 2002). Stranding records indicate that when immature loggerheads reach 15-24 in (40-60 cm) SCL, they begin to reside in coastal inshore waters of the continental shelf throughout the U.S. Atlantic and Gulf of Mexico (Witzell 2002).

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

---

[2] Neritic refers to the nearshore marine environment from the surface to the sea floor where water depths do not exceed 200 m.

Like juveniles, non-nesting adult loggerheads also use the neritic zone. However, these adult loggerheads 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 Indian River Lagoon, Florida, are regularly used by juveniles but not by adult loggerheads. Adult loggerheads do tend to use estuarine areas with more open ocean access, such as the Chesapeake Bay in the U.S. mid-Atlantic. Shallow-water habitats with large expanses of open ocean access, such as Florida Bay, provide year-round resident foraging areas for significant numbers of male and female adult loggerheads (Conant et al. 2009).

Offshore, adults primarily inhabit continental shelf waters, from New York south through Florida, The Bahamas, Cuba, and the Gulf of Mexico. Seasonal use of mid-Atlantic shelf waters, especially offshore 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 also been documented (Hawkes et al. 2007; Georgia Department of Natural Resources [GADNR], unpublished data; South Carolina Department of Natural Resources [SCDNR], unpublished data). Satellite telemetry has identified the shelf waters along the west Florida coast, the Bahamas, Cuba, and the Yucatán Peninsula as important resident areas for adult female loggerheads 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 loggerheads 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 in the United States, and along the north coast of Cuba (A. Bolten and K. Bjorndal, University of Florida, unpublished data). Moncada et al. (2010) report the recapture of 5 adult female loggerheads in Cuban waters originally flipper-tagged in Quintana Roo, Mexico, which indicates that Cuban shelf waters likely also provide foraging habitat for adult females that nest in Mexico.

Status and Population Dynamics

A number of stock assessments and similar reviews (Conant et al. 2009; Heppell et al. 2003; NMFS 2009a; NMFS 2001; NMFS and USFWS 2008; TEWG 1998; TEWG 2000; TEWG 2009) have examined the stock status of loggerheads in the Atlantic Ocean, but none have been able to develop a reliable estimate of absolute population size.

Numbers of nests and nesting females can vary widely from year to year. Nesting beach surveys, though, can provide a reliable assessment of trends in the adult female population, due to the strong nest site fidelity of female loggerhead sea turtles, as long as such studies are sufficiently long and survey effort and methods are standardized (e.g., NMFS and USFWS 2008). NMFS and USFWS (2008) concluded that the lack of change in 2 important demographic parameters of loggerheads, remigration interval and clutch frequency, indicate that time series on numbers of nests can provide reliable information on trends in the female population.

Peninsular Florida Recovery Unit

The Peninsular Florida Recovery Unit (PFRU) is the largest loggerhead nesting assemblage in the Northwest Atlantic. A near-complete nest census (all beaches including index nesting beaches) undertaken from 1989 to 2007 showed an average of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females per year (NMFS and USFWS 2008). The statewide estimated total for 2017 was 96,912 nests (FWRI nesting database).

In addition to the total nest count estimates, the Florida Fish and Wildlife Research Institute (FWRI) uses an index nesting beach survey method. The index survey uses standardized data-collection criteria to measure seasonal nesting and allow accurate comparisons between beaches and between years. This provides a better tool for understanding the nesting trends (Figure 10). FWRI performed a detailed analysis of the long-term loggerhead index nesting data (1989-2017; http://myfwc.com/research/wildlife/sea-turtles/nesting/loggerhead-trend/). Over that time period, 3 distinct trends were identified. From 1989-1998, there was a 24% increase that was followed by a sharp decline over the subsequent 9 years. A large increase in loggerhead nesting has occurred since, as indicated by the 71% increase in nesting over the 10-year period from 2007 and 2016. Nesting in 2016 also represented a new record for loggerheads on the core index beaches. FWRI examined the trend from the 1998 nesting high through 2016 and found that the decade-long post-1998 decline was replaced with a slight but non-significant increasing trend. Looking at the data from 1989 through 2016, FWRI concluded the overall trend was uncertain, likely due to the wide variability between 2012 and 2016 resulting in widening confidence intervals. Nesting at the core index beaches declined in 2017 to 48,033, and rose slightly again to 48,983 in 2018 and then 53,507 in 2019, which is the 3rd highest total since 2001. However, it is important to note that with the wide confidence intervals and uncertainty around the variability in nesting parameters (changes and variability in nests/female, nesting intervals, etc.) it is unclear whether the nesting trend equates to an increase in the population or nesting females over that time frame (Ceriani, et al. 2019).

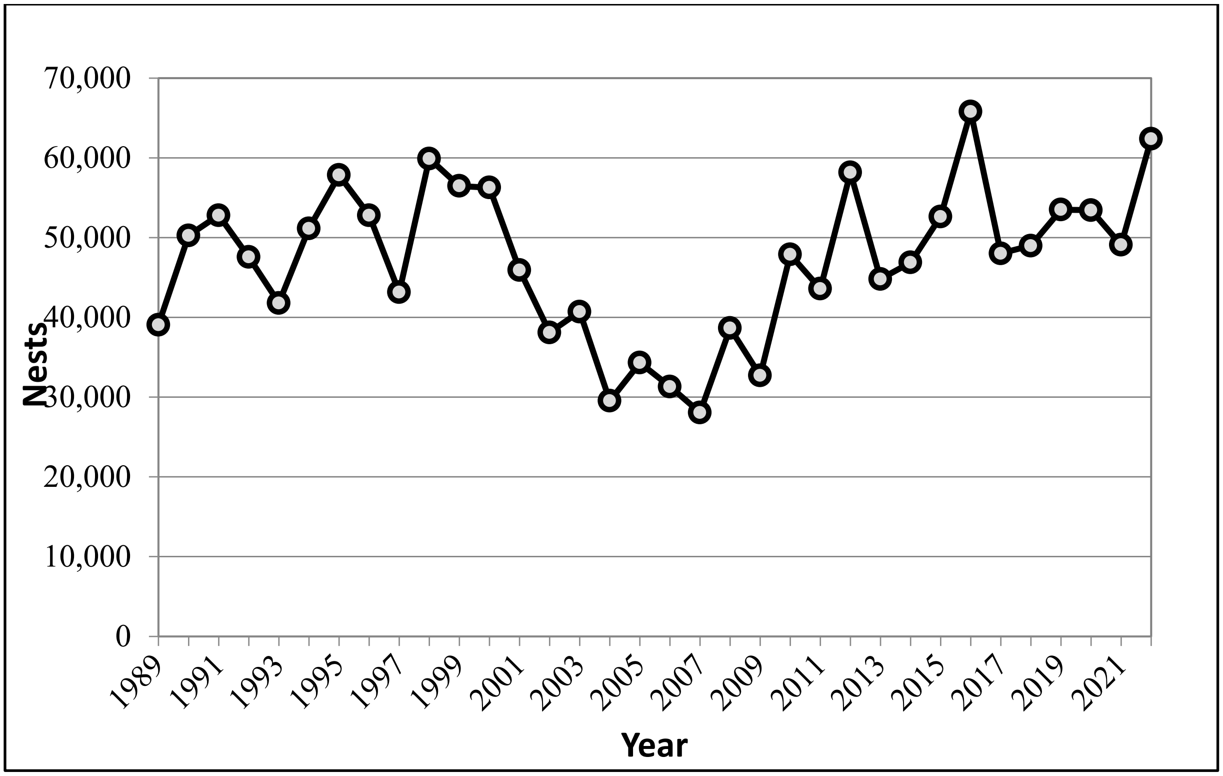


Figure 10. Loggerhead sea turtle nesting at Florida index beaches since 1989.

Northern Recovery Unit
Annual nest totals from beaches within the Northern Recovery Unit (NRU) averaged 5,215 nests from 1989-2008, a period of near-complete surveys of NRU nesting beaches (GADNR unpublished data, North Carolina Wildlife Resources Commission [NCWRC] unpublished data, SCDNR unpublished data), and represent approximately 1,272 nesting females per year, assuming 4.1 nests per female (Murphy and Hopkins 1984). The loggerhead nesting trend from daily beach surveys showed a significant decline of 1.3% annually from 1989-2008. Nest totals from aerial surveys conducted by SCDNR showed a 1.9% annual decline in nesting in South Carolina from 1980-2008. Overall, there are strong statistical data to suggest the NRU had experienced a long-term decline over that period of time.

Data since that analysis (Table 3) are showing improved nesting numbers and a departure from the declining trend. Georgia nesting has rebounded to show the first statistically significant increasing trend since comprehensive nesting surveys began in 1989 (Mark Dodd, GADNR press release, http://www.georgiawildlife.com/node/3139). South Carolina and North Carolina nesting have also begun to shift away from the past declining trend. Loggerhead nesting in Georgia, South Carolina, and North Carolina all broke records in 2015 and then topped those records again in 2016. Nesting in 2017 and 2018 declined relative to 2016, back to levels seen in 2013 to 2015, but then bounced back in 2019, breaking records for each of the three states and the overall recovery unit.

Table 3. Total Number of NRU Loggerhead Nests (GADNR, SCDNR, and NCWRC nesting datasets compiled at Seaturtle.org).

	Nests Recorded			
Year	**Georgia**	**South Carolina**	**North Carolina**	**Totals**
2008	1,649	4,500	841	**6,990**
2009	998	2,182	302	**3,472**
2010	1,760	3,141	856	**5,757**
2011	1,992	4,015	950	**6,957**
2012	2,241	4,615	1,074	**7,930**
2013	2,289	5,193	1,260	**8,742**
2014	1,196	2,083	542	**3,821**
2015	2,319	5,104	1,254	**8,677**
2016	3,265	6,443	1,612	**11,320**
2017	2,155	5,232	1,195	**8,582**
2018	1,735	2,762	765	**5,262**
2019	3,945	8,774	2,291	**15,010**
2020	2,786	5,551	1,335	**9,672**
2021	2,493	5,639	1,448	**9,580**
2022	4,071	7,970	1,906	**13,947**

In addition to the statewide nest counts, South Carolina also conducts an index beach nesting survey similar to the one described for Florida. Although the survey only includes a subset of nesting, the standardized effort and locations allow for a better representation of the nesting trend over time. Increases in nesting were seen for the period from 2009 to 2013, with a subsequent steep drop in 2014. Nesting then rebounded in 2015 and 2016, setting new highs each of those years. Nesting in 2017 dropped back down from the 2016 high, but was still the second highest on record. After another drop in 2018, a new record was set for the 2019 season, with a return to 2016 levels in 2020 and 2021, before a rebound to the second highest level on record in 2022 (Figure 11).

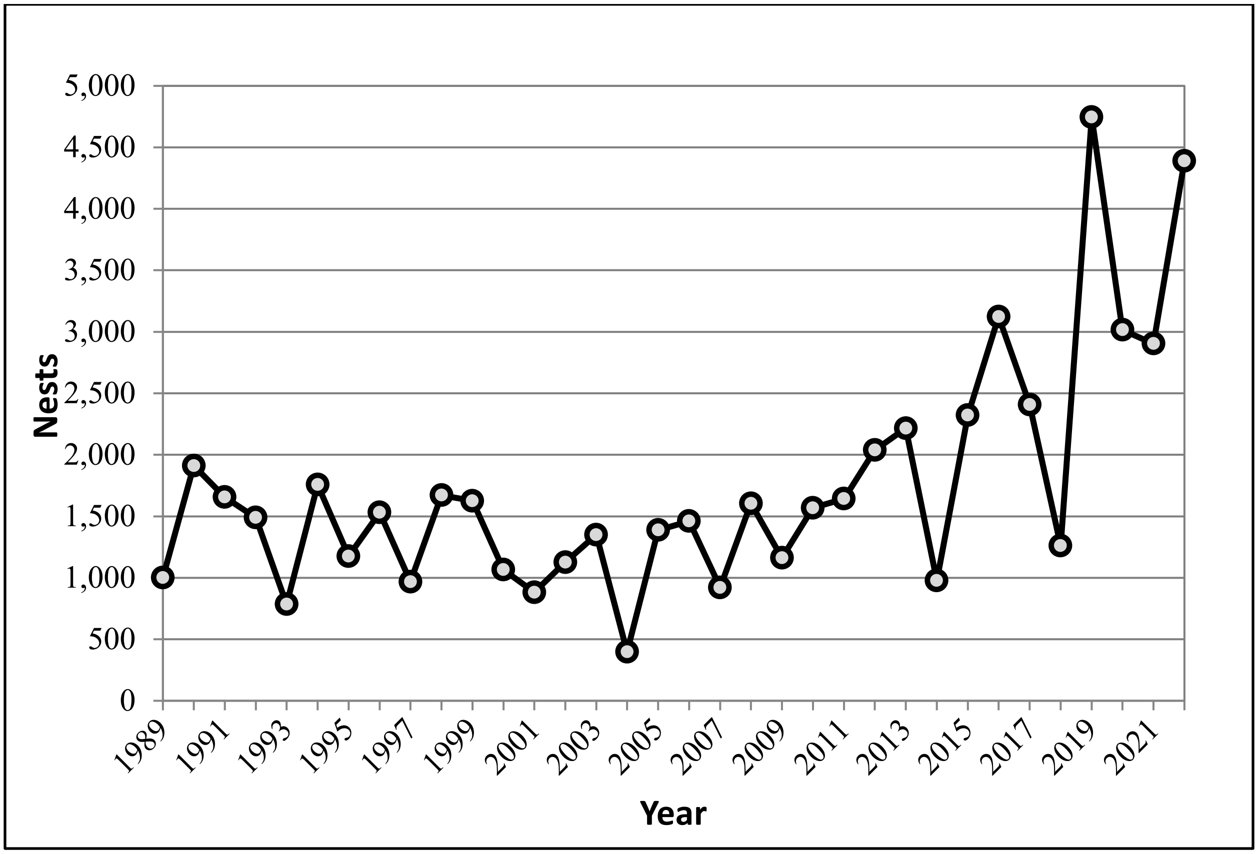


Figure 11. South Carolina index nesting beach counts for loggerhead sea turtles (http://www.dnr.sc.gov/seaturtle/nest.htm).

Other NWA DPS Recovery Units

The remaining 3 recovery units—Dry Tortugas (DTRU), Northern Gulf of Mexico (NGMRU), and Greater Caribbean (GCRU)—are much smaller nesting assemblages, but they are still considered essential to the continued existence of the species. Nesting surveys for the DTRU are conducted as part of Florida's statewide survey program. Survey effort was relatively stable during the 9-year period from 1995 to 2004, although the 2002 year was missed. Nest counts ranged from 168 to 270, with a mean of 246, but there was no detectable trend during this period (NMFS and USFWS 2008). Nest counts for the NGMRU are focused on index beaches rather than all beaches where nesting occurs. Analysis of the 12-year dataset (1997 to 2008) of index nesting beaches in the area shows a statistically significant declining trend of 4.7% annually. Nesting on the Florida Panhandle index beaches, which represents the majority of NGMRU nesting, had shown a large increase in 2008, but then declined again in 2009 and 2010 before rising back to a level similar to the 2003 to 2007 average in 2011. Nesting survey effort has been inconsistent among the GCRU nesting beaches, and no trend can be determined for this subpopulation (NMFS and USFWS 2008). Zurita et al. (2003) found a statistically significant increase in the number of nests on 7 of the beaches on Quintana Roo, Mexico, from 1987 to

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 2008).

In-water Trends

Nesting data are the best current indicator of sea turtle population trends, but in-water data also provide some insight. In-water research suggests the abundance of neritic juvenile loggerheads is steady or increasing. Although Ehrhart et al. (2007) found no significant regression-line trend in a long-term dataset, researchers have observed notable increases in catch per unit effort (CPUE) (Arendt et al. 2009; Ehrhart et al. 2007; Epperly et al. 2007). Researchers believe that this increase in CPUE is likely linked to an increase in juvenile abundance, although it is unclear whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence. Bjorndal et al. (2005), cited in NMFS and USFWS (2008), caution about extrapolating localized in-water trends to the broader population and relating localized trends in neritic sites to population trends at nesting beaches. The apparent overall increase in the abundance of neritic loggerheads in the southeastern United States may be due to increased abundance of the largest oceanic/neritic juveniles (historically referred to as small benthic juveniles), which could indicate a relatively large number of individuals around the same age may mature in the near future (TEWG 2009). In-water studies throughout the eastern United States, however, indicate a substantial decrease in the abundance of the smallest oceanic/neritic juvenile loggerheads, a pattern corroborated by stranding data (TEWG 2009).

Population Estimate

Our SEFSC developed a preliminary stage/age demographic model to help determine the estimated impacts of mortality reductions on loggerhead sea turtle population dynamics (NMFS 2009a). The model uses the range of published information for the various parameters including mortality by stage, stage duration (years in a stage), and fecundity parameters such as eggs per nest, nests per nesting female, hatchling emergence success, sex ratio, and remigration interval. Resulting trajectories of model runs for each individual recovery unit, and the western North Atlantic population as a whole, were found to be very similar. The model run estimates from the adult female population size for the western North Atlantic (from the 2004 to 2008 time frame), suggest the adult female population size is approximately 20,000 to 40,000 individuals, with a low likelihood of females' numbering up to 70,000 (NMFS 2009a). A less robust estimate for total benthic females in the western North Atlantic was also obtained, yielding approximately 30,000 to 300,000 individuals, up to less than 1 million (NMFS 2009a). A preliminary regional abundance survey of loggerheads within the northwestern Atlantic continental shelf for positively identified loggerhead in all strata estimated about 588,000 loggerheads (interquartile range of 382,000 to 817,000). When correcting for unidentified turtles in proportion to the ratio of identified turtles, the estimate increased to about 801,000 loggerheads (interquartile range of 521,000 to 1,111,000) (NMFS 2011a).

Threats

The threats faced by loggerhead sea turtles are well summarized in the general discussion of threats in Section 4.1.1. Yet the impact of fishery interactions is a point of further emphasis for this species. The joint Loggerhead Biological Review Team determined that the greatest threats to the NWA DPS of loggerheads result from cumulative fishery bycatch in neritic and oceanic habitats (Conant et al. 2009).

Regarding the impacts of pollution, loggerheads may be particularly affected by organochlorine contaminants; they have the highest organochlorine concentrations (Storelli et al. 2008) and metal loads (D'Ilio et al. 2011) in sampled tissues among the sea turtle species. It is thought that dietary preferences were likely to be the main differentiating factor among sea turtle species. Storelli et al. (2008) analyzed tissues from stranded loggerhead sea turtles and found that mercury accumulates in sea turtle livers while cadmium accumulates in their kidneys, as has been reported for other marine organisms like dolphins, seals, and porpoises (Law et al. 1991).

While oil spill impacts are discussed generally for all species in Section 4.1.1, specific impacts of the DWH oil spill event on loggerhead sea turtles are considered here. Impacts to loggerhead sea turtles occurred to offshore small juveniles as well as large juveniles and adults. A total of 30,800 small juvenile loggerheads (7.3% of the total small juvenile sea turtle exposures to oil from the spill) were estimated to have been exposed to oil. Of those exposed, 10,700 small juveniles are estimated to have died as a result of the exposure. In contrast to small juveniles, loggerheads represented a large proportion of the adults and large juveniles exposed to and killed by the oil. There were 30,000 exposures (almost 52% of all exposures for those age/size classes) and 3,600 estimated mortalities. A total of 265 nests (27,618 eggs) were also translocated during response efforts, with 14,216 hatchlings released, the fate of which is unknown (DWH Trustees 2016). Additional unquantified effects may have included inhalation of volatile compounds, disruption of foraging or migratory movements due to surface or subsurface oil, ingestion of prey species contaminated with oil or dispersants, and loss of foraging resources that could lead to compromised growth or reproductive potential. There is no information currently available to determine the extent of those impacts, if they occurred.

Unlike Kemp’s ridleys, the majority of nesting for the NWA DPS occurs on the Atlantic coast and, thus, loggerheads were impacted to a relatively lesser degree. However, it is likely that impacts to the NGMRU of the NWA DPS would be proportionally much greater than the impacts occurring to other recovery units. Impacts to nesting and oiling effects on a large proportion of the NGMRU recovery unit, especially mating and nesting adults likely had an impact on the NGMRU. Based on the response injury evaluations for Florida Panhandle and Alabama nesting beaches (which fall under the NFMRU), the DWH Trustees (2016) estimated that approximately 20,000 loggerhead hatchlings were lost due to DWH oil spill response activities on nesting beaches. Although the long-term effects remain unknown, the DWH oil spill event impacts to the Northern Gulf of Mexico Recovery Unit may result in some nesting declines in the future due to a large reduction of oceanic age classes during the DWH oil spill event. Although adverse impacts occurred to loggerheads, the proportion of the population that is expected to have been exposed to and directly impacted by the DWH oil spill event is relatively low. Thus, we do not believe a population-level impact occurred due to the widespread distribution and nesting location outside of the Gulf of Mexico for this species.

Specific information regarding potential climate change impacts on loggerheads is also available. Modeling suggests an increase of 2°C in air temperature would result in a sex ratio of over 80% female offspring for loggerheads nesting near Southport, North Carolina. The same increase in air temperatures at nesting beaches in Cape Canaveral, Florida, would result in close to 100% female offspring. Such highly skewed sex ratios could undermine the reproductive capacity of the species. More ominously, an air temperature increase of 3°C is likely to exceed the thermal threshold of most nests, leading to egg mortality (Hawkes et al. 2007). Warmer sea surface temperatures have also been correlated with an earlier onset of loggerhead nesting in the spring (Hawkes et al. 2007; Weishampel et al. 2004), short inter-nesting intervals (Hays et al. 2002), and shorter nesting seasons (Pike et al. 2006). We expect these issues may affect other sea turtle species similarly.

5 ENVIRONMENTAL BASELINE

5.1 Overview

This section describes the effects of past and ongoing human and natural factors contributing to the current status of the species, their habitats, and the ecosystem within the action area without the additional effects of the proposed action. In the case of ongoing actions, this section includes the effects that may contribute to the projected future status of the species, their habitats, and ecosystem. The environmental baseline describes the species' health based on information available at the time of the consultation.

By regulation, the environmental baseline for an Opinion refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the 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 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 CFR 402.02).

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 endangered and threatened individuals that occur in an action area, that will be exposed to effects from the action under consultation. This focus is important because, in some states or life history stages, or areas of their ranges, 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.

5.2 Baseline Status of ESA-Listed Species Considered for Further Analysis

As stated in Section 2.2 (Action Area), the proposed action occurs throughout the C&SF watershed area from the headwaters of the Kissimmee River down to and through Florida Bay and the Keys, including LOK, CRE, the SLE, LWL, the Greater Everglades, and Southern Coastal Systems (Florida Bay and Biscayne Bay).

Based on STSSN data and information within their respective status reports, green sea turtles (NA DPS), Kemp's ridley sea turtles, and loggerhead sea turtles (NWA DPS) may be located in the action area and may be affected by the proposed action. All of these sea turtle species are migratory, traveling to forage grounds or for reproduction purposes. The nearshore waters of Florida from the SLE and around the peninsula to CRE, are used by these species of sea turtle as developmental and foraging habitat. NMFS believes that no individual sea turtle is likely to be a permanent resident of the nearshore waters of this area, although some individuals may be present at any given time. These same individuals will migrate into offshore waters of the Gulf of Mexico, Caribbean Sea, and other areas of the North Atlantic Ocean at certain times of the year, and thus may be affected by activities occurring there. Therefore, the status of the sea turtles species in the action area, as well as the threats to these sea turtles is supported by the species accounts in Section 4 (Status of ESA-Listed Species).

5.3 Additional Factors Affecting the Baseline Status of ESA-Listed Species Considered for Further Analysis

5.3.1 Federal Actions

Federally Managed Fisheries
There are a variety of federal fisheries that may operate in or near the action area, though most federal fishing will occur seaward. Threatened and endangered sea turtle and fish species are adversely affected by fishing gears used in and near the action area. Trawl gear and gillnets have been documented to interact with sea turtles, as well as sturgeon, smalltooth sawfish, scalloped hammerhead shark, and giant manta ray. Hook and line gear, including longlines affect listed shark species, smalltooth sawfish, giant manta rays, and sea turtles. Pot fisheries are yet another gear known to affect sea turtles and giant manta rays. For all federal fisheries for which there is a fishery management plan (FMP), impacts have been evaluated through Section 7 consultation. Some of these consultations resulted in subsequent rulemaking to reduce the impacts of the specific fisheries on protected species. Examples include additional monitoring of and TED requirements in the southeast U.S. shrimp fisheries, as well as gear limitations and mandatory possession and use of sea turtle release equipment to reduce bycatch mortality in Atlantic highly migratory species (HMS) fisheries and reef fish fisheries. All Opinions had an ITS and determined that fishing activities, as considered (i.e., with conservation requirements) would not jeopardize any listed species. Current anticipated take levels associated with these fisheries reflect the impact on listed species of each activity anticipated from the date of the ITS forward in time. A summary of each of consultation is provided below; more detailed information can be found in the respective fisheries' most recent Opinions, which are also cited in the corresponding sections below, and are incorporated herein by reference.

Southeastern Shrimp Trawl Fisheries
NMFS has prepared Opinions on shrimp trawling numerous times over the years (most recently 2021). The consultation history is closely tied to the lengthy regulatory history governing the use of TEDs and a series of regulations aimed at reducing potential for incidental mortality of sea turtles in commercial shrimp trawl fisheries. However, the fishery is also known to affect smalltooth sawfish, giant manta rays, and sturgeons. By the late 1970s, there was evidence that

thousands of sea turtles were being killed annually in the Southeast (Henwood and Stuntz 1987). In 1990, the National Research Council concluded the Southeast shrimp trawl fishery affected more sea turtles than all other activities combined and was the most significant anthropogenic source of sea turtle mortality in the U.S. waters, in part due to the high reproductive value of turtles taken in this fishery (NRC 1990).

The level of annual mortality described in (NRC 1990) is believed to have continued until 1992-1994, when U.S. regulations required all shrimp trawlers in the Atlantic and Gulf of Mexico to use TEDs, allowing at least some sea turtles to escape nets before drowning (NMFS 2002). TEDs approved for use have had to demonstrate 97% effectiveness in excluding sea turtles from trawls in controlled testing. These regulations have been refined over the years to ensure that TED effectiveness is maximized through proper placement and installation, configuration (e.g., width of bar spacing), flotation, and more widespread use.

Despite the apparent success of TEDs for some species of sea turtles (e.g., Kemp's ridleys), it was later discovered that TEDs were not adequately protecting all species and size classes of sea turtles. Analyses by Epperly and Teas (2002) indicated that the minimum requirements for the escape opening dimension in TEDs in use at that time were too small for some sea turtles and that as many as 47% of the loggerheads stranding annually along the Atlantic and Gulf of Mexico were too large to fit the existing openings. On December 2, 2002, NMFS completed an Opinion on shrimp trawling in the southeastern U.S. (NMFS 2002) under proposed revisions to the TED regulations requiring larger escape openings (68 FR 8456, February 21, 2003). This Opinion determined that the shrimp trawl fishery under the revised TED regulations would not jeopardize the continued existence of any sea turtle species and would be unlikely to adversely affect other ESA-listed species in the action area. The determination was based in part on the Opinion's analysis that showed the revised TED regulations were expected to reduce shrimp trawl related mortality by 94% for loggerheads and 97% for leatherbacks. In February 2003, NMFS implemented the revisions to the TED regulations.

On May 9, 2012, NMFS completed an Opinion that analyzed the implementation of the sea turtle conservation regulations that contain TED provisions, and the operation of the Southeast U.S. shrimp fisheries in federal waters under the Magnuson-Stevens Act (NMFS 2012a). The Opinion also considered a proposed amendment to the sea turtle conservation regulations to withdraw the alternative tow time restriction at 50 CFR 223.206(d)(2)(ii)(A)(3) for skimmer trawls, pusher-head trawls, and wing nets (butterfly trawls) and instead require all of those vessels to use TEDs. The Opinion concluded that the proposed action was not likely to jeopardize the continued existence of any sea turtle species. An ITS was provided that used anticipated trawl effort and fleet TED compliance (i.e., compliance resulting in overall average sea turtle catch rates in the shrimp otter trawl fleet at or below 12%) as surrogates for sea turtle takes. On November 21, 2012, NMFS determined that a Final Rule requiring TEDs in skimmer trawls, pusher-head trawls, and wing nets was not warranted and withdrew the proposal. The decision to not implement the Final Rule created a change to the proposed action analyzed in the 2012 Opinion. Consequently, NMFS reinitiated consultation on November 26, 2012. Consultation was completed in April 2014 and determined the implementation of the sea turtle conservation regulations and the operation of the Southeast U.S. shrimp fisheries in federal waters under the Magnuson-Stevens Act was not likely jeopardize the continued existence of any sea turtle species, smalltooth sawfish, Gulf sturgeon, and Atlantic sturgeon, while not adversely affecting other ESA-listed species and critical habitats. Subsequently, on December 20, 2019, NMFS published a final rule requiring all skimmer trawl vessels 40 ft and greater in length to use TEDs with 3-inch bar spacing or less, beginning on April 1, 2021 (84 FR 70048).

A new consultation on the shrimp fishery including the new TED requirement was completed on April 26, 2021. The Opinion concluded that the proposed action was not likely to jeopardize the continued existence of any sea turtle species, smalltooth sawfish, Gulf sturgeon, Atlantic sturgeon, and giant manta ray; while not adversely affecting other ESA-listed species and critical habitats. An ITS was provided to estimate the quantity of both capture and mortality of each species.

Gulf of Mexico Reef Fish Fishery

The Gulf of Mexico reef fish fishery uses 2 basic types of gear: spear or powerhead, and hook-and-line gear. Hook-and-line gear used in the fishery includes both commercial bottom longline and commercial and recreational vertical line (e.g., handline, bandit gear, rod-and-reel). Trap gear was phased-out completely by February 2007, but prior to that the gear likely resulted in a few sea turtle and smalltooth sawfish entanglements.

Prior to 2008, the reef fish fishery was believed to have a relatively moderate level of sea turtle bycatch attributed to the hook-and-line component of the fishery, with approximately 107 captures and 41 mortalities annually, all species combined, for the entire fishery (NMFS 2005). The hook-and-line components of the fishery have likely always had the most adverse effects on smalltooth sawfish. In 2008, our SEFSC observer program and subsequent analyses indicated that the overall amount and extent of incidental take for sea turtles specified in the ITS of the 2005 Opinion on the reef fish fishery had been severely exceeded by the bottom longline component (approximately 974 captures and at least 325 mortalities estimated for the period July 2006 to 2007).

In response, we published an emergency rule prohibiting the use of bottom longline gear in the reef fish fishery shoreward of a line approximating the 50-fathom depth contour in the eastern Gulf of Mexico, essentially closing the bottom longline sector of the reef fish fishery in the eastern Gulf of Mexico for 6 months pending the implementation of a long-term management strategy. The GMFMC developed a long-term management strategy via a new amendment (Amendment 31 to the Reef Fish FMP). The amendment included a prohibition on the use of bottom longline gear in the Gulf of Mexico reef fish fishery, shoreward of a line approximating the 35-fathom contour east of Cape San Blas, Florida, from June through August; a reduction in the number of bottom longline vessels operating in the fishery via an endorsement program; and a restriction on the total number of hooks that may be possessed onboard each Gulf of Mexico reef fish bottom longline vessel to 1,000, only 750 of which may be rigged for fishing.

On October 13, 2009, we completed an Opinion that analyzed the expected effects of the operation of the Gulf of Mexico reef fish fishery under the changes proposed in Amendment 31 (NMFS 2009b). The Opinion concluded that sea turtle takes would be substantially reduced compared to the fishery as it was previously prosecuted, and that operation of the fishery would not jeopardize the continued existence of any sea turtle species. Amendment 31 was implemented on May 26, 2010. In August 2011, we reinitiated consultation to address the DWH event and potential changes to the environmental baseline. Reinitiation of consultation was not related to any material change in the fishery itself, violations of any terms and conditions of the 2009 Opinion, or exceedance of the ITS. The resulting September 11, 2011, Opinion concluded the operation of the Gulf reef fish fishery is not likely to jeopardize the continued existence of any listed species, and an ITS was provided (NMFS 2011b).

South Atlantic Snapper-Grouper Fishery
The South Atlantic snapper-grouper fishery uses spear and powerheads, black sea bass pots, and hook-and-line gear. Hook-and-line gear used in the fishery includes commercial bottom longline gear and commercial and recreational vertical line gear (i.e., handline, bandit gear, and rod-and-reel). The most recent consultation on the fishery was completed in 2016 (NMFS 2016), which concluded the proposed action was not likely to jeopardize the continued existence of the North Atlantic right whale, NWA DPS of the loggerhead sea turtle, leatherback sea turtle, Kemp's ridley sea turtle, NA or SA DPS of the green sea turtle, hawksbill sea turtle, U.S. DPS of the smalltooth sawfish, and Nassau grouper, and an ITS was provided.

Coastal Migratory Pelagics (CMP) Fishery
We completed a Section 7 consultation on the authorization of CMP fishery in the Gulf of Mexico and South Atlantic (NMFS 2007a). Commercial fishers target king and Spanish mackerel with hook-and-line (i.e., handline, rod-and-reel, and bandit), gillnet, and cast net gears. Recreational fishers use only rod-and-reel gear. Trolling is the most common hook-and-line fishing technique used by both commercial and recreational fishers. A winter troll fishery operates along the east and south Gulf coast. Although run-around gillnets accounted for the majority of the king mackerel catch from the late 1950s through 1982, handline gear has been the predominant gear used in the commercial king mackerel fishery since 1993 (NMFS 2007a). The gillnet fishery for Gulf king mackerel is restricted to the use of "run-around" gillnets in Monroe and Collier Counties in January. Run-around gillnets are still the primary gear used to harvest Spanish mackerel, but the fishery is relatively small because Spanish mackerel are typically more concentrated in state waters where gillnet gear is prohibited. The 2007 Opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles, as well as smalltooth sawfish may be adversely affected by the gillnet component of the fishery. The authorization of the fishery was not expected to jeopardize the continued existence of any of these species, and an ITS was provided.

A June 18, 2015 Opinion, amended on November 18, 2017 (to assess effects on the NA and SA DPSs of green sea turtle as well as Nassau grouper) and May 1, 2023 (to assess potential effects to giant manta ray, oceanic whitetip shark, and Rice whale), comprises the most recent completed Section 7 consultation on the operation of the CMP fishery in the Gulf of Mexico and South Atlantic. The 2015 Opinion, as amended, concluded that the proposed action may adversely affect but is not likely to jeopardize the continued existence of any listed species, and an ITS was provided.

Spiny Lobster Fishery
We completed a Section 7 consultation on the Gulf and South Atlantic Spiny Lobster FMP on August 27, 2009 (NMFS 2009c). The commercial component of the fishery consists of diving,

bully net and trapping sectors; recreational fishers are authorized to use bully net and hand-harvest gears. Of the gears used, only traps are expected to result in adverse effects on sea turtles. The consultation determined the authorization of the fishery would not jeopardize any listed species. An ITS was issued for takes in the commercial trap sector of the fishery. Fishing activity using traps is limited to waters off south Florida and, although the FMP does authorize the use of traps in federal waters, historic and current effort is very limited. Thus, potential adverse effects on sea turtles are believed to also be very limited.

Stone Crab Fishery
We completed a Section 7 consultation on the Gulf of Mexico Stone Crab FMP on September 28, 2009 (NMFS 2009d). The commercial component of the fishery is traps; recreational fishers use traps or dive (i.e., hand harvest) for stone crabs. Of the gears used, only commercial traps are expected to result in adverse effects on sea turtles or smalltooth sawfish. The number of commercial traps actually in the water is very difficult to estimate, and the number of traps used recreationally is unquantifiable with any degree of accuracy. The consultation determined the authorization of the fishery was likely to adversely affect sea turtles and smalltooth sawfish, but would not jeopardize their continued existence; an ITS was issued for takes in the commercial trap sector of the fishery. On October 28, 2011, we repealed the federal FMP for this fishery, and the fishery is now managed exclusively by the state of Florida. Since the State of Florida has essentially been the lead management agency for the fishery in both state and federal waters for some time, little change in how the fishery operates or amount of the effort occurring in the fishery is expected because of the repeal of the federal FMP. Therefore, the anticipated adverse effects described in the Opinion completed before the repeal of the federal FMP are expected to continue to occur to listed species.

Dolphin/Wahoo Fishery
The South Atlantic FMP for the dolphin and wahoo fishery was approved in December 2003. We conducted a formal Section 7 consultation to consider the effects on sea turtles of authorizing fishing under the FMP (NMFS 2003). The August 27, 2003, Opinion concluded that green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles may be adversely affected by the longline component of the fishery, but it was not expected to jeopardize their continued existence. An ITS for sea turtles was provided with the Opinion.

Dredging
Marine dredging vessels are common within U.S. coastal waters, and construction and maintenance of federal navigation channels and dredging in sand mining sites (borrow areas) have been identified as sources of sea turtle and sturgeon mortality. Hopper dredges are capable of moving relatively quickly compared to sea turtle swimming speed and can thus overtake, entrain, and kill sea turtles as the suction draghead(s) of the advancing dredge overtakes the resting or swimming turtle. Entrained sea turtles rarely survive.

To reduce take of listed species, relocation trawling may be utilized to capture and move sea turtles. In relocation trawling, a boat equipped with nets precedes the dredge to capture protected species and then release the animals out of the dredge pathway, thus avoiding lethal take. Seasonal in-water work periods, when a species is absent from the project area, also assists in reducing incidental take.

Although the underwater noises from dredge vessels are typically continuous in duration (for periods of days or weeks at a time) and strongest at low frequencies, they are not believed to have any long-term effect on sea turtles.

In summary, dredging and disposal to maintain navigation channels, and removal of sediments for beach nourishment occurs frequently and throughout the range of sea turtles annually. This activity has, and continues to, threaten sea turtles.

We originally completed regional Opinions on the impacts of USACE's hopper-dredging operation in 1997 for dredging along the South Atlantic (i.e., SARBO) and in 2003 for operations in the Gulf of Mexico (i.e., GRBO). On March 27, 2020, we completed a new consultation for SARBO (NMFS 2020a). This Opinion concluded the proposed action is not likely to jeopardize the continued existence of the following turtle species or DPSs: NA or SA DPS of green sea turtle; Kemp's ridley, leatherback, or the NWA DPS of loggerhead sea turtle. An ITS was issued for these affected species, which relied on running triennial take limits. We revised the GRBO in 2007 (NMFS 2007b), which concluded that Gulf of Mexico hopper dredging would adversely affect 4 sea turtle species (i.e., green, hawksbill, Kemp's ridley, and loggerheads) but would not jeopardize their continued existence. An ITS for adversely affected species was issued in this revised Opinion.

The above-listed regional Opinions consider maintenance dredging and sand mining operations. We have produced numerous other "free-standing" Opinions that analyzed hopper dredging projects (e.g., navigation channel improvements and beach restoration projects) that did not fall partially or entirely under the scope of actions contemplated by these regional Opinions. Any free-standing Opinions had its own ITS and determined that hopper dredging during the proposed action would not adversely affect any species of sea turtles or other listed species, or destroy or adversely modify critical habitat of any listed species.

Vessel Activity

Watercraft are the greatest contributors to overall noise in the sea and have the potential to interact with sea turtles through direct impacts or propellers. Sound levels and tones produced are generally related to vessel size and speed. Larger vessels generally emit more sound than smaller vessels, and vessels underway with a full load, or those pushing or towing a load, are noisier than unladen vessels. Vessels operating at high speeds have the potential to strike sea turtles. Potential sources of adverse effects from federal vessel operations in the action area include operations of the Bureau of Ocean Energy Management (BOEM), Federal Energy Regulatory Commission, USCG, NOAA, and USACE.

Federally-Permitted Discharges

Federally regulated stormwater and industrial discharges and chemically treated discharges from sewage treatment systems may impact ESA-listed species. We continue to consult with EPA to minimize the effects of these activities on both listed species and designated critical habitats.

The USACE has been managing Lake Okeechobee water levels, under the Flood Control Act of 1948, for decades to ensure the lake does not top the HHD and threaten lives of those in the communities located south of the lake. While the proposed action is the implementation of a new water control plan, which will have effects into the future as analyzed in this Opinion, current and past water control plans have had effects in the past, and those past effects have contributed to the current status of the species in the action area, and in that respect, the past effects are part of the environmental baseline. Since 2008 LORS08 has been the managing framework to regulate congressionally authorized project purposes which included flood control, water supply, fish and wildlife enhancement, navigation, and recreation, for the lake. The flood control management schedule allowed the USACE to release lake water into both the Caloosahatchee and St. Lucie Rivers to control lake level between 11.5 and 17.25 ft. Releases in turn affected downstream estuaries and any protected species that use those areas. NMFS completed informal consultation with the USACE in 2007, concurring that the LORS08 operating schedule would not result in adverse effects to ESA-listed species or critical habitat in the action area. Consultation was reinitiated following a legal challenge and another informal consultation was completed in March 2020. Operations under LORS08 would cease with approval and implementation of LOSOM.[3]

ESA Section 10 Research Permits
Regulations developed under the ESA allow for the issuance of permits allowing take of certain ESA-listed species for the purposes of scientific research under Section 10(a)(1)(a) of the ESA. Since issuance of the permit is a federal activity, the action must be reviewed for compliance with Section 7(a)(2) of the ESA to ensure that issuance of the permit does not result in jeopardy to the species or adverse modification of its critical habitat. Authorized activities range from photographing, capturing, measuring, weighing, sampling (blood and tissue) and tagging ESA-listed species though these activities vary based on species. The number of authorized takes varies widely depending on the research and species involved, but may involve the taking of hundreds of individuals annually. Most takes authorized under these permits are expected to be (and are) non-lethal.

5.3.2 State and Private Actions

A number of activities in state waters that may directly or indirectly affect listed species include recreational and commercial fishing, construction, discharges from wastewater systems, dredging, ocean pumping and disposal, and aquaculture facilities. The impacts from some of these activities are difficult to measure. However, where possible, conservation actions through the ESA Section 7 process, ESA Section 10 permitting, and state permitting programs are being implemented to monitor or study impacts from these sources. Increasing coastal development and ongoing beach erosion will result in increased demands by coastal communities, especially beach resort towns, for periodic privately funded or federally sponsored beach nourishment

---

[3] It is worth noting that the causal connection between releases of nutrient rich waters from LOK and the existence of red tide had not been acknowledged in past consultations on water control plans for LOK. The change in approach in this Opinion is based on new information related to our evolving understanding of the relationship between the nutrient-rich waters from LOK and HABs, such as red tide. If the USACE were not changing water control plans for LOK, the same new information would have triggered reinitiation of consultation on the current water control plan, LORS08.

projects. Some of these activities may affect listed species and their critical habitat by burying nearshore habitats that serve as foraging areas. Additional discussion on some of these activities follows.

State Fisheries
Various fishing methods used in state commercial and recreational fisheries, including fly nets, trawling, pot fisheries, pound nets, and rod and reel are all known to incidentally take protected sea turtles but information on these fisheries is sparse (NMFS 2001). Most of the state data are based on extremely low observer coverage, or protected species were not part of data collection; thus, these data provide insight into gear interactions that could occur but are not indicative of the magnitude of the overall problem.

Trawl Fisheries
Other trawl fisheries, such as ones operating for blue crab and sheepshead, may also interact with sea turtles in state waters. Many of these vessels are shrimp trawlers that alter their gear in other times of the year to target these other species. At this time, however, we lack sufficient information to quantify the level of anticipated take that may be occurring in these other trawl fisheries.

Recreational Fishing
Recreational fishing from private vessels may occur in the action area, and these activities may interact with sea turtles. For example, observations of state recreational fisheries have shown that sea turtles are known to bite baited hooks and frequently ingest the hooks. Hooked species have been reported by the public fishing from boats, fishing piers, beaches, banks, and jetties, and from commercial anglers fishing for reef fish and for sharks with both single rigs and bottom longlines. Additionally, lost fishing gear such as line cut after snagging on rocks, or discarded hooks and line, can also pose an entanglement threat to ESA-listed species in the area.

5.3.3 Marine Debris, Pollution, and Environmental Contamination

In general, marine pollution includes a wide variety of impacts stemming from a diversity of activities and sources. Sources of pollutants within or adjacent to the action area include, but are not limited to, marine debris and plastics, noise pollution from vessel traffic activities, atmospheric loading of pollutants such as PCBs, agricultural and industrial runoff into rivers and canals emptying into bays and estuaries, and groundwater and other discharges. Nutrient loading from land-based sources such as coastal community discharges is known to stimulate plankton blooms in closed or semi-closed estuarine systems (Brand and Compton 2007, Anderson et al. 2008).

Additional direct and indirect sources of pollution include dredging (i.e., resuspension of pollutants in contaminated sediments) and aquaculture, each of which can degrade marine habitats used by sea turtles (Colburn et al. 1996). The development of marinas and docks in inshore waters can negatively impact nearshore habitats. An increase in the number of docks built increases boat and vessel traffic. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive estuarine and coastal habitats. Sea turtles may be exposed to these contaminant concentrations when in near shore habitats and may accumulate these contaminants during their life cycles.

Sea turtles may ingest marine debris, particularly plastics, which can cause intestinal blockage and internal injury, dietary dilution, malnutrition, and in turtles, increased buoyancy, which, in turn, can result in poor health, reduced growth rates and reproductive output, or death (Nelms et al. 2016). Entanglement in plastic debris (including ghost fishing gear) is known to cause lacerations, increase drag (which increases energetic costs of locomotion and reduces the ability to forage effectively or escape threats), and may lead to drowning or death by starvation.

5.3.4 Coastal Development and Vessel Traffic

Beachfront development, lighting, and beach erosion control all are ongoing activities along the southeastern U.S. coastline (i.e., throughout the action area). These activities potentially reduce or degrade sea turtle nesting habitats or interfere with hatchling movement to sea. Nocturnal human activities along nesting beaches may also discourage sea turtles from nesting sites. The extent to which these activities reduce sea turtle nesting and hatchling production is unknown. Still, more and more coastal counties are adopting stringent protective measures to protect hatchling sea turtles from the disorienting effects of beach lighting.

Commercial traffic and recreational boating pursuits can have adverse effects on sea turtles in particular via propeller and boat strike damage. The STSSN includes many records of vessel interactions (propeller injury) with sea turtles (NOAA 2023). Data show that vessel traffic is one cause of sea turtle mortality (Hazel and Gyuris 2006; Lutcavage et al. 1997). Data indicate that live- and dead-stranded sea turtles showing signs of vessel-related injuries continue in a high percentage of stranded sea turtles in coastal regions of the southeastern United States, particularly off Florida where there are high levels of vessel traffic.

5.3.5 Stochastic Events

Stochastic (i.e., random) events, such as hurricanes, occur in the southeastern U.S., and can affect the action area. These events are by nature unpredictable, and their effect on the recovery of the species is unknown; yet, they have the potential to directly impede recovery if animals die as a result or indirectly if important habitats are damaged. Conversely, these events, such as the record 2020 Atlantic hurricane season, may also result in some benefits to listed species, particularly sea turtles. For example, the impacts of hurricanes may compromise fisheries infrastructure and reduce fishing effort, which may subsequently reduce fishery related bycatch. Other stochastic events, such as a winter cold snap, can injure or kill sea turtles.

5.3.6 Climate Change

In addition to the information on climate change presented in the Section 3 (Status of the Species) for sea turtles, the discussion below presents further background information on global climate change as well as past and predicted future effects of global climate change we expect throughout the action area. Also, below is the available information on predicted effects of climate change in the action area and how listed sea turtles may be affected by those predicted environmental changes. The effects are summarized on the time span of the proposed action, for which we can realistically analyze impacts, yet are discussed and considered for longer time periods when feasible. Yet, as mentioned previously, the potential effects, and the expected related climate change effects to ESA-listed species, are the result of slow and steady shift or alterations over a long time-period, and forecasting any specific critical threshold that may occur at some point in the future (e.g., several decades) is highly uncertain. As a result, for the purposes of this Opinion we have elected to view the effects of climate change on affected species over the next few decades. While climate change is also relevant to the Cumulative Effects section of this Opinion, we are synthesizing all additional information here rather than include partial discussions in other sections of this Opinion.

Background Information on Global Climate Change

The global mean temperature has risen 0.76ºC (1.36°F) over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007). Precipitation has increased nationally by 5 to 10 percent, mostly due to an increase in heavy downpours (NAST 2000). In comparison, ocean temperatures have only increased by about 0.18°F in the last century, with the changes occurring from the surface to depths of about 2,300 ft. There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and other pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007); these trends are most apparent over the past few decades. Information on future impacts of climate change in the action area is discussed below.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next century. Both of the principal climate models used by the National Assessment Synthesis Team (NAST) project warming in the southeast by the 2090s, but at different rates (NAST 2000): the Canadian model scenario shows the southeast U.S. experiencing a high degree of warming, which translates into lower soil moisture as higher temperatures increase evaporation; the Hadley model scenario projects less warming and a significant increase in precipitation (about 20%). The scenarios examined, which assume no major interventions to reduce continued growth of world greenhouse gases (GHG), indicate that temperatures in the U.S. will rise by about 5° to 9°F on average in the next 100 years, which is more than the projected global increase (NAST 2000).

The Intergovernmental Panel on Climate Change (IPCC) has considered multiple scenarios for temperature over the next century as well and described these as Reasonable Concentration Pathways (RCP). RCP8.5 has been termed the “business as usual” scenario that considers climate effects associated with rates of greenhouse gas consumption at the time of development. More recent literature (e.g. Hausfather and Peters 2020) has made the case that this scenario is more of a worst case scenario considering widespread reductions in fossil fuel consumption and a push into greener energy sources. RCP8.5 modeled temperature increases of 2.6 to 4.8 percent by 2100 in comparison to the period 1986 to 2005. More generally, a warming of about 0.4°F per decade is projected for the next 2 decades over a range of emission scenarios (IPCC 2007). An updated scenario SSP3-7.0 estimates increases in temperature with increases ranging from 2.8 to 4.6°C by 2100, relative to 1850 to 1900 (IPCC 2021). This newer scenario suggests an increase of 1.5°C by 2040. This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has resulted in increased precipitation, river discharge, and glacial and sea-ice melting (Greene et al. 2008).

The past 3 decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene et al. 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (Greene et al. 2008, IPCC 2007). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are expected to be the result of changes in the earth's atmosphere caused by anthropogenic forces (IPCC 2007). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC 2007). Data from the 1960s through 2006 show that the NAO index increased from minimum values in the 1960s to strongly positive index values in the 1990s, but declined since (IPCC 2007). This warming extends more than 0.62 miles deep—deeper than anywhere in the world oceans—and is particularly evident under the Gulf Stream/ North Atlantic Current system (IPCC 2007). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (Greene et al. 2008; IPCC 2007). There is evidence that the NADW has already freshened significantly (IPCC 2007). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the whole earth system (Greene et al. 2008).

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on smaller geographic scales, such as the Mississippi Sound or the Mid-Atlantic Bight, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions of the U.S. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHG emissions due to emissions that have already occurred (NAST 2000); therefore, it is also expected to continue during LOSOM. It is very likely that the magnitude and frequency of ecosystem changes will increase in the next 25 to 50 years, and it is possible that changes will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation (IPCC 2007).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Consequences could be a decrease in the amount of DO in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch et al. 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al. 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change.

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.4°F per decade; and 3) a rise in sea level (NAST 2000). Sea level is expected to continue rising: during the twentieth century global sea level has increased 6 to 8 in. It is unclear what effects these changes to the climate will have upon the proposed actions of LOSOM.

Effects of Climate Change on Sea Turtles

As there is significant uncertainty in the rate and timing of change, as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on sea turtles. Yet, sea turtle species have persisted for millions of years. They are ectotherms, meaning that their body temperatures depends on ambient temperatures. Throughout this time they have experienced wide variations in global climate conditions and are thought to have previously adapted to these changes through changes in nesting phenology and behavior (Poloczanska et al. 2009). Given this, climate change at normal rates (i.e., thousands of years) is not thought to have historically been a problem for sea turtle species. At the current rate of global climate change; however, future effects to sea turtles are probable. Climate change has been identified as a threat to all species of sea turtles found in the action area (Conant et al. 2009; NMFS and USFWS 2013; NMFS et al. 2011; Seminoff et al. 2015). Trying to assess the likely effects of climate change on sea turtles; however, is extremely difficult given the uncertainty in all climate change models, the difficulty in determining the likely rate of temperature increases, and the scope and scale of any accompanying habitat or behavior effects. In the Northwest Atlantic, specifically, loggerhead, green, and leatherback sea turtles are predicted to be among the more resilient species to climate change, while Kemp's ridley turtles are among the least resilient (Fuentes et al. 2013). Leatherbacks may be more resilient to climate change in the Northwest Atlantic because of their wide geographic distribution, low nest-site fidelity, and gigantothermy (Dutton et al. 1999; Fuentes et al. 2013; Robinson et al. 2009). Gigantothermy refers to the leatherbacks ability to use their large body size, peripheral tissues as insulation, and circulatory changes in thermoregulation (Paladino et al. 1990). Leatherbacks achieve and maintain substantial differentials between body and ambient temperatures through adaptations for heat production, including adjustments of the metabolic rate, and retention (Wallace and Jones 2008). However, modeling results show that global warming poses a "slight risk" to females nesting in French Guiana and Suriname relative to those in Gabon/Congo and West Papua, Indonesia (Dudley et al. 2016).

Sea turtles are most likely to be affected by climate change due to:

1. Changing air and land temperatures and rainfall at nesting beaches that could affect reproductive output including hatching success, hatchling emergence rate, and hatchling sex ratios;
2. Sea level rise, which could result in a reduction or shift in available nesting beach habitat, an increased risk of erosion and nest inundation, and reduced nest success;
3. Changes in the abundance and distribution of forage species, which could result in changes in the foraging behavior and distribution of sea turtle species as well as changes in sea turtle fitness and growth;
4. Changes in water temperature, which could possibly lead to a shift in their range, changes in phenology (timing of nesting seasons, timing of migrations) and different threat exposure; and
5. Increased frequency and severity of storm events, which could impact nests and nesting habitat, thus reducing nesting and hatching success.

Current approaches have limited power to predict the magnitude of future climate change, associated impacts, whether and to what extent some impacts will offset others, or the adaptive capacity of this species. By 2040, sea surface temperatures are expected to rise 0.8 to 1.5°C (IPCC 2007, IPCC 2021). It is unknown if that is enough of a change to contribute to shifts in the range, distribution and recruitment of sea turtles or their prey. Theoretically, we expect that as waters in the action area warm, more sea turtles could be present or present for longer periods.

As climate continues to warm, feminization of sea turtle populations is a concern for many sea turtle species, which undergo temperature-dependent sex determinations. Rapidly increasing global temperatures may result in warmer incubation temperatures and higher female-biased sex ratios (Glen and Mrosovsky 2004; Hawkes et al. 2009). Increases in precipitation might cool beaches (Houghton et al. 2007), mitigating some impacts relative to increasing sand temperature. Though the predicted level of warming over the period of the action is small (i.e., <1°C), feminization occurs over a small temperature range (1 to 4°C) (Wibbels 2003) and several populations in the action area already are female biased (Gledhill 2007; Laloë et al. 2016; Patino-Martinez et al. 2012; Witt et al. 2010). The existing female bias among juvenile loggerhead sea turtles is estimated at approximately 3:2 females per males (Witt et al. 2010).

Feminization is a particular concern in tropical nesting areas where over 95% female-biased nests are already suspected for green turtles, and leatherbacks are expected to cross this threshold within a decade (Laloë et al. 2014; Laloë et al. 2016; Patino-Martinez et al. 2012). It is possible for populations to persist, and potentially increase with increased egg production, with strong female biases (Broderick et al. 2000; Coyne and Landry 2007; Godfrey et al. 1999; Hays et al. 2003), but population productivity could decline if access to males becomes scarce (Coyne 2000). Low numbers of males could also result in the loss of genetic diversity within a population. Behavioral changes could help mitigate the impacts of climate change, including shifting breeding season and location to avoid warmer temperatures. For example, the start of the nesting season for loggerheads has already shifted as the climate has warmed (Weishampel et al. 2004). Nesting selectivity could also help mitigate the impacts of climate on sex ratios as well (Kamel and Mrosovsky 2004).

At St. Eustatius in the Caribbean, there is an increasing female-biased sex ratio of green turtle hatchlings (Laloë et al. 2016). While this is partly attributable to imperfect egg hatchery practices, global climate change is also implicated as a likely cause as warmer sand temperatures at nesting beaches can result in the production of more female embryos. At this time, we do not know how much of this bias is also due to hatchery practices as opposed to temperature. Global warming may exacerbate this female skew. An increase in female bias is predicted in St. Eustatius, with only 2.4% male hatchlings expected to be produced by 2030 (Ibid). The study also evaluated leatherback sea turtles on St. Eustatius. The authors found that the model results project the entire feminization of the green and leatherback sea turtles due to increased air temperature within the next century (Ibid). The extent to which sea turtles may be able to cope with this change, by selecting cooler areas of the beach or shifting their nesting distribution to other beaches with smaller increases in sand temperature, is currently unknown.

Several leatherback nesting areas are already predominantly female, a trend that is expected to continue with some areas expecting at least 95% female nests by 2028 (Gledhill 2007; Laloë et al. 2016; Patino-Martinez et al. 2012). Hatchling success has declined in St. Croix (Garner et al. 2017), though there is some evidence that the overall trend is not climate or precipitation related (Rafferty et al. 2017). Excess precipitation is known to negatively impact hatchling success in wet areas, but can have a positive effect in dry climates (Santidrián Tomillo et al. 2015). In Grenada, increased rainfall (another effect of climate change) was found to have a cooling influence on leatherback nests, so that more male producing temperatures (less than 29.75°C) were found within the clutches (Houghton et al. 2007). There is also evidence for very wet conditions inundating nests or increasing fungal and mold growth, reducing hatching success (Patino-Martinez et al. 2014). Very dry conditions may also affect embryonic development and decrease hatchling output. Leatherbacks have a tendency towards individual nest placement preferences, with some clutches deposited in the cooler tide zone of beaches and have relatively weak nesting site fidelity; this may mitigate the effects of long-term changes in climate on sex ratios (Fuentes et al. 2013; Kamel and Mrosovsky 2004).

If nesting can shift over time or space towards cooler sand temperatures, these effects may be partially offset. A shift towards earlier onset of loggerhead nesting was associated with an average warming of 0.8°C in Florida (Weishampel et al. 2004). Early nesting could also help mitigate some effects of warming, but has also been linked to shorter nesting seasons in this population (Pike et al. 2006), which could have negative effects on hatchling output. Nesting beach characteristics, such as the amount of precipitation and degree of shading, can effectively cool nest temperatures (Lolavar and Wyneken 2015). However, current evidence suggests that the degree of cooling resulting from precipitation or shading effects is relatively small and therefore, even under these conditions, the production of predominantly female nests is still possible (Ibid). However, the impact of precipitation, as well as humidity and air temperature, on loggerhead nests is site specific and data suggest temperate sites may see improvements in hatchling success with predicted increases in precipitation and temperature (Montero et al. 2018; Montero et al. 2019). Conversely, tropical areas already produce 30% less output than temperate regions and reproductive output is expected to decline in these regions (Pike 2014).

Warming sea temperatures are likely to result in a shift in the seasonal distribution of sea turtles in the action area. In the northern part of the action area, sea turtles may be present earlier in the year if northward migrations from their southern overwintering grounds begin earlier in the spring. Likewise, if water temperatures are warmer in the fall, sea turtles could remain in the more northern areas later in the year. Potential effects of climate change include range expansion and changes in migration routes as increasing ocean temperatures shift range-limiting isotherms north (Robinson et al. 2009). McMahon and Hays (2006) reported that warming has caused a generally northerly migration of the 15°C sea surface temperature isotherm from 1983 to 2006. In response to this, leatherbacks have expanded their range in the Atlantic north by 330 km (Ibid). An increase in cold stunning of Kemp's ridley sea turtles in New England has also been linked to climate change and could pose an additional threat to population resilience (Griffin et al. 2019).

Furthermore, although nesting occurs in the south and mid-Atlantic (i.e., North Carolina and into Virginia), recent observations have caused some speculation that the nesting range of some sea turtle species may shift northward as the climate warms and that nest crowding may increase as sea level rises and available nesting habitat shrinks (Reece et al. 2013). Recent instances include a Kemp's ridley nesting in New York in July 2018 (96 hatchlings), a loggerhead nesting in Delaware in July 2018 (48 hatchlings), and a loggerhead nesting in Maryland in September 2017 (7 live hatchlings). The ability to shift nesting in time and space towards cooler areas could reduce some of the temperature-induced impacts of climate change (e.g., female biased sex ratio). Fuentes et al. (2020) modelled the geographic distribution of climatically suitable nesting habitat for sea turtles in the U.S. Atlantic under future climate scenarios, identified potential range shifts by 2050, determined sea-level rise impacts, and explored changes in exposure to coastal development as a result of range shifts. Overall, the researchers found that, with the exception of the northern nesting boundaries for loggerhead sea turtles, the nesting ranges were not predicted to change. Fuentes et al. (2020) noted that range shifts may be hindered by expanding development. They also found that loggerhead sea turtles would experience a decrease (10%) in suitable nesting habitat followed by green turtles. No significant change was predicted in the distribution of climatically suitable nesting area for leatherbacks by 2050. Sea level rise is projected to inundate current habitats; however, new beaches will also be formed and suitable habitats could be gained, with leatherback sea turtles potentially experiencing the biggest gain in suitable habitat (Ibid).

Climate change may also increase hurricane activity, leading to an increase in debris in nearshore and offshore environments. This, in turn, could increase the occurrence of entanglements, ingestion of pollutants, or drowning. In addition, increased hurricane activity may damage nesting beaches or inundate nests with seawater. Increasing temperatures are expected to result in increased polar melting and changes in precipitation that may lead to rising sea levels (Titus and

Narayanan 1995). Hurricanes and tropical storms occur frequently in the action area. They impact nesting beaches by increasing erosion and sand loss and depositing large amounts of debris on the beach. A lower level of leatherback nesting attempts occurred on sites more likely to be impacted by hurricanes (Dewald and Pike 2014). These storm events may ultimately affect the amount of suitable nesting beach habitat, potentially resulting in reduced productivity (TEWG 2007). These storms may also result in egg loss through nest destruction or inundation. Climate change may be increasing the frequency and patterns of hurricanes (IPCC 2014), which may result in more frequent impacts. These environmental/climatic changes could result in increased erosion rates along nesting beaches, increased inundation of nesting sites, a decrease in available nesting habitat, and an increase in nest crowding (Baker et al. 2006; Daniels et al. 1993; Fish et al. 2005; Reece et al. 2013). Changes in environmental and oceanographic conditions (e.g., increases in the frequency of storms, changes in prevailing currents), as a result of climate change, could accelerate the loss of sea turtle nesting habitat, and thus, loss of eggs (Antonelis et al. 2006; Baker et al. 2006; Conant et al. 2009; Ehrhart et al. 2014).

Tidal inundation and excess precipitation can contribute to reduced hatchling output, particularly in wetter climates (Pike 2014; Pike et al. 2015; Santidrián Tomillo et al. 2015). This is especially problematic in areas with storm events and in highly-developed areas where the beach has nowhere to migrate. Females may deposit eggs seaward of erosion control structures, potentially subjecting nests to repeated tidal inundation. A study by the USGS found that sea levels in a 620-mile “hot spot” along the East Coast are rising 3 to 4 times faster than the global average (Sallenger et al. 2012). More recently, a study found record breaking rates of sea-level rise along the U.S. Southeast and Gulf coasts with rates of sea-level rise of about a half an inch per year since 2010—three times higher than the global average over the same period (Dangendorf et al. 2023). Sallenger et al. (2012) predicted sea levels will rise an additional 20 to 27 cm along the Atlantic coast “hot spot” in the next 100 years. The disproportionate sea level rise is due to the slowing of Atlantic currents caused by fresh water from the melting of the Greenland Ice Sheet. Sharp rises in sea levels from North Carolina to Massachusetts could threaten wetland and beach habitats, and negatively affect sea turtle nesting along the North Carolina coast. If warming temperatures moved favorable nesting sites northward, it is possible that rises in sea level could constrain the availability of nesting sites on existing beaches (Reece et al. 2013). There is limited evidence of a potential northward range shift of nesting loggerheads in Florida, and it is predicted that this shift, along with sea level rise, could result in more crowded nesting beaches (Ibid).

In the case of the Kemp’s ridley, most of their critical nesting beaches are undeveloped and may still be available for nesting despite shifting landward. Unlike much of the Texas coast, the Padre Island National Seashore (PAIS) shoreline in Texas, where increasing numbers of Kemp’s ridley are nesting, is accreting. Given the increase in nesting at the PAIS, as well as increasing and slightly cooler sand temperatures than at other primary nesting sites, PAIS could become an increasingly important source of males for a species, which already has one of the most restricted nesting ranges of all sea turtles. Nesting activity of Kemp’s ridleys in Florida has also increased over the past decade, suggesting the population may have some behavioral flexibility to adapt to a changing climate (Pike 2013). Still, current models predict long-term reductions in sea turtle fertility as a result of climate change. These effects, however, may not be seen for 30 to 50 years because of the longevity of sea turtles (Davenport 1997; Hawkes et al. 2007; Hulin and Guillon 2007).

Changes in water temperature may also alter the forage base and, therefore, the foraging behavior of sea turtles (Conant et al. 2009). Likewise, if changes in water temperature affected the prey base for green, loggerhead, Kemp's ridley, or leatherback sea turtles, there may be changes in the abundance and distribution of these species in the action area. Depending on whether there was an increase or decrease in the forage base or a seasonal shift in water temperature, there could be an increase or decrease in the number of sea turtles in the action area. Seagrass habitats may suffer from decreased productivity and increased stress due to sea level rise, as well as changes in salinity, light levels, and temperature (Duarte 2002; Saunders et al. 2013; Short and Neckles 1999). If seagrasses in the action area decline, it is reasonable to expect that the number of foraging green sea turtles would also decline as well. Rising water temperatures, and associated changes in marine physical oceanographic systems (e.g., salinity, oxygen levels, and circulation), may also impact the distribution and abundance of leatherback prey (i.e., jellyfish) and, in turn, impact the distribution and foraging behavior of leatherbacks (Attrill et al. 2007; Brodeur et al. 1999; NMFS and USFWS 2013; Purcell 2005; Richardson et al. 2009). Loggerhead sea turtles are thought to be generalists (NMFS and USFWS 2008), and, therefore, may be more resilient to changes in prey availability. As noted above, because we do not know the adaptive capacity of these individuals, or what level of temperature change would cause a shift in distribution, it is not possible to predict changes to the foraging behavior of sea turtles in the coming decades. If sea turtle distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact to sea turtles due to the availability of food. Similarly, if sea turtles shifted to areas where different forage was available, and sea turtles were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. However, should climatic changes cause sea turtles to shift to an area or time where insufficient forage is available, impacts to these species would be greater. Despite site-specific vulnerabilities of the NWA DPS of loggerhead sea turtles, this DPS may be more resilient to changing climate than other management units (Fuentes et al. 2013). Van Houtan and Halley (2011) recently developed climate based models to investigate loggerhead nesting (considering juvenile recruitment and breeding remigration) in the Northwest Atlantic and North Pacific. These models found that climatic conditions and oceanographic influences explain loggerhead nesting variability. Specifically, the climate models alone explained an average 60% (range 18% to 88%) of the observed nesting changes in the Northwest Atlantic and North Pacific over the past several decades. In terms of future nesting projections, modeled climate data predict a positive trend for Florida nesting (NWA DPS), with increases through 2040 as a result of the Atlantic Multidecadal Oscillation (Van Houtan and Halley 2011). In a separate model, Arendt *et al* (2013) suggested that the variability represents a lagged perturbation response to historical anthropogenic impacts. The nest count increases since 2008 may reflect a potential recovery response (Ibid).

6 EFFECTS OF THE ACTION

6.1 Overview

Effects of the action are all consequences to 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 the effect would not occur but for the proposed action and the effect 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 CFR 402.02).

In this section of our Opinion, we assess the effects of the action on green (NA DPS), Kemp's ridley, and loggerhead (NWA DPS) sea turtles that are likely to be adversely affected. The analysis in this section forms the foundation for our jeopardy analysis in Section 8. The quantitative and qualitative analyses in this section are based upon the best available commercial and scientific data on species biology and the effects of the action. Data are limited, so we are often forced to make assumptions to overcome the limits in our knowledge. Sometimes, the best available information may include a range of values for a particular aspect under consideration, or different analytical approaches may be applied to the same data set. In those cases, the uncertainty is resolved in favor of the species. NMFS generally selects the value that would lead to conclusions of higher, rather than lower risk to endangered or threatened species.

6.2 Effects of the Proposed Action on ESA-Listed Species Considered for Further Analysis

As discussed in the analyses for the other ESA-listed species above (Section 3.1.2), LOK releases could modify the habitat and forage base in the downstream estuaries (CRE and SLE). Freshwater from LOK could reduce salinity in the estuaries if large enough quantities are delivered downstream. This modified salinity regime within the estuaries could affect sea turtles and all other organisms that rely on the area as habitat. Nutrients, largely in the form of nitrogen and phosphorous, from LOK releases could also affect both the habitat and available forage base in the downstream estuaries. Increased nutrient loads can both cause and exacerbate microalgal blooms. Algal blooms can reduce water transparency thus impacting seagrasses along the bottom and also reduce dissolved oxygen as part of diurnal nutrient cycling. Some forms of algae produce toxins that are released into the water and adversely affect the faunal community. Finally, LOK releases can also deliver freshwater algae directly to the estuaries. Depending on the salinity and the species of algae, the blooms can persist or die, but in either case they can reduce water clarity and dissolved oxygen levels, thus affecting the habitat and faunal community. LOK releases into estuaries may be carried into coastal waters and may lead to enhancement of naturally occurring red tide events associated with *K. brevis* (Medina et al. 2020, Medina et al. 2022). Red tide bloom events (cells ≥ 100,000 cells/liter) are known to adversely affect a variety of marine and estuarine fauna including sea turtles (Landsberg 2002, Foley et al. 2019). Although the attributional pathway for the relative contribution of Lake Okeechobee nutrients to red tide enhancement in CRE and SLE is highly variable and scientific uncertainty remains, a review of the recent literature (Medina et al. 2020, Medina et al. 2022) indicates it is probable (i.e., more likely than not) that LOK releases move nutrients from LOK into CRE and SLE that, under certain conditions, may lead to red tide enhancement. We conservatively estimate nutrients in LOK releases may interact with nearshore waters out to 1 mile offshore of CRE between 26.4°N and 26.8°N and out to 1 mile offshore SLE between 27.1° and 27.4°N. This action area accounts for the variability of currents and circulation patterns within and at the mouth of each of the estuaries along with the potential of LOK nutrients to enhance existing nearshore red tide events, which may extend over extremely large areas (e.g., 10s to 100s of miles).

Changes to either the habitat or faunal community could affect sea turtles and their use of the area. Effects could come in the form of avoidance of the area, decreased or modified feeding in the area, or potential exclusion from migratory pathways. If the proposed action occurs during sea turtle nesting season, any adverse effects along the beaches could affect nesting. In the case of HABs, toxins produced by certain algae such as *K. brevis* (red tide) can affect sea turtle nervous systems and ultimately their ability to breath.

6.2.1 Routes of Effect That Are Not Likely to Adversely Affect ESA-Listed Species

Temporary habitat loss
As discussed in Section 6.2, LOK releases could modify the salinity regime of the downstream estuaries and thus the potential use of these habitats by sea turtles. Sea turtles may choose to avoid areas of altered salinity due to the water quality conditions or due to a modified prey base resulting from altered salinity. However, releases have been ongoing under the current regulation schedule (i.e., LORS08) for over a decade providing the prevailing conditions for sea turtles and their prey. Further, the salinity modeling provided in the Biological Assessment indicated any changes to salinity would be minor and temporary in the estuarine portions of the action area. We believe the modified release schedule, which intends to reduce high flow release events, will not have any measurable effect on sea turtles habitat use. Thus, effects associated with potential habitat loss due to the proposed action will be insignificant.

LOK releases could also modify habitat through the introduction of algae and nutrients that fuel algal blooms. Increased microalgae within the water column can reduce water transparency, affecting the ability of seagrass to photosynthesize. If blooms persist, seagrasses can die and be replaced by various macroalgae. Given that green sea turtles specifically feed on seagrass and the periphyton that grows on seagrass, reductions in seagrass could adversely affect green turtles' use of these areas for forage. Similarly, if the prey base for other sea turtle species rely on seagrass communities their densities could be affected and sea turtles may choose to feed elsewhere. Algae blooms stemming from nutrient inputs could also result in decreased dissolved oxygen during diurnal nutrient cycling. Reduced dissolved oxygen may reduce the amount of prey in the area, thereby restricting use of the area by foraging sea turtles. However, releases have been ongoing under the current regulation schedule for over a decade providing the prevailing conditions for sea turtles and their prey in the action area. Any avoidance of bloom areas has been temporary and we believe any changes to the environment associated with the new regulation schedule will be minor. Therefore, we believe habitat loss associated with nutrients and small algae blooms due to the proposed action will have an insignificant effect on sea turtles.

Foraging
LOK releases could affect estuarine water quality and food web dynamics that rely on water quality. Sea turtles forage on a variety of organisms depending on species and life stage, ranging from seagrass to invertebrates to fish. Changes in water quality could affect their available prey. For example, extended microalgal blooms could cause seagrass mortality through reduced water

clarity or reduced fish and invertebrates through limited dissolved oxygen levels. Sea turtles are mobile and likely to avoid areas if there is insufficient prey or poor water clarity but their diet could be affected if similar prey items are not available in nearby unaffected areas. However, we believe this potential effect will be insignificant as the estuaries are a mosaic of habitats with a wide range of prey items. We expect typical food sources will be available even if sea turtles are temporarily displaced.

6.2.2 Routes of Effect That Are Likely to Adversely Affect ESA-Listed Species

LOK releases could deliver nutrients that fuel HABs. In some cases the algae produce toxins that can adversely affect sea turtles. Red tide (*K. brevis*) is a dinoflagellate species that forms HABs on Florida's west coast. Red tide blooms are naturally occurring phenomena that originate offshore. Wind and circulation patterns move blooms toward shore (Steidinger and Haddad 1981, Weisberg et al. 2019) where they interact with additional sources of nutrients (notably nitrogen and phosphorus) that can feed their intensity and or duration (Brand and Compton 2007, Heil et al. 2014, Medina et al. 2022). Red tide cells produce a brevetoxin that has been shown to kill sea turtles (Foley et al. 2019) and a variety of other marine organisms when cell counts are elevated (Landsberg 2002). We believe releases from LOK are likely to contribute to red tide enhancement (e.g., intensity and or duration), and thus affect sea turtles that may be in or near the action area. The following is an analysis of those effects.

To determine the potential effects of LOK releases to red tide enhancement (e.g., increased intensity or duration) in the downstream CRE and SLE, as well as the effects of those blooms on sea turtles, NMFS applied an updated version of the analysis developed by Foley et al. (2019), which is described in more detail below. In the Biological Assessment, the USACE describes the LOSOM action area off CRE as including "…the Gulf beaches on the west side of Estero Island, Sanibel Island, Captiva Island, and Gasparilla Island, along Bunche Beach, the west side of Cayo Costa State Park, and the northern edge of Pine Island beach" and off SLE as including "…the Atlantic beaches on the east side of the SIRL [South Indian River Lagoon], and on the east side of St. Lucie Inlet State Park and Hobe Sound National Wildlife Refuge." This description suggests potential offshore impacts from LOK releases near CRE from Estero Beach (26.4°N) to Gasparilla Island (26.8°N). Off SLE, where releases are lower, the described area ranges from Hobe Sound (27°N) to SIRL (approximately 27.4°N). We summarized traditional sea turtle strandings data within NMFS statistical zones associated with the CRE (Zone 4: 26°N to 27°N) and SLE (Zone 27: 27°N to 28°N) and further refined strandings to consider those occurring in the more confined latitudinal range for the west coast (Zone 4) as described above. Strandings proportions were found to be concentrated around the estuary mouths as greater than 50% of the total zone strandings were found in these locations despite these areas accounting for approximately 40% of the zone.

Foley et al. (2019) found that sea turtle mortality is associated with red tides when the concentration of *K. brevis* cells reaches 100,000 cells per liter. FWC sampled over 400 stranded sea turtles for brevetoxin and found that during these red tide bloom events (e.g., when *K. brevis* concentrations are ≥100,000 cells/L for a given month and Zone), ~70% of the stranded Kemp's ridley and loggerhead turtles and ~30% of the stranded green turtles had brevetoxin concentrations in their tissues that are within the range associated with a significant impact and probable mortality due to red tide (A. Foley, FWC, pers. comm. to N. Farmer, NOAA, 24 Feb 2023). These results from sampled turtles have held consistent through time and represent the proportion of sea turtles, by species, significantly affected by red tide (e.g., either died or stranded because of red tide or would have if another mortality factor had not acted first)(A. Foley, FWC, pers. comm. To N. Farmer, NOAA, 24 Feb 2023). Red tide is the only HAB-related source of mortality documented for Zones 4 and 27. FWC and NOAA have also periodically tested stranded sea turtles from Zone 4 for saxitoxin (neurotoxin most commonly associated with paralytic shellfish poisoning), domoic acid (neurotoxin from Pseudo-nitzchia), and microcystin (toxin found in cyanobacteria). Exposures to domoic acid and saxitoxins have been documented in other Zones (e.g., 3, 25 to 26); however, concentrations of these toxins in stranded animals have been low enough that they do not appear to play a notable role in mortality for Zone 4. To date, NOAA and FWC do not report increases in strandings during cyanobacteria blooms, such as those blooms observed in SLE (B. Stacy, NOAA, pers. comm. to N. Farmer, NOAA, 24 Feb 2023).

Since 2008, in Zone 27 (SLE) there has only been one month when red tide was at or above 100,000 cells per liter: October of 2018. During this bloom event, FWC documented 8 traditional strandings (5 green turtles and 3 loggerheads). Three of the green turtles and all 3 loggerheads were found dead. Two of the green turtles were found alive. One of these live turtles was rehabilitated and released and the other died and was necropsied. Applying the Foley et al. (2019) scalars of 0.7 for loggerhead and Kemp's ridley turtles and 0.3 for green turtles, we estimate 2 loggerhead and 2 green sea turtle mortalities were attributable to red tide during the 2008 to 2022 period in Zone 27.

Red tides are far more prevalent along Florida's west coast, as 60 months of bloom-level (≥100,000 cells/liter) red tide events have been documented since 2008. From 2008 to 2022, 2,681 sea turtles stranded (both dead and alive) within Zone 4 (Figure 12)—1,619 within the smaller action area. Of the number found in the action area, 801 were found during *K. brevis* bloom events (298 loggerheads, 309 Kemp's ridley, 190 green, and 4 unidentified to species). We assigned the 4 unidentified turtles to species using the proportional stranding ratio across the 2,681 total strandings (47.7% loggerhead, 26.1% Kemp's ridley, 24.4% green) resulting in 1.90 (rounded to 2) loggerhead, 1.04 (rounded to 1) Kemp's ridley, and 0.98 (rounded to 1) green turtles. Using the scalars identified by Foley et al. (2019), indicates that 210 loggerhead (298 + 2 x .7 = 210), 217 Kemp's ridley (309 + 1 x .7 = 217), and 57 green (190 + 1 x .3 = 57.3) sea turtles had brevetoxin levels high enough to cause death. Converting these values to annual mortality rates, results in 14 loggerhead (210/15=14), 14.5 Kemp's ridley (217/15=14.5), and 3.8 green (57/15=3.8) sea turtle mortalities per year attributable to red tide.

From 2008 to 2022, 96 turtles found in the subsample of Zone 4 (CRE between 26.4°N and 26.8°N) during months of red tide blooms were found alive (25 loggerhead, 28 Kemp's ridley, and 45 green). FWC's disposition record for live-stranded turtles was complete for the period 2020 to 2021, indicating 55.2% of live-stranded sea turtles ultimately died and 44.8% were released. This disposition data for live stranded turtles was the only complete dataset available. Applying those disposition scalars, while employing a standard mathematical approach to rounding, we estimate that about 11 loggerhead (25 x .448 = 11.2), 13 Kemp's ridley (28 x .448 = 12.5), , and 20 green (45 x .448 = 20.2) turtles were observed to survived red tide exposure during the LORS08 time period. While rounding to the nearest whole number presents a source of potential error, it is likely offset by the uncertainty in survival ratio given the limited time period (2020-2021) by which survival was estimated. Because the non-lethal take estimates are based on previously reported live stranded turtles, and not all affected sea turtles are expected to strand, it is likely non-lethal effects of red tide are far more expansive to sea turtles in the action area.

We estimate that only 10 to 20% of stranded sea turtles are recovered (Epperly et al. 1996, Hart et al. 2006). Therefore, we must also account for the number of sea turtle takes that may occur but are unlikely to be observed. To account for unobserved takes, we bootstrapped our LORS08 lethal and non-lethal take estimates 1000 times and divided those estimates by random numbers drawn from a uniform distribution ranging from 10 to 20%. Total annual mortality estimates during bloom events (between 2008 and 2022) range from 130–260 loggerhead, 125–250 Kemp's ridley, and 30–60 green turtles. Non-lethal annual totals are estimated as 6–13 loggerhead, 7–14 Kemp's ridley, and 9–18 green sea turtles.

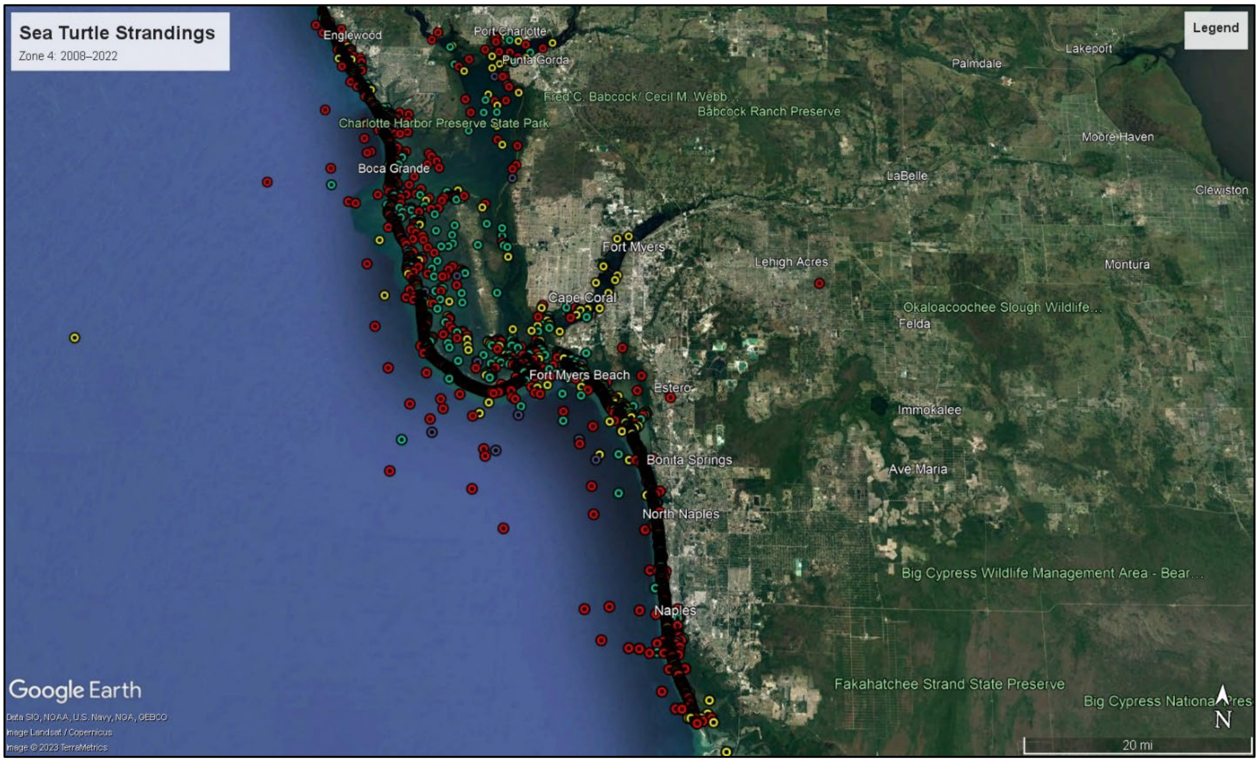


Figure 12. Loggerhead (red), Kemp's ridley (yellow), green (green), hawkbill (blue), and unidentified (purple) sea turtle strandings (traditional strandings) in Zone 4, 2008 to 2022.

To determine the relative contribution of LOSOM operations to these lethal and non-lethal takes (see above), we considered several scenarios. First, the Supplemental HAB Analysis of the Biological Assessment, for WY2017 to 2021, reports the relative contribution of LOK to the total watershed is shown as 28% total phosphorous (TP) and 36% total nitrogen (TN) for CRE, and 23% TP and 35% TN for SLE, respectively. We scaled the lethal and non-lethal turtle takes proportional to these total loads to determine the upper baseline for LORS08 period contributions to red tide enhancement. Under LOSOM, annual flows would be reduced by 4% in

CRE and 40% in SLE (scenarios 1 and 2), and these reductions are referenced in the BA as follows: "*...minimizing lake releases to the Northern Estuaries during peak periods with high potential for lake algal blooms would be an appropriate parameter to consider in the LOSOM analysis…[resulting in a] corresponding reduction in direct nutrient loading from LOK given those flow reductions.*"

The BA also refines the reductions from LORS08 flows to LOSOM flows during high algal bloom months; LOSOM provides reductions of 23% in CRE (June to Aug) and 65% in SLE (May to Aug)(scenarios 3 and 4). Although these are not the months of peak nearshore red tide (Aug to Dec), a recent study by Medina et al. (2022) notes time-lagged effects of nutrient delivery to red tide enhancement. We also evaluated reducing the lethal and non-lethal sea turtle takes from the LORS08 period to LOSOM operations using these high algal bloom month scalars (e.g., 23% and 65%).

Further analysis by USACE indicated that during peak nearshore red tide months (e.g., Aug to Dec), flows under LOSOM operations into CRE might increase by 9%. In contrast during these same peak nearshore red tide months, flows into SLE were estimated to reduce by 11%. These modified flows were considered under scenarios 5 and 6 below.

The BA (Table 5-11) also presented reductions in chlorophyll-a (Chl-a) as a proxy for Nitrogen, showing flow reductions of 21% in CRE for >20 ppb and 43% in SLE for >20 ppb. However, there are increased flows into CRE when Chl-a is >40 ppb and >60 ppb. This is caveated in the BA as follows: "*...Water managers will consider all the available information on an algal bloom in real time when determining when and how much to release from LOK, therefore during implementation there will likely be less releases to the CRE during an actual bloom event than the conclusions from analyzing the Algal Bloom Risk Performance Metric alone*;" however, this is neither modeled nor guaranteed. Given that "*...it is possible that nutrient input to the Northern Estuaries from LOK releases may intensify existing algal blooms when they are present…*," it is also possible that the LOSOM changes may have no effect in reducing estuarine and nearshore red tide risk relative to LORS08. Given the variability of flow during different periods of chlorophyll-a measures, we were unable to model this scenario.

To determine the maximum possible LOK-attributable nutrient contributions to red tide intensification under LOSOM, we scaled the proportional contribution of LORS08 flow schedules to the TP or TN additions to the CRE and SLE action areas, then reduced those two proxies by each of the three potential reductions associated with LOSOM changes to flow. We then estimated the red tide attributable sea turtle mortalities and non-lethal takes based on the calculated LOK-attributable nutrient contributions under LOSOM. However, the dynamics of *K. brevis* blooms are extremely complex, with multiple available nutrient sources from the broader west Florida shelf watershed, regenerated Nitrogen from dead fish and pelagic N_2 fixation supporting blooms, and time lags in ecosystem responses (Heil et al. 2014). To address this complexity, we considered the source contributions evaluated by Heil et al. (2014). They determined that a small red tide bloom (>100,000 cells/liter) within the estuary could be 100% fueled by Caloosahatchee River nitrogen flux in a high flow scenario, such as in 2005 when releases from LOK were highest but under the same scenario, the Caloosahatchee River nitrogen flux would only provide 13% of the required nitrogen for a coastal bloom (Figure 1 in Heil et al

2014). To account for this variation, we considered sea turtles were most likely to be affected in coastal blooms and scaled our analysis around the 13% nitrogen contribution to small blooms associated with the high flow Caloosahatchee River results provided in Heil et al. (2014). We developed a beta distribution (Figure 13) centered around a 13% median from which to draw random samples in our bootstrap modeling. Doing so increases the precision of the bootstrap model to better represent the contribution of LOK nitrogen that results in coastal HAB events where turtles are most likely to be affected.

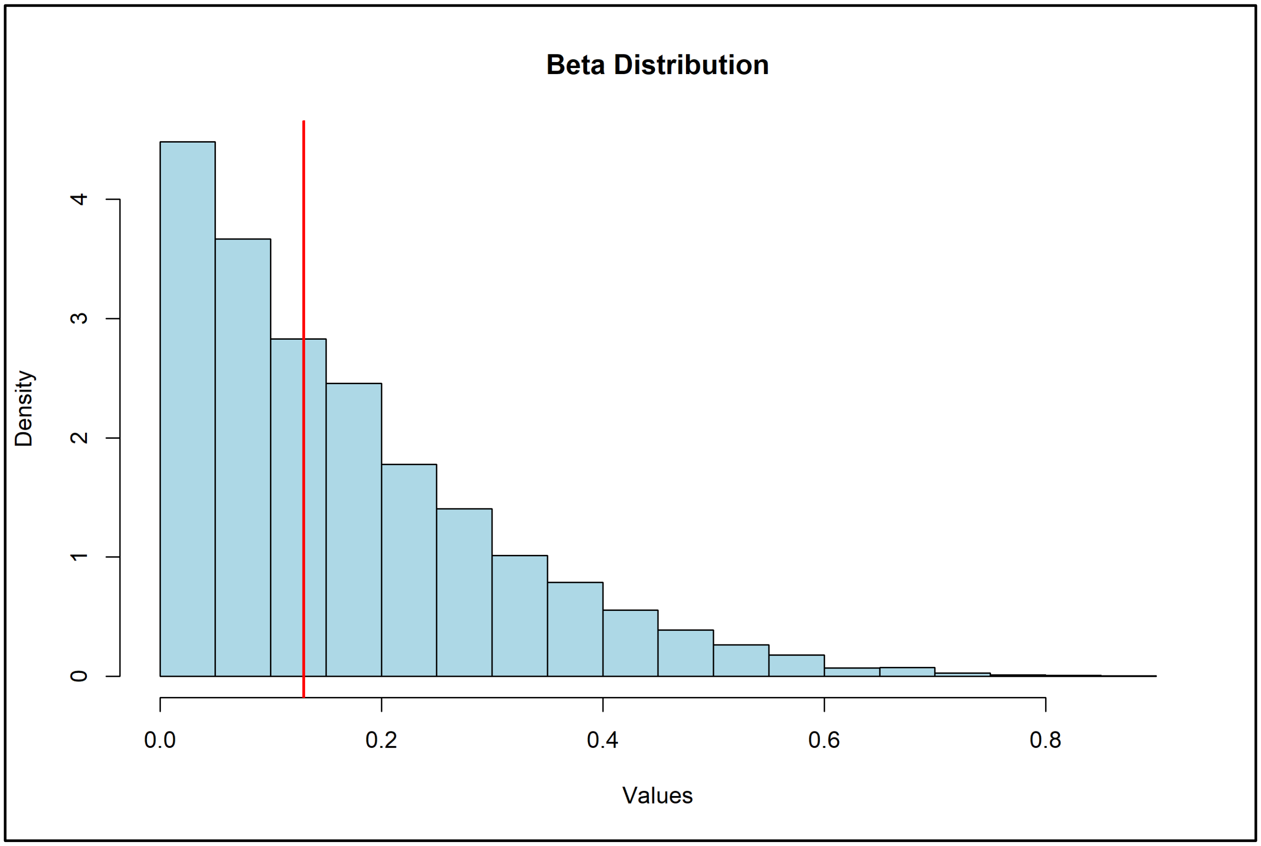


Figure 13. Beta distribution developed around a median set at 13% (red line) to reflect the contribution of Caloosahatchee River nitrogen flux to a coastal red tide bloom during high flow.

We evaluated each of the six scenarios (1. annual reduction of TN, 2. annual reduction of TP, 3. reduction of TN during peak months, 4. reduction of TP during peak months, 5. increase (CRE) or decrease (SLE) of TN Aug-Dec, 6. increase of TP (CRE) or decrease (SLE) Aug-Dec) for each of the three species and two areas across 1000 bootstrapped runs each. To reflect the stochastic nature of short-term bloom dynamics and rain-induced inputs into the broader watershed along with the previously discussed LOK releases under LOSOM, during each scenario with 1000 bootstrapped runs, we multiplied the LOK-attributable nutrient contributions by random draws from the beta distribution that set the median value at 0.13, associated with the 13% N contribution to coastal blooms as reported by Heil et al. 2014. This additional step represented variability in the attributional pathway of LOSOM water releases relative to nutrient contributions from the remaining watershed and offshore environment to overall red tide enhancement. Results of the bootstrap analysis across all 36 scenarios (6 flow/nutrient scenarios x 3 species x 2 areas (CRE and SLE)) are provided in Appendix A. Anticipated mortality in the SLE attributable to LOSOM operations was extremely rare. In the CRE, loggerhead, Kemp's ridley, and green sea turtle mortality, was anticipated (Figure 14). The levels of lethal take estimated were relatively similar across scenarios, with estimates ranging from near zero to a maximum of approximately 45 Kemp's ridley and loggerheads. More green sea turtles were anticipated to survive red tide exposure, followed by Kemp's ridley, followed by loggerhead (Figure 15).

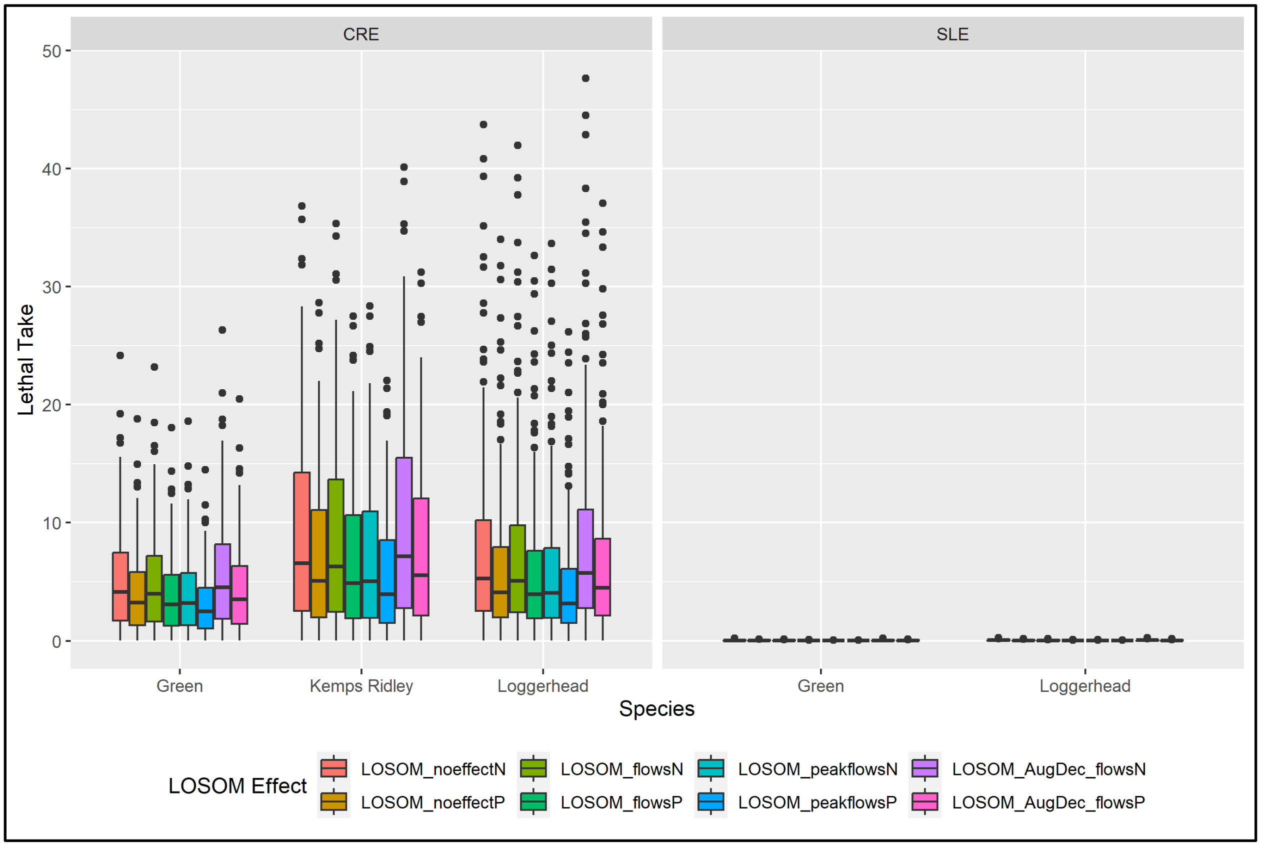


Figure 14. Lethal take anticipated under the current LORS08 management (labeled LOSOM_noeffectN and LOSOM_noeffectP) and six scenarios used to evaluate LOSOM contributions to red tide enhancement.

"*noeffectN*" - no changes to contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution; "*noeffectP*" - no changes to contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution; "*flowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on annual reduction in flow (Scenario 1); "*flowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on annual reduction in flow (Scenario 2); "*peakflowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on high harmful algal bloom months reduction in flow (Scenario 3); "*peakflowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on high harmful algal bloom months reduction in flow (Scenario 4). Note approach accounts for only 10 to 20% of strandings being observed.

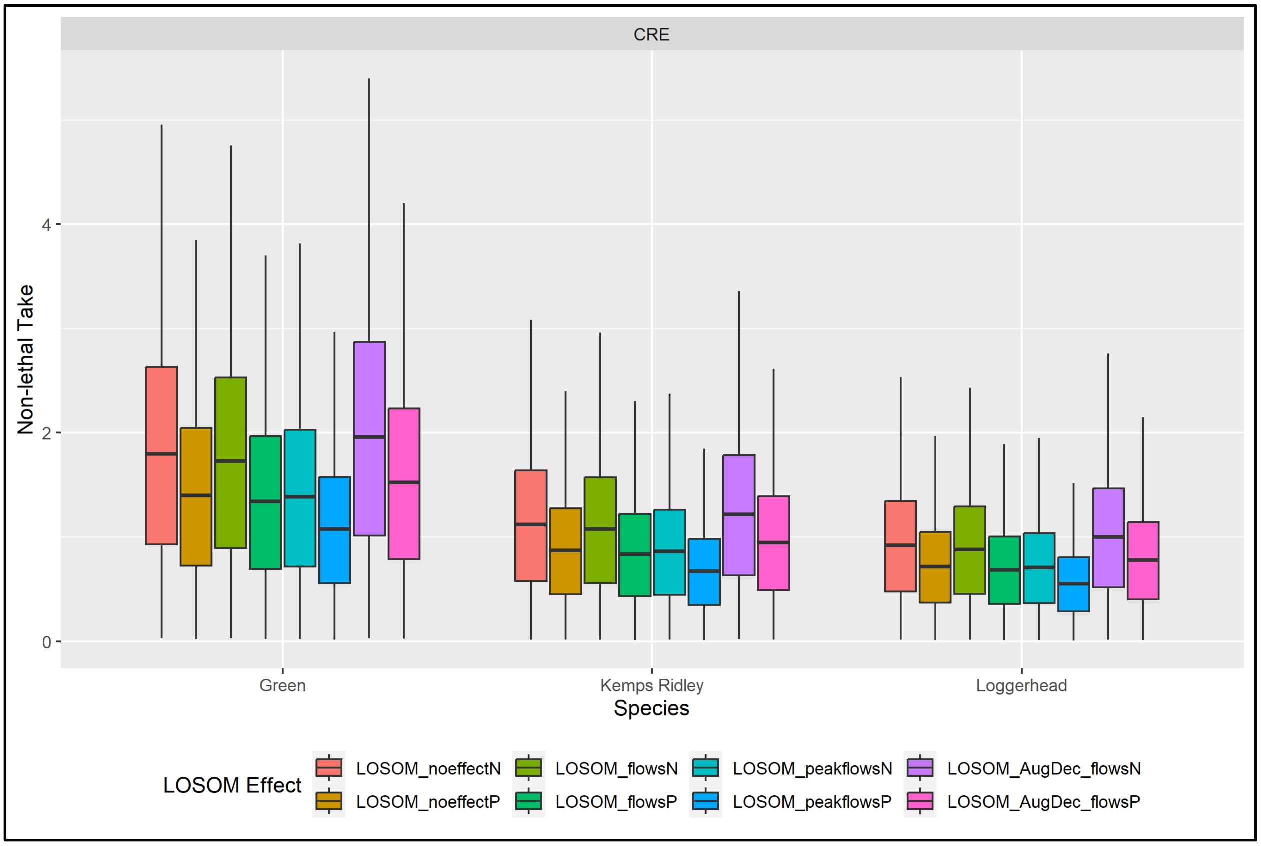


Figure 15. Non-lethal take anticipated under the current LORS08 management (labeled LOSOM_noeffectN and LOSOM_noeffectP) and six scenarios used to evaluate LOSOM contributions to red tide enhancement.
"*noeffectN*" - no changes to contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution; "*noeffectP*" - no changes to contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution; "*flowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on annual reduction in flow; "*flowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on annual reduction in flow; "*peakflowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on high harmful algal bloom months reduction in flow; "*peakflowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on high harmful algal bloom months reduction in flow. Note approach accounts for only 10 to 20% of strandings being observed.

Although multiple scenarios were considered and presented above, it is our opinion that the scenario for annual changes in releases relative to nitrogen (scenario 1 - 4% reduction for CRE, labeled "flowsN" in Figures 14 and 15) is the most appropriate conservative (for the species) proxy for the changes from LORS08 to LOSOM related to potential for red tide enhancement. The west central Florida shelf is characterized by elevated phosphorus levels associated with mining (McPherson and Miller 1990) and nitrogen limitations (Dixon et al 2014, Heil et al. 2014). Therefore, even small increases in nitrogen can result in increased algal mass. Based on these results, the median predicted annual lethal take of sea turtles as a result of red tide attributed to the proposed action is 8 loggerhead, 7 Kemp's ridley, and 5 green turtles. The median predicted non-lethal take of sea turtles as a result of the proposed action is 1 loggerhead, 1 Kemp's ridley, and 1 green turtle. As a precautionary approach, we will consider the running

10-year average of the median take values as well as the annual maximum potential take values when conducting our jeopardy analyses in Section 8.

7 CUMULATIVE EFFECTS

ESA Section 7 regulations require NMFS to consider cumulative effects in formulating its Opinions (50 CFR 402.14). Cumulative effects include the effects of future state or private actions, not involving federal activities, that are reasonably certain to occur within the action area considered in this Opinion (50 CFR 402.02). NMFS is not aware of any future projects that may contribute to cumulative effects. Within the action area, the ongoing activities and processes described in the environmental baseline are expected to continue and NMFS did not identify any additional sources of potential cumulative effect. Although the present human uses of the action area are expected to continue, some may occur at increased levels, frequency, or intensity in the near future as described in the environmental baseline.

8 INTEGRATION AND SYNTHESIS - JEOPARDY ANALYSIS

Jeopardy Analysis

To "jeopardize the continued existence of" a species means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and the recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Thus, in making this determination for each species, we must look at whether the proposed action directly or indirectly reduces the reproduction, numbers, or distribution of a listed species. If there is a reduction in 1 or more of these elements, we evaluate whether the action would be expected to cause an appreciable reduction in the likelihood of both the survival and the recovery of the species.

The NMFS and USFWS's ESA Section 7 Handbook (USFWS and NMFS 1998) defines survival and recovery, as these terms apply to the ESA's jeopardy standard. Survival means "the species' persistence…beyond the conditions leading to its endangerment, with sufficient resilience to allow recovery from endangerment." The Handbook further explains that survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a sufficiently large population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter. Per the Handbook and the ESA regulations at 50 CFR 402.02, recovery means "improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Recovery is the process by which species' ecosystems are restored or threats to the species are removed or both so that self-sustaining and self-regulating populations of listed species can be supported as persistent members of native biotic communities.

Recovery plans include criteria, which, when met, would result in downlisting (i.e., changing the listing from endangered to threatened) or delisting (i.e., removal of the species from the List of Endangered and Threatened Wildlife). Recovery criteria can be viewed as targets, or values, by which progress toward achievement of recovery objectives can be measured. Recovery criteria may include such things as population numbers and sizes, management or elimination of threats by specific mechanisms, and specific habitat conditions. In newer recovery plans, recovery criteria are often framed in terms of population parameters (Demographic Recovery Criteria) and the 5 listing factors (Listing Factor Recovery Criteria). For some species, the plans have not been recently updated and do not include specific Demographic and Listing Factor Recovery Criteria. Regardless of whether these are included, we evaluate each species in the context of the criteria and objectives in its recovery plan.

The analyses conducted in the previous sections of this Opinion serve to provide a basis to determine whether the proposed action would be likely to jeopardize the continued existence of green (NA DPS), Kemp's ridley and loggerhead (NWA DPS) sea turtles. In Section 6.0, we outlined how the proposed action can adversely affect these species. Now, we turn to an assessment of the species response to these impacts, in terms of overall population effects, and whether those effects of the proposed action, when considered in the context of the Status of the Species (Section 4), the Environmental Baseline (Section 5), and the Cumulative Effects (Section 7), will jeopardize the continued existence of the affected species. For any species listed globally, our jeopardy determination must evaluate whether the proposed action will appreciably reduce the likelihood of survival and recovery at the species' global range. For any species listed as DPSs, a jeopardy determination must evaluate whether the proposed action will appreciably reduce the likelihood of survival and recovery of that DPS. The analysis in Section 6 resulted in a range of take values for each species and a reported median for those ranges. Despite the uncertainty in the estimation analysis, the median represents the central tendency of annual take that we expect to occur if there is a red tide bloom. However, to take a precautionary approach in assessing the likelihood of jeopardy for each species, we will assess the effect of take both at ten years of the median level and a single year at the maximum value for each species. In taking this approach, we recognize there is substantial variability anticipated in annual takes, with some years well below and some years well above the median. These take levels (e.g., ten years at median levels or a single year at the maximum value) are established as reinitiation triggers discussed in Section 9 below, so it is possible that a single year of take would reach these higher levels, before reinitiation of consultation is triggered to reevaluate the effects of the action. Considering the annual median take over the long term and the maximum take for a single year assures that the long term trend does not exceed our expectations and also allows us to evaluate abnormally high single year events.

8.1 Green sea turtles

Within waters of south Florida, only individuals from the NA DPS of green sea turtle can be found. We estimate that the proposed action is likely to result in a median of 6 interactions that will result in 5 mortalities of green sea turtles (NA DPS) per year (60 interactions and 50 mortalities over ten years). The maximum estimates for these calculations increase potential interactions to 28 with 23 mortalities in a single year. The non-lethal interaction of up to 5 green sea turtles (28 interactions - 23 mortalities from direct effects) from the NA DPS per year is not expected to have any measurable impact on the reproduction, numbers, or distribution of this species. Non-lethal interactions (injury or illness associated with red tide) will not result in a reduction in numbers of the species, as we anticipate these affected sea turtles to fully recover such that no reductions in reproduction or numbers of this species are anticipated. Since these interactions may occur anywhere within the action area and would remain within the same general area upon recovery, we anticipate no change in the distribution of NA DPS green sea turtles. The mortality of up to 23 green sea turtles from the NA DPS in a single year or 50 mortalities over 10 years is an obvious reduction in numbers. These moralities could also result in a potential reduction in future reproduction, assuming some individuals would be female and would have survived to reproduce in the future. For example, an adult green sea turtle can lay 3 to 4 clutches of eggs every 2 to 4 years, with approximately 110 to 115 eggs/nest, of which a small percentage are expected to survive to sexual maturity. These mortalities are anticipated to occur over just a portion of the action area but given green sea turtles in the NA DPS generally have large ranges, no reduction in the distribution is expected.

Whether the reductions in numbers and reproduction of this species would appreciably reduce its likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. In Section 4 (Status of ESA-listed species), we presented the status of the DPS, outlined threats, and discussed information on estimates of the number of nesting females and nesting trends at primary nesting beaches. In Section 5 (Environmental Baseline), we outlined the past and present impacts of all state, federal, or private actions and other human activities in or having effects in the action area that have affected and continue to affect this DPS. We also included an extensive section on Climate Change in Section 5.3.6. Section 7 (Cumulative Effects) discussed the effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area. These effects are in addition to the other ongoing effects to the species, such as bycatch in fisheries, effects from other federal actions, and the potential effects of climate change, all of which were already discussed in detail in the preceding sections of this Opinion. It is important to note that virtually all of the effects discussed, including the effects from LOK releases under the current water control plan, LORS08, have been occurring and affecting the species for at least the last decade. All of the previously discussed effects are part of the baseline upon which this analysis is founded, and the associated population level implications for the species are reflected in the species current population trends.

Seminoff et al. (2015) estimated that there are greater than 167,000 nesting green sea turtle females in the NA DPS. The nesting at Tortuguero, Costa Rica, accounts for approximately 79% of that estimate (approximately 131,000 nesters), with Quintana Roo, Mexico (approximately 18,250 nesters; 11%), and Florida, U.S. (approximately 8,400 nesters; 5%), also accounting for a large portion of the overall nesting (Seminoff et al. 2015). At Tortuguero, Costa Rica, the number of nests laid per year from 1999 to 2010 increased, despite substantial human impacts to the population at the nesting beach and at foraging areas (Campell and Lagueux 2005; Troëng and Rankin 2005). Nesting locations in Mexico along the Yucatan Peninsula indicate the number of nests laid each year has declined, but by 2000 this increased to over 1,500 nests/year (NMFS and USFWS 2007a). By 2012, more than 26,000 nests were counted in Quintana Roo (J. Zurita, *El Centro De Investigaciones De Quintana Roo*, unpublished data, 2013, in Seminoff et al. 2015). In Florida, most nesting occurs along the eastern central Atlantic coast, where a mean of 5,055 nests were deposited each year from 2001 to 2005 (Meylan et al. 2006) and 10,377 each year from 2008 to 2012 (B. Witherington, FWC, pers. comm., 2013). As described in Section 4 of this Opinion, nesting has increased substantially over the last 20 years and peaked in 2019 with 53,016 nests statewide in Florida, though the number of nests dropped in the years since the peak.

Although the anticipated mortalities would result in an instantaneous reduction in absolute population numbers, the NA DPS of green sea turtles would not be appreciably affected. For a population to remain stable, sea turtles must replace themselves through successful reproduction at least once over the course of their reproductive lives, and at least one offspring must survive to reproduce itself. If the hatchling survival rate to maturity is greater than the mortality rate of the population, the loss of breeding individuals would be exceeded through recruitment of new breeding individuals. For approximately the last 30 years, the abundance trend information, based largely on nesting data, has clearly been increasing, while a similar number of mortalities associated with water releases from LOK has been occurring. While the increasing abundance trend appears to have ended in recent years, overall numbers remain high relative to prior decades. Given the low numbers of mortalities associated with the proposed action, 23 green sea turtles each year representing a very small fraction (<0.0003% annually) of the overall NA DPS female nesting population estimated by Seminoff et al. (2015), the loss of those individuals is highly unlikely to have any measurable effect on the population. As described in Section 4, although the DWH oil spill event is expected to have resulted in adverse impacts to green sea turtles, there is no information to indicate, or basis to believe, that a significant population-level impact has occurred that would have changed the species' status to an extent that expected interactions from LOSOM implementation would result in a detectable change in the population status of NA DPS green sea turtles in the Atlantic. Any impacts are not thought to alter the population status to a degree in which the number of mortalities from the proposed actions could be seen as reducing the likelihood of survival and recovery of the species.

As mentioned in previous sections, some of the likely effects commonly associated with climate change are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The potential effects, and the expected related effects to ESA-listed species (e.g., impacts to sea turtle nesting beaches and hatchling sex ratios, associated effects to prey species, etc.) stemming from climate change are the result of a slow and steady shift over a long time-period, and forecasting any specific critical threshold that may occur at some point in the future (e.g., several decades) is highly uncertain. Therefore, we do not expect the effects of climate change will present an additional risk to the NA DPS green sea turtle population in the context of the effects from this action.

In summary, green sea turtle nesting at the primary nesting beaches within the range of the NA DPS has been increasing over the past 2 decades, against the background of the past and ongoing human and natural factors (i.e., the environmental baseline) that have contributed to the current status of the species. We believe these nesting trends are indicative of a species with a high number of sexually mature individuals. Since the long-term abundance trend information for NA DPS green sea turtles reflects a relatively large number of individuals, we believe up to 5 non-lethal interactions and the mortality of up to 23 green sea turtles in a single year or 50 mortalities over 10 years will not have any measurable effect on the population. After analyzing the magnitude of the effects of the proposed action, in combination with the past, present, and future expected impacts to the DPS discussed in this Opinion, we believe the proposed action covered under this Opinion is not reasonably expected to cause an appreciable reduction in the likelihood of survival of the green sea turtle NA DPS in the wild.

As described in Section 5 (Environmental Baseline), regulatory actions have been taken to reduce anthropogenic effects to green sea turtles in the Atlantic. These include measures to reduce the number and severity of green sea turtle interactions in fisheries, which are causes of green sea turtle mortality in the Atlantic. Since most of these regulatory measures have been in place for several years now, it is likely that current nesting trends reflect the benefit of these measures to Atlantic green sea turtles. Therefore, the current nesting trends for green sea turtles in the Atlantic are likely to continue to improve as a result of the regulatory actions taken for these and other fisheries. There are no new known sources of mortality for green sea turtles in the Atlantic other than potential, yet to be identified, impacts from the DWH oil spill event.

The recovery plan for Atlantic green sea turtles (NMFS and USFWS 1991) lists the following recovery objectives, which are relevant to the proposed action in this Opinion, and must be met over a period of 25 years:

- The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years;
- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.

Along the Atlantic coast of eastern central Florida, a mean of 5,055 nests were deposited each year from 2001 to 2005 (Meylan et al. 2006) and 10,377 each year from 2008 to 2012 (B. Witherington, FWC, pers. comm., 2013, as cited in Seminoff et al. 2015). Nesting has increased substantially over the last 20 years and peaked in 2011 with 15,352 nests statewide (Chaloupka et al. 2007; B. Witherington, FWC, pers. comm., 2013 as cited in Seminoff et al. 2015). The status review estimated total nester abundance for Florida at 8,426 turtles (Seminoff et al. 2015). As described above, sea turtle nesting in Florida is increasing. For the most recent 6-year period of statewide nesting beach survey data, there were 53,102 in 2017, 4,546 in 2018, and 53,016 in 2019, 26,656 in 2020, 32,680 in 2021, and 37,028 in 2022 (see https://myfwc.com/research/wildlife/sea-turtles/nesting/green-turtle/). Thus, this recovery criterion continues to be met.

Several actions are being taken to address the second objective; however, there are currently few studies, and no estimates, available that specifically address changes in abundance of individuals on foraging grounds. A study in the central region of the Indian River Lagoon (along the east coast of Florida) found a 661% increase in juvenile green sea turtle capture rates over a 24-year study period from 1982 to 2006 (Ehrhart et al. 2007). Wilcox et al. (1998) found a dramatic increase in the number of green sea turtles captured from the intake canal of the St. Lucie nuclear power plant on Hutchinson Island, Florida beginning in 1993. During a 16-year period from 1976 to 1993, green sea turtle captures averaged 24 per year. Green sea turtle catch rates for 1993, 1994, and 1995 were 745%, 804%, and 2,084% above the previous 16-year average annual catch rates (Wilcox et al. 1998). In a study of sea turtles incidentally caught in pound net gear fished in inshore waters of Long Island, New York, Morreale and Standora (2005) documented the capture of more than twice as many green sea turtles in 2003 and 2004 with less pound net gear fished, compared to the number of green sea turtles captured in pound net gear in the area during the 1990s. Yet other studies have found no difference in the abundance (decreasing or increasing) of green sea turtles on foraging grounds in the Atlantic (Bjorndal et al. 2005; Epperly et al. 2007). Given the clear increases in nesting, however, it is reasonably likely that numbers on foraging grounds have increased.

Based on the lack of impediment to accomplishing the relevant recovery objectives, in combination with the past, present, and future expected impacts to the DPS discussed in this Opinion, we believe the proposed action is not reasonably expected to cause an appreciable reduction in the likelihood of recovery of the green sea turtle NA DPS in the wild.

We conclude the non-lethal take of up to 5 and loss of up to 23 NA DPS green sea turtles in a single year or 60 interactions and 50 mortalities over ten years as a result of the proposed action considered in this Opinion—even amidst other ongoing threats to the species including bycatch mortality from fisheries, other federal actions (i.e., anticipated take issued in other Opinions), or and the potential effects of climate change—will not appreciably reduce the likelihood of survival for green sea turtles. This conclusion is based on the above findings where we demonstrated the number of interactions and mortalities are not expected to measurably affect the overall abundance of the relatively large population, and that we have implemented other conservation measures to reduce the number of NA DPS green sea turtle mortalities, which should result in increases to the numbers of NA DPS green sea turtles that would otherwise not have occurred in the absence of those regulatory measures. Given the proposed action is not expected to measurably affect abundance, it will also not appreciably reduce the likelihood of recovery of NA DPS green sea turtles. Therefore, we conclude the proposed action considered in this Opinion is not expected to cause an appreciable reduction in the likelihood of either the survival or recovery of the NA DPS of green sea turtles in the wild.

8.2 Kemp’s ridley sea turtles

Concentrated in the shallow waters of the Gulf of Mexico and Atlantic coast, we expect Kemp’s ridley sea turtles to be affected by the proposed action. We estimate that the proposed action is likely to result in a total of 8 Kemp’s ridley sea turtles becoming affected by red tides per year with 7 resulting in mortality (80 interactions and 70 mortalities over ten years). The maximum estimates for these calculations increase potential interactions to 44 with 41 mortalities in a single year. The non-lethal injury/illness of up to 3 Kemp’s ridley sea turtles (44 total - 41 mortalities) per year is not expected to have any measurable impact on the reproduction, numbers, or distribution of this species. Either male or female Kemp’s ridleys may be affected by HABs because available information suggests that both sexes occur in the action area.

Whether the reductions in numbers and reproduction of this species would appreciably reduce its likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. In Section 4 (Status of Species), we presented the status of Kemp’s ridley sea turtles, outlined threats, and discussed information on estimates of the number of nesting females and nesting trends at primary nesting beaches. In Section 5 (Environmental Baseline), we outlined the past and present impacts of all state, federal, or private actions and other human activities in or having effects in the action area that have affected and continue to affect this species. We also included an extensive section on Climate

Change in Section 5.3.6. Section 7 (Cumulative Effects) discussed the effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area. These effects are in addition to the other ongoing effects to the species, such as bycatch fisheries, effects from other federal actions, and the potential effects of climate change, all of which were already discussed in detail in the preceding sections of this Opinion. It is important to note that virtually all of the effects discussed, including the effects from the currently operating water control plan (LORS08), have been occurring and affecting the species for at least the past decade. All of the previously discussed effects are part of the baseline upon which this analysis is founded, and the associated population level implications for the species are reflected in the species current population trends.

Nest count data provides the best available information on the number of adult females nesting each year. As is the case with other sea turtles species, nest count data must be interpreted with caution given that these estimates provide a minimum count of the number of nesting Kemp's ridley sea turtles. In addition, the estimates do not account for adult males or juveniles of either sex. Without information on the proportion of adult males to females and the age structure of the population, nest counts cannot be used to estimate the total population size (Meylan 1982; Ross 1996). Nevertheless, the nesting data does provide valuable information on the extent of Kemp's ridley nesting and the trend in the number of nests laid, and represents the best proxy we have for estimating population changes.

Nesting data show a long term population increase from 1989 to 2009. Since that period the population of nesting females has fluctuated with high nest counts in 2011, 2012, 2017, and 2020 but low nest counts in 2010, 2014, 2015 and 2019. Record high nesting was observed in 2017, with 24,570 nests recorded (Gladys Porter Zoo 2017). At this time, it is unclear whether the increases and declines in nesting seen over the past decade represents a population oscillating around an equilibrium point or if nesting will decline or increase in the future. A small nesting population has also been emerging in the United States, primarily in Texas. From 1980 to 1989, there were an average of 0.2 nests/year at PAIS, rising to 3.4 nests/year from 1990 to 1999, 44 nests/year from 2000-2009, and 110 nests per year from 2010 to 2019. There was a record high of 353 nests in 2017 (NPS 2020). It is worth noting that nesting in Texas has largely paralleled the trends observed in Mexico, characterized by a significant decline in 2010, a peak in 2017 (NMFS 2020b), decreases in 2018 and 2019 (NPS 2020), and additional rebounds in 2020 and 2022.

Estimates of the adult female nesting population reached a low of approximately 250 to 300 in 1985 (NMFS and USFWS 2015; TEWG 2000). Galloway et al. (2016) developed a stock assessment model for Kemp's ridley to evaluate the relative contributions of conservation efforts and other factors toward this species' recovery. Terminal population estimates for 2012 for ages 9+ suggest that the respective nesting female population size was 28,113 (SD = 2,987) (Gallaway et al. 2016). Using the standard IUCN protocol for sea turtle assessments, the number of mature individuals was recently estimated at 22,341 (Wibbels and Bevan 2019). The calculation took into account the average annual nests from 2016-2018 (21,156), a clutch frequency of 2.5 per year, a remigration interval of 2 years, and a sex ratio of 3.17 females per male. Based on the data in their analysis, the assessment concluded the current population trend is unknown (Wibbels and Bevan 2019). However, some positive outlooks for the species include recent conservation actions, including the expanded TED requirements in the skimmer trawl sector of the shrimp fisheries (84 FR 70048, December 20, 2019; 86 FR 16676, March 31, 2021) and a decrease in the amount of overall shrimping off the coast of Tamaulipas and in the Gulf of Mexico (NMFS and USFWS 2015).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by nuclear DNA analyses (i.e., microsatellites) (NMFS et al. 2011). If this holds true, then rapid increases in population over one or two generations would likely prevent any negative consequences in the genetic variability of the species (NMFS et al. 2011). Additional analysis of the mtDNA taken from samples of Kemp's ridley turtles at Padre Island, Texas, showed six distinct haplotypes, with one found at both Padre Island and Rancho Nuevo (Dutton et al. 2006).

Kemp's ridley turtles mature and nest at an age of 7 to 15 years, which is earlier than other sea turtles. A younger age at maturity may be a factor in the response of this species to recovery actions. The required use of TEDs in shrimp trawls in the United States under the sea turtle conservation regulations and in Mexican waters as required by their federal regulations has had dramatic effects on the recovery of Kemp's ridley sea turtles. Kemp's ridley sea turtles total mortality (all sources) declined by about one-third with the early implementation of TEDs, and it has been estimated that after 1996 mortality declined by almost 60% compared to pre-TED levels.

The proposed action would reduce the species' population compared to the number that would have been present in the absence of the proposed action, assuming all other variables remained the same. Using the estimate of mature animals in Wibbels and Bevan (2019), the loss of up to 41 animals in a single year represents an approximate 0.002% reduction of the overall sexually-mature population. However, we expect at least a portion of these turtles are small, sexually-immature juvenile sea turtles, many of which would not survive to reach maturity and reproduce. As a result, we believe the reduction in the overall Kemp's ridley sea turtle population (immature and mature) is much less significant considering sea turtle species are expected to have increasing numbers of specimens when looking at overall population by descending age (i.e., older to younger). The proposed action could also result in a potential reduction in future reproduction, assuming at least some of these individuals would be female and would have survived to reproduce in the future. The annual loss of adult females could preclude the production of thousands of eggs and hatchlings, of which a small percentage is expected to survive to sexual maturity. Thus, the death of any females that would otherwise have survived to sexual maturity would eliminate their contribution to future generations, and result in a reduction in sea turtle reproduction. Though anticipated lethal interactions are expected to occur in the western portion of the action area, sea turtles generally have large ranges in which they disperse. Thus, no reduction in the distribution of Kemp's ridley sea turtles is expected from red tide-related mortalities. Whether the reductions in numbers and reproduction of Kemp's ridley sea turtles would appreciably reduce their likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. In addition, the species' limited range and low global abundance make it particularly vulnerable to new sources of mortality as well as demographic and environmental stochasticity, which are often difficult to predict with any certainty.

It is likely that the Kemp's ridley was the sea turtle species most affected by the DWH oil spill event on a population level. In addition, sea turtle strandings documented from 2010 to present in Alabama, Louisiana, and Mississippi primarily involved Kemp's ridley sea turtles. Necropsy results indicated that a significant proportion of turtle mortality was caused by forced submergence, which is commonly associated with fishery interactions (77 FR 27413, May 10, 2012). As described in Section 5 (Environmental Baseline), regulatory actions have been taken to reduce anthropogenic effects to Kemp's ridley sea turtles. These include measures implemented to reduce the number and severity of Kemp's ridley sea turtle interactions in the Mid-Atlantic large mesh gillnet, Mid-Atlantic summer flounder, Mid-Atlantic scallop dredge, and the Virginia pound net fisheries. In 2021, TED requirements in a portion of the skimmer trawl sector of the shrimp fisheries became effective, further reducing impacts to sea turtles.

There are no new, known sources of mortality for Kemp's ridley sea turtles other than potential ongoing impacts from the DWH oil spill event, and highly uncertain potential future impacts associated with climate change. As mentioned in previous sections, some of the likely effects commonly associated with climate change are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The potential effects, and the expected related effects to ESA-listed species (e.g., impacts to sea turtle nesting beaches and hatchling sex ratios, associated effects to prey species, etc.) stemming from climate change are the result of a slow and steady shift over a long time-period, and forecasting any specific critical threshold that may occur at some point in the future (e.g., several decades) is highly uncertain. We do not expect the effects of climate change will present an additional risk to the Kemp's ridley sea turtle population in the context of effects from this action. Furthermore, the effects on Kemp's ridley sea turtles from the proposed action are not likely to appreciably reduce overall population numbers over time due to current population size, expected recruitment, and the implementation of additional conservation requirements in the shrimp trawl fisheries, even in light of the adverse impacts expected to have occurred from the DWH oil spill event.

It is important to remember that with significant inter-annual variation in nesting data, sea turtle population trends necessarily are measured over decades and the long-term trend line better reflects the population increase in Kemp's ridleys. With the recent nesting data, the population trend has become less clear. Nonetheless, data from 1990 to present continue to support that Kemp's ridley sea turtles have shown a generally increasing nesting trend. Even with reported biennial fluctuations in nesting numbers from Mexican beaches, all years since 2006 have reported over 10,000 nests per year, indicating an increasing population over the previous decades. We believe this long-term trend in nesting is likely evidence of a generally increasing population, as well as a population that is maintaining (and potentially increasing) its genetic diversity. These nesting data are indicative of a species with a high number of sexually mature individuals. All of those positive population trends have arisen while fisheries, LOK releases, and other federal actions have been ongoing and adversely affecting the species along with all the other adverse effects included in the baseline. The loss of up to 7 Kemp's ridleys in a single year or 70 mortalities over 10 years is not expected to change the trend in nesting, the distribution of, or the reproduction of Kemp's ridley sea turtles. Therefore, we do not believe the proposed action will cause an appreciable reduction in the likelihood of survival of this species in the wild.

The recovery plan for the Kemp's ridley sea turtle (NMFS et al. 2011) lists the following recovery objectives for downlisting that are relevant to the proposed action assessed in this Opinion:

- Demographic: A population of at least 10,000 nesting females in a season (as measured by clutch frequency per female per season) distributed at the primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained. Methodology and capacity to implement and ensure accurate nesting female counts have been developed.
- Listing factor: TED regulations, or other equally protective measures, are maintained and enforced in U.S. and Mexican trawl fisheries (e.g., shrimp, summer flounder, whelk) that are known to have an adverse impact on Kemp's ridley turtles in the Gulf of Mexico and Northwest Atlantic Ocean.

With respect to the demographic recovery objective, the nesting numbers in the most recent three years indicate there were 11,140 nests in 2019, 18,068 in 2020, and 17,671 in 2021 on the main nesting beaches in Mexico. Based on 2.5 clutches/female/season, these numbers represent approximately 4,456 (2019), 7,227 (2020), and 7,068 (2021) nesting females in each season. The number of nests reported annually declined from 2011 to 2014 before increasing annually until 2017. A similar decline in nesting counts occurred following the record year in 2017 and lasted until 2019 before beginning another increase. Although there has been a substantial increase in the Kemp's ridley population within the last few decades, the number of nesting females is still below the number of 10,000 nesting females per season required for downlisting (NMFS and USFWS 2015). Since we concluded that the potential loss of Kemp's ridley sea turtles is not likely to have any detectable effect on nesting trends, we do not believe the proposed action will impede progress toward achieving this recovery objective. The 3 non-lethally affected Kemp's ridley turtles in a single year are expected to fully recover from red tide effects and would not affect the adult female nesting population or number of nests per nesting season. Thus, we believe the proposed action will not result in an appreciable reduction in the likelihood of Kemp's ridley sea turtles' recovery in the wild.

In regards to the listing factor recovery criterion, the recovery plan states, "the highest priority needs for Kemp's ridley recovery are to maintain and strengthen the conservation efforts that have proven successful. In the water, successful conservation efforts include maintaining the use of TEDs in fisheries currently required to use them, expanding TED-use to all trawl fisheries of concern, and reducing mortality in gillnet fisheries. Adequate enforcement in both the terrestrial and marine environment also is also noted as essential to meeting recovery goals" (NMFS et al. 2011). NMFS expanded the use of TEDs in skimmer trawls in 2021, which should aid in the recovery of the species. The required use of TEDs in shrimp trawls in the United States under sea turtle conservation regulations and in Mexican waters has had dramatic effects on the recovery of Kemp's ridley sea turtles.

In summary, the non-lethal take of up to 3 and loss of up to 41 Kemp's ridley sea turtles in a single year or 80 interactions and 70 mortalities over ten years as a result of the action considered in this Opinion—even amidst other ongoing threats to the species including bycatch mortality from fisheries, other federal actions (i.e., anticipated take issued in other Opinions), and the potential effects of climate change—will not appreciably reduce the likelihood of survival and recovery for Kemp's ridley sea turtles given the long term nesting trend, the population size, and ongoing and future measures that should reduce the number of Kemp's ridley sea turtle injuries and mortalities.

8.3 Loggerhead sea turtles (NWA DPS)

We estimate that the proposed action will result in a total of 9 loggerhead sea turtle interactions with 8 resulting in mortality each year (90 interactions and 80 mortalities over ten years). The maximum take estimates for these calculations increase potential interactions to 42 with 39 mortalities. The non-lethal effect of HABs (red tide) on up to 3 loggerhead sea turtles (42 - 39 mortalities) from the NWA DPS in a single year is not expected to have any measurable impact on the reproduction, numbers, or distribution of this species. Non-lethal effects such as illness or injury will not result in a reduction in numbers of the species, as we anticipate these non-lethally effected turtles to recover such that no reductions in reproduction or numbers of this species are anticipated. These interactions are expected to occur within the western portion of the action area and are expected to stay within the same general area through recovery so we anticipate no change in the distribution of NA DPS green sea turtles. The mortality of up to 39 loggerhead sea turtles in a single year or 80 mortalities over 10 years from the NWA DPS due to the proposed action each year will reduce the number of loggerhead sea turtles compared to the number that would have been present in the absence of the proposed actions (assuming all other variables remained the same). These lethal interactions would also result in a future reduction in reproduction due to lost reproductive potential, as some of these individuals would be females who would have reproduced in the future, thus eliminating each female individual's contribution to future generations. For example, an adult female loggerhead sea turtle in the NWA DPS can lay 3 or 4 clutches of eggs every 2 to 4 years, with 100 to 126 eggs per clutch (NMFS and USFWS 2008). The annual loss of adult female sea turtles, on average, could preclude the production of thousands of eggs and hatchlings of which a small percentage would be expected to survive to sexual maturity. A reduction in the distribution of loggerhead sea turtles is not expected from lethal interactions attributed to the proposed action. Because loggerheads generally have large ranges in which they disperse, the distribution of loggerhead sea turtles in the action area is not expected to be affected.

Whether the reductions in loggerhead sea turtle numbers and reproduction as a result of the proposed action would appreciably reduce the likelihood of survival for loggerheads depends on what effect these reductions in numbers and reproduction would have on overall population sizes and trends. In Section 4 (Status of ESA-Listed Species), we reviewed the status of the NWA DPS of loggerhead sea turtles in terms of nesting, female population trends, and several of the most recent assessments based on population modeling. In Section 5 (Environmental Baseline), we outlined the past and present impacts of all state, federal, or private actions and other human activities in or having effects in the action area that have affected and continue to affect this species. We also included an extensive section on Climate Change in Section 5.3.6. Section 7 (Cumulative Effects) discussed the effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area. These effects are in addition to the other ongoing effects to the species, such as bycatch in fisheries, effects from other federal actions, and the potential effects of climate change, all of which were already discussed in detail in the preceding sections of this Opinion. It is important to note that virtually all of the effects discussed, including the effects from the currently operating water control plan (LORS08), have been occurring and affecting the species for at least the past decade. All of the previously discussed effects are part of the baseline upon which this analysis is founded, and the associated population level implications for the species are reflected in the species' current population trends.

Loggerhead sea turtles are a slow growing, late-maturing species. Because of their longevity, loggerhead sea turtles require high survival rates throughout their life to maintain a population. In other words, late-maturing species cannot tolerate too much anthropogenic mortality without going into decline. Conant et al. (2009) concluded that loggerhead natural growth rates are small, natural survival needs to be high, and even low to moderate mortality can drive the population into decline. Because recruitment to the adult population takes many years, population modeling studies suggest even small increased mortality rates in adults and subadults could substantially impact population numbers and viability (Chaloupka and Musick 1997; Crouse et al. 1987; Crowder et al. 1994).

NMFS (2009e) estimated the minimum adult female population size for the NWA DPS[4] in the 2004 to 2008 time frame to likely be between approximately 20,000 to 40,000 individuals (median 30,050), with a low likelihood of being as many as 70,000 individuals. Another estimate for the entire NWA DPS was a mean of 38,334 adult females using data from 2001 to 2010 (Richards et al. 2011). A much less robust estimate for total benthic females in the NWA DPS was also obtained, with a likely range of approximately 30,000 to 300,000 individuals, up to less than 1,000,000. NMFS (2011a) preliminarily estimated the loggerhead population in the NWA DPS along the continental shelf of the Eastern Seaboard during the summer of 2010 at 588,439 individuals (estimate ranged from 381,941 to 817,023) based on positively identified individuals. Our Northeast Fisheries Science Center's point estimate increased to approximately 801,000 individuals when including data on unidentified sea turtles that were likely loggerheads. NMFS (2011a) underestimates the total population of loggerheads since it did not include Florida's east coast south of Cape Canaveral (including offshore SLE) or the Gulf of Mexico (including offshore CRE). These are areas where large numbers of loggerheads can also be found, and are partially within the LOSOM action area. As such, NMFS (2011a) provides an estimate of a subset of the entire population. These numbers were derived prior to additional years of increased nesting.

Florida accounts for more than 90% of U.S. loggerhead nesting. FWRI examined the trend from the 1998 nesting high through 2016 and found that the decade-long post-1998 decline was replaced with a slight but non-significant increasing trend. Looking at the data from 1989 through 2016, FWRI concluded there was no significant trend in nest counts, perhaps due to wide confidence intervals associated with data from 2012 to 2016. Nesting at the core index beaches declined in 2017 to 48,033, but rose to over 53,000 by 2019, the third highest total since 2001. However, it is important to note that with the wide confidence intervals and uncertainty around the variability in nesting parameters (changes and variability in nests/female, nesting intervals, etc.), it is unclear whether the nesting trend equates to an increase in the population or nesting females over that time frame (Ceriani et al. 2019).

---

[4] We refer to the NWA DPS, even when discussing information in references published prior to the 2011 DPS listing, for consistency and ease of interpretation in this analysis.

In summary, abundance estimates accounting for only a subset of the entire loggerhead sea turtle population in the NWA DPS indicate the population is large (i.e., several hundred thousand individuals). Furthermore, overall long-term nesting trends have been level or increasing over the years.

The proposed action could remove up to 39 individuals in a single year or 80 over ten years. These 39 removed individuals represent approximately 0.0001% annually on the low end of the NMFS (2011a) estimate of 381,941 loggerheads within the Northwest Atlantic continental shelf (as opposed to pelagic juveniles on the open ocean). As noted above, this estimate reflects a subset of the entire population for the NWA DPS of loggerhead sea turtles, and thus these individuals represent an even smaller proportion of the population removed. While the loss of up to 39 individuals in a single year or 80 over ten years is an impact to the population, in the context of the overall population's size and current trend, we do not expect it to result in a detectable change to the population numbers or trend. The amount of loss is smaller than the error associated with estimating (through extrapolation) the overall population in the 2011 report. Consequently, we expect the population within the NWA DPS to remain large (i.e., hundreds of thousands of individuals) and to retain the potential for recovery. We also expect the proposed action will not cause the population to lose genetic heterogeneity, broad demographic representation, or successful reproduction, nor affect loggerheads' ability to meet their lifecycle requirements, including reproduction, sustenance, and shelter. Therefore, we conclude the proposed action is not likely to appreciably reduce the likelihood of the NWA DPS of loggerhead sea turtles' survival in the wild.

As mentioned in previous sections, some of the likely effects commonly associated with climate change are sea level rise, increased frequency of severe weather events, and change in air and water temperatures. The potential effects, and the expected related effects to ESA-listed species (e.g., impacts to sea turtle nesting beaches and hatchling sex ratios, associated effects to prey species, etc.) stemming from climate change are the result of a slow and steady shift over a long time-period, and forecasting any specific critical threshold that may occur at some point in the future (e.g., several decades) is highly uncertain. In some instances, species' behavioral changes may mitigate some of the impacts, including shifting breeding season and location to avoid warmer temperatures. For example, the start of the nesting season for loggerheads has already shifted as the climate has warmed (Weishampel et al. 2004). We do not expect the effects of climate change will present an additional risk to the NWA DPS loggerhead sea turtle population in the context of the effects of this action.

The recovery plan for the Northwest Atlantic population of loggerhead sea turtles (NMFS and USFWS 2008) was written prior to the loggerhead sea turtle DPS listings. However, this plan deals with the populations that comprise the current NWA DPS and is, therefore, the best information on recovery criteria and goals for the DPS. The plan's recovery goal for loggerhead sea turtles is "to ensure that each recovery unit meets its Recovery Criteria alleviating threats to the species so that protection under the ESA is no longer necessary" (NMFS and USFWS 2008). The plan then identifies 13 recovery objectives needed to achieve that goal. Elements of the proposed action support or implement the specific actions needed to achieve a number of these recovery objectives. Thus, we do not believe the proposed action impedes the progress of the recovery program or achieving the overall recovery strategy.

The plan lists the following recovery objectives that are relevant to the effects of the proposed action:

- 1. Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.
- 2. 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.
- 4. Manage sufficient feeding, migratory, and inter-nesting marine habitats to ensure successful growth and reproduction

The recovery plan anticipates that, with implementation of the plan, the NWA DPS will recover within 50 to 150 years, but notes that reaching recovery in only 50 years would require a rapid reversal of the then-declining trends of the NRU, PFRU, and NGMRU. The minimum end of the range assumes a rapid reversal of the current declining trends; the higher end assumes that additional time will be needed for recovery actions to bring about population growth.

Ensuring that the number of nests in each recovery unit is increasing is the recovery plans first recovery objective and, moreover, is the plan's overarching objective with associated demographic criteria. Nesting trends in most recovery units have been stable or increasing over the past couple of decades. As noted previously, we believe the future takes predicted will be similar to the levels of take that have occurred in the past and those past takes did not impede the positive trends we are currently seeing in nesting during that time. We also indicated that the potential lethal take of up to 83 loggerhead sea turtles a year is so small in relation to the overall population on the continental shelf (which does not include the large, but unknown pelagic population numbers), that it would be hardly detectable. For these reasons, we do not believe the proposed action will impede achieving this recovery objective.

The proposed action also does not conflict with Recovery Objectives 2. While neritic juveniles could be affected by and die from red tide blooms, the quantity of loggerheads affected as a result of LOK releases is very small in relation to the size of the population. For this reason, we do not believe the proposed action will impede achieving this recovery objective.

The proposed action could affect nearshore marine habitats used for feeding, migration, and inter-nesting resting which could conflict with Recovery Objective 4. However, the action is only expected to influence a small portion of marine habitat and thus there should be plenty of sufficient habitat unaffected for loggerhead use. Further, any effects to the marine habitat are expected to be limited in duration, thus unlikely to affect the recovery objective over the long-term. For these reasons, we do not believe the proposed action will impede achieving this recovery objective.

Based on the lack of impediment to accomplishing the relevant recovery objectives, in combination with the past, present, and future expected impacts to the DPS discussed in this Opinion, we believe the proposed action is not reasonably expected to cause an appreciable reduction in the likelihood of recovery of the loggerhead sea turtle NWA DPS in the wild.

The potential for up to 39 loggerhead sea turtle mortalities from the NWA DPS in a single year or 80 individuals over ten years will result in a reduction in numbers when they occur, but it is unlikely to have any detectable influence on the trends noted above, even when considered in context with information in Sections 4 (Status of the Species), 5 (Environmental Baseline), and 7 (Cumulative Effects) discussed in this Opinion. Similarly, we do not expect the non-lethal interaction with 3 loggerhead sea turtles per year from the NWA DPS to have any detectable influence on the recovery objectives. Therefore, we conclude the proposed action considered in this Opinion—even amidst other ongoing threats to the species including bycatch mortality from fisheries, other federal actions (i.e., anticipated take issued in other Opinions), and the potential effects of climate change—is not expected to cause an appreciable reduction in the likelihood of either the survival or recovery of the NWA DPS of loggerhead sea turtles in the wild.

9 CONCLUSION

We reviewed the Status of the Species, the Environmental Baseline, the Effects of the Action, and the Cumulative Effects using the best available data.

The proposed action will result in the take of green (NA DPS), Kemp's ridley, and loggerhead (NWA DPS) sea turtles. Given the nature of the proposed action and the information provided above, we conclude that the action, as proposed, is not likely to jeopardize the continued existence of any of these listed species/DPSs.

10 INCIDENTAL TAKE STATEMENT

10.1 Overview

Section 9 of the ESA and protective regulations issued pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. *Take* is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct (ESA Section 2(19)). *Incidental take* refers to takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that would otherwise be considered prohibited under Section 9 or Section 4(d) but which is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the Reasonable and Prudent Measures and the Terms and Conditions of the Incidental Take Statement of the Opinion.

The USACE has a continuing duty to ensure compliance with the reasonable and prudent measures and terms and conditions included in this Incidental Take Statement. If the USACE (1) fails to assume and implement the terms and conditions or (2) fails to require the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the operations document, the protective coverage of Section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USACE must report the progress of the action and its impact on the species to NMFS as specified in the Incidental Take Statement (50 CFR 402.14(i)(3)).

Throughout this Opinion, NMFS acknowledges that the USACE controls the infrastructure to hold and release water, but that they are not the agency responsible for regulating nutrient inputs into the lake or nutrient outputs from the lake. Nevertheless, the effects of nutrients on the downstream estuaries and listed species would not occur but for the water releases described in the proposed action. The USACE agrees that species may be taken incidental to LOSOM, but they do dispute that they are responsible for the take because they have limited discretion on how LOSOM is operated and do not have authority to regulate nutrients. NMFS takes no position on the jurisdictional question of whether the USACE is responsible for any taking of a species incidental to their activities. However, the USACE will need to comply with the following terms and conditions in order to effectuate the exemption to take as described in Section 7(o) of the ESA.

10.2 Amount or Extent of Anticipated Incidental Take

Based on the above information and analyses, NMFS believes that the proposed action is likely to adversely affect the NA DPS of green sea turtles, Kemp's ridley sea turtles, and the NWA DPS of loggerhead sea turtles. These effects will result from LOK releases contributing to red tide bloom intensity and duration on the west coast of Florida. Because red tide blooms are known to result in sea turtle mortality (Foley et al. 2019), we expect that a portion of dead turtles stranded during red tide blooms are attributable to LOK releases. NMFS anticipates the following incidental take may occur each year a red tide bloom occurs as a result of the proposed action (Table 4).

Table 4. Anticipated Annual Incidental Take (reported as both Median and Maximum) Related to LOSOM. Mortality represented in parentheses.

Species	Median Take	Maximum Take
Green sea turtle (NA DPS)	6 (5)	28 (23)
Kemp's ridley sea turtle	8 (7)	44 (41)
Loggerhead sea turtle (NWA DPS)	9 (8)	42 (39)

10.3 Effect of Take

NMFS has determined that the anticipated incidental take specified in Section 10.2 is not likely to jeopardize the continued existence of green (NA DPS), Kemp's ridley, or loggerhead (NWA DPS) sea turtles, if the project is implemented as proposed.

10.4 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires NMFS to issue to any federal agency whose proposed action is found to comply with Section 7(a)(2) of the ESA, but may incidentally take individuals of listed species, a statement specifying the impact of that taking. The Incidental Take Statement must specify the Reasonable and Prudent Measures necessary to minimize the impacts of the incidental taking from the proposed action on the species, and Terms and Conditions to implement those 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 CFR 402.02). Per Section 7(o)(2), any incidental taking that complies with the specified terms and conditions is not considered to be a prohibited taking of the species concerned.

The Reasonable and Prudent Measures and terms and conditions are required to document the incidental take by the proposed action and to minimize the impact of that take on ESA-listed species (50 CFR 402.14(i)(1)(ii) and (iv)). These measures and terms and conditions must be implemented by the USACE for the protection of Section 7(o)(2) to apply. The USACE has a continuing duty to ensure compliance with the reasonable and prudent measures and terms and conditions included in this Incidental Take Statement. If the USACE fails to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms, or fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse. To monitor the impact of the incidental take, the USACE must report the progress of the action and its impact on the species to SERO PRD as specified in the Incidental Take Statement [50 CFR 402.14(i)(3)].

NMFS has determined that the following Reasonable and Prudent Measures are necessary and appropriate to minimize impacts of the incidental take of ESA-listed species related to the proposed action. The following Reasonable and Prudent Measures and associated terms and conditions are established to implement these measures, and to document incidental takes. Only incidental takes that occur while these measures are in full implementation are not considered to be a prohibited taking of the species. These restrictions remain valid until reinitiation and conclusion of any subsequent Section 7 consultation.

RPM 1: Monitoring – water quality and flow parameters

Because nutrients originating from LOK releases can enhance red tide blooms in the downstream estuaries and associated nearshore environments, monitoring nutrients and flow rates, which deliver nutrients, will be important for assessing potential take of sea turtles. The USACE will be required to monitor (through the gathering of available data collected by the agencies responsible for water quality such as Florida DEP and the water management districts) and report water releases (flow) and nutrients (e.g., TN, TP) from LOK. The USACE will also be required to use collected data to calculate sea turtle takes associated with effects of the proposed action (red tide formation or enhancement) in the downstream estuaries and nearshore marine environment. These data sources will be used in conjunction with sea turtle data collected under RPM #2 to assess sea turtle take under this Opinion. Further, modeling of physical and chemical data collected may reveal a superior approach to computing the relative contribution of LOK releases to sea turtle take.

RPM 2: Monitoring – sea turtle takes

The USACE will coordinate with the Sea Turtle Stranding Network to monitor strandings in the portions of Zone 4 (Gulf coast from 26.4 to 26.8°N) and Zone 27 (Atlantic coast from 27.1 to 27.4°N) that reflect the action area, focused on months with bloom events (*K. brevis* cell counts ≥100,000 cells/liter). This monitoring will be important for assessing levels of sea turtle mortality associated with the proposed action, and confirming the continued appropriateness of the take analysis in this opinion.

10.5 Terms and Conditions

To be exempt from the prohibitions established by Section 9 of the ESA, the USACE must comply with the following Terms and Conditions and provide reports to NMFS on their implementation.

Annual Report to NMFS:

The USACE shall provide annual written reports to NMFS. These reports shall document bloom periods and the number of sea turtles stranded in or near the bloom events along with the other requirements described in RPM #1 (e.g., information on monthly flow rates and nutrient levels during release events from LOK) and RPM #2 (e.g., sea turtle stranding and necropsy data). The annual report should provide details of when and how nearshore red tide considerations were incorporated into the LOSOM release schedule. The annual reports should be sent to NMFS at the following email address: **takereport.nmfsser@noaa.gov** and should include the biological opinion title (LOSOM) and the ECO consultation number (SER-2022-00967) in the subject line of the email.

Calculation of Takes to Determine Reinitiation of Consultation

The Annual Reports to NMFS will be used to monitor annual and cumulative take to ensure that overall impacts to sea turtles do not exceed levels considered in this biological opinion. Exceedance of the median values in Table 4 in any single year does not represent an exceedance that requires reinitiation of consultation. Statistically, observed values can be expected to exceed the median value half the time, without necessarily representing a significant deviation from expected levels. Reinitiation will be triggered if calculated lethal take exceeds the maximum annual lethal take level described in Appendix A in any single year. Additionally, reinitiation will be triggered if the cumulative calculated total take or lethal take over any consecutive 10 year period exceeds 10 times the median anticipated take values in Table 4. Table 5 summarizes the values for these two, independent reinitiation triggers.

Table 5. Calculated Sea Turtle Take Levels by Species that, if Exceeded, Will Require Reinitiation of Consultation. Mortality Represented in Parentheses.

Species	Single Year*	10-Year**
Green sea turtle (NA DPS)	(23)	60(50)
Kemp’s ridley sea turtle	(41)	80(70)
Loggerhead sea turtle (NWA DPS)	(39)	90(80)

*Based on Maximum annual mortality estimates
**Based on median annual estimates multiplied over 10 years

General Method for Calculating Sea Turtle Takes:

$$T_{y,spp} = \frac{\sum_{m=Jan}^{Dec}\left(N_{m-1}^{CRE} \times \varepsilon_{m}^{CRE} \times \theta_{m,spp}^{CRE} \times \rho_{spp}^{CRE} + N_{m-1}^{SLE} \times \varepsilon_{m}^{SLE} \times \theta_{m,spp}^{SLE} \times \rho_{spp}^{SLE}\right)}{\sigma_{y,spp}}$$

Where:

N_{m-1}^{CRE} and N_{m-1}^{SLE} are the total nitrogen load percentage contribution of LOK to the CRE and SLE relative to the total nitrogen load to each basin from all sources[5], respectively, as measured over the preceding month (*m-1)*;

ε_{m}^{CRE} and ε_{m}^{SLE} are the mean uncertainties in LOK role in red tide enhancement in CRE and SLE, respectively;

$\theta_{m,spp}^{CRE}$ and $\theta_{m,spp}^{SLE}$ are observed numbers of stranded turtles within the CRE and SLE action areas for a given species (*spp*), respectively, during each month with *K. brevis* counts exceeding 100,000 cells/L. For months with *K. brevis* counts less than 100,000 cells/L, these values are 0;

ρ_{spp}^{CRE} and ρ_{spp}^{SLE} are the red tide attributable strandings rate within CRE and SLE for a given species, respectively, during months with *K. brevis* counts exceeding 100,000 cells/L;

$\sigma_{y,spp}$ is the annual mean unobserved strandings rate for a given species, and

$T_{y,spp}$ is total annual estimated take per species, to be compared against the incidental take allowances from Table 5 for the given species.

---

[5] Note that in the calculations in Section 6.2.2, *N* was approximated as the product of mean percent total nitrogen load contributions of LOK to the CRE and SLE, relative to the basin, respectively, during LORS08 operations (see Figures 1-2 and 1-4 in the “Supplemental Document to the Biological Assessment for the Lake Okeechobee Operating Manual – August 2022”), then reduced by anticipated flow reductions from LOSOM operations.

Required monitoring described in Term and Condition (T&C) 1-1 will provide the monthly values for N and the monitoring in T&C 2-1 will provide the monthly values for θ. The remaining terms (i.e., parameters ρ, ε, and σ) will use the default (mean) values used for this opinion's take analysis, summarized in Table 6. These input values may be updated depending on the results of USACE-supported monitoring and associated analysis described in the Terms and Conditions below. If the USACE develops new scientific information that indicates the inputs should be changed, they should propose those changes in an Annual Report. NMFS and the USACE will confer, and NMFS will amend this ITS if the proposed changes are considered to be non-transient changes to the best available scientific information.

Table 6. Default (mean) Parameters ρ, ε, and σ to be used to Monitor Sea Turtle Take until Updated by USACE-Supported Monitoring and Associated Analysis.

Species	ε_m^{CRE}	ρ_{spp}^{CRE}	ε_m^{SLE}	ρ_{spp}^{SLE}	$\sigma_{y,spp}$
Green	0.505	0.3	0.505	0.3	0.15
Kemp's ridley	0.505	0.7	0.505	0.7	0.15
Loggerhead	0.505	0.7	0.505	0.7	0.15

The following Terms and Conditions implement Reasonable and Prudent Measure #1:

T&C 1-1: Monitoring to inform flows and relative nutrient contributions. Figures 1-1 and 1-2 in the "Supplemental Document to the Biological Assessment for the Lake Okeechobee System Operating Manual (LOSOM)" for WY2017 to 2021 (e.g., during LORS08 operations) provided total nitrogen (TN) and total phosphorous (TP) load contributions from LOK to CRE and SLE, respectively, relative to the broader basin (i.e., 28% TP and 36% TN for CRE, and 23% TP and 35% TN for SLE, respectively). These values were the starting point for considering relative LOK nutrient contributions to HAB-attributable sea turtle takes associated with the proposed action. Similarly, the Biological Assessment provided the anticipated reductions in annual and monthly flows to CRE and SLE under LOSOM relative to LORS08. To inform reinitiation trigger parameters N_{m-1}^{CRE} and N_{m-1}^{SLE}, USACE must continue monitoring the relative contribution of LOK to TN and TP loads in CRE and SLE, respectively, relative to the broader basin, through monthly sampling, and provide these monthly percentages in each Annual Report to NMFS.

The following Terms and Conditions implement Reasonable and Prudent Measure #2:

T&C 2-1: Monitoring to quantify level of red tide attributable sea turtle take. Coordinate with the Sea Turtle Salvage and Stranding Network to obtain monthly total numbers of stranded sea turtles within the portion of Zone 4 (Gulf coast from 26.4 to 26.8°N) and Zone 27 (Atlantic coast from 27.1 to 27.4°N) that reflect the action area during months in which red tide bloom events (*K. brevis* cell counts ≥100,000 cells/liter) occur. To inform reinitiation trigger parameters $\theta_{m,spp}^{CRE}$ and $\theta_{m,spp}^{SLE}$ (and possibly $\sigma_{y,spp}$), USACE shall provide total observed (and estimated unobserved) strandings in these zones during red tide bloom events in the Annual Report to NMFS. NMFS recommends contacting Brian Stacey (NMFS) and Allen Foley (FWC) for guidance on fulfilling this requirement.

11 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authority to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation Recommendations identified in Opinions can assist action agencies in implementing their responsibilities under Section 7(a)(1). Conservation recommendations are discretionary activities designed to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans, or to develop information. The following conservation recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the USACE:

- Provide support for research that assesses the impacts of red tide on sea turtle physiology.
- Research or fund efforts to reduce nutrient releases from Lake Okeechobee.
- Explore options to better characterize the linkage between LOK watershed water quality, LOK releases, and algae blooms in the Caloosahatchee and St. Lucie Rivers, downstream estuaries, nearshore coastal waters, and red tide attributable sea turtle mortality. USACE should consider: monthly remote sensing for water temperature and algae levels (Chlorophyll a), biweekly sampling for *K. brevis* concentrations, monthly chemical analysis of water samples to determine and trace the proportion of LOK TN and TP that supply downstream blooms, and monitoring flow rates at S77, S79, and the mouth of the Caloosahatchee River combined with *in situ* optical monitoring of nutrients (see Pace et al. 2022). Optical monitoring should consider using the platinum-cobalt scale to assess water color at S77, S79, and near the mouth of the Caloosahatchee River. Findings from these efforts could be used to update and improve the effects analysis in updates to this biological opinion and also to better inform water management efforts to reduce the impacts of red tide on sea turtles and the rest of the natural and human environment.
- To inform reinitiation trigger parameters ε_m^{CRE} and ε_m^{SLE}, the USACE should periodically (e.g., once every 3 years) use collected data to model nutrient and flow related effects to the downstream estuaries where sea turtles and other protected species (e.g., smalltooth sawfish, giant manta rays) overlap with project effects and provide this updated analysis in their Annual Report to NMFS.
- The sea turtle take estimates in this opinion assume that during red tide bloom events, 70% of all loggerhead and Kemp’s ridley turtle strandings and 30% of all green turtle strandings are attributable to red tide. To determine if these assumptions remain valid, especially in this specific region, the USACE is encouraged to support biotoxin analysis for sea turtles recovered during CRE bloom events, to determine if red tide was the proximate cause of mortality. The brevotoxin enzyme-linked immunosorbent assay (ELISA) analysis of magnitude of red tide exposure is run on liver, kidney, and gastrointestinal content; the cost is approximately $300 per animal NMFS recommends contacting Brian Stacey (NOAA) for guidance on successfully meeting this requirement, potentially through a contract.

NMFS requests that the USACE include discussion of their implementation of these Conservation Recommendations in its Annual Report to NMFS.

12 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed action. As provided in 50 CFR 402.16, reinitiation of formal consultation is required and shall be requested by the USACE or by the Service, where discretionary federal action agency involvement or control over the action has been retained, or is authorized by law, and if: (a) the amount or extent of incidental take specified in the Incidental Take Statement is exceeded (see Section 10.5), (b) new information reveals effects of the action on listed species or critical habitat in a manner or to an extent not considered in this Opinion, (c) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Opinion, or (d) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the USACE must immediately request reinitiation of formal consultation and project activities may only resume if the USACE establishes that such continuation will not violate Sections 7(a)(2) and 7(d) of the ESA.

13 LITERATURE CITED

Ackerman, R.A. 1997. The Nest Environment and the Embryonic Development of Sea Turtles. Pages 83-106 *in* P.L. Lutz and J.A. Musick, editors. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Addison, D. 1997. Sea Turtle Nesting on Cay Sal, Bahamas, Recorded June 2-4, 1996. Bahamas Journal of Science, 5(1):34-35.

Addison, D., and B. Morford. 1996. Sea Turtle Nesting Activity on the Cay Sal Bank, Bahamas. Bahamas Journal of Science, 3(3):31-36.

Aguilar, R., J. Mas, and X. Pastor. 1994. Impact of Spanish Swordfish Longline Fisheries on the Loggerhead Sea Turtle *Caretta Caretta* Population in the Western Mediterranean. Pages 91-96 *in* J.I. Richardson and T. H. Richardson, editors. Proceedings of the 12th Annual Workshop on Sea Turtle Biology and Conservation. U.S. Department of Commerce, Jekyll Island, Georgia.

Aguirre, A.A., G.H. Balazs, T. Spraker, S.K.K. Murakawa, and B. Zimmerman. 2002. Pathology of Oropharyngeal Fibropapillomatosis in Green Turtles *Chelonia Mydas*. Journal of Aquatic Animal Health, 14:298-304.

Anderson, D.M., J.M. Burkholder, W.P. Cochlan, P.M.Glibert, C.J. Gobler, C.A. Heil, R.M. Kudela, M.L. Parsons, J.E.J. Rensel, D.W. Townsend, V.L. Trainer, and G.A. Vargo. 2008. Harmful Algal Blooms and Eutrophication: Examining Linkages from Selected Coastal Regions of the United States. Harmful Algae, 8:39-53.

Antonelis, G.A., J.D. Baker, T.C. Johanos, R.C. Braun, and A.L. Harting. 2006. Hawaiian Monk Seal (*Monachus Schauinslandi*): Status and Conservation Issues. Atoll Research Bulletin 543:75-101.

Arendt, M., J. Byrd, A. Segars, P. Maier, J. Schwenter, J.B.D. Burgess, J.D. Whitaker, L. Liguori, L. Parker, D. Owens, and G. Blanvillain. 2009. Examination of Local Movement and Migratory Behavior of Sea Turtles During Spring and Summer Along the Atlantic Coast off the Southeastern United States. South Carolina Department of Natural Resources, Marine Resources Division.

Arendt, M.D., J.A. Schwenter, B.E. Witherington, A.B. Meylan, and V.S. Saba. 2013. Historical Versus Contemporary Climate Forcing on the Annual Nesting Variability of Loggerhead Sea Turtles in the Northwest Atlantic Ocean. PLOS ONE, 8(12).

Attrill, M.J., J. Wright, and M. Edwards. 2007. Climate-Related Increases in Jellyfish Frequency Suggest a More Gelatinous Future for the North Sea. Limnology and Oceanography, 52(1): 480-485.

Baker, J., C. Littnan, and D. Johnston. 2006. Potential Effects of Sea-Level Rise on Terrestrial Habitat and Biota of the Northwestern Hawaiian Islands. Page 3 *in* Twentieth Annual Meeting Society for Conservation Biology Conference, San Jose, California.

Balazs, G.H. 1982. Growth Rates of Immature Green Turtles in the Hawaiian Archipelago. Pages 117-125 *in* K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Balazs, G.H. 1983. Recovery Records of Adult Green Turtles Observed or Originally Tagged at French Frigate Shoals, Northwestern Hawaiian Islands. National Oceanographic and Atmospheric Administration, National Marine Fisheries Service, NOAA-TM-NMFS-SWFC-36.

Banks K.W., Riegl B.M., Richards V.P., Walker B.K., Helmle K.P., Jordan L.K.B., Phipps J., Shivji M.S., Spieler R.E., and Dodge R.E. 2008. The Reef Tract of Continental Southeast Florida (Miami-Dade, Broward and Palm Beach Counties, USA), in Riegl B.M., Dodge R.E. (eds) Coral Reefs of the USA. Springer, 173-218 (184, 185).

Bass, A.L., and W.N. Witzell. 2000. Demographic Composition of Immature Green Turtles (*Chelonia Mydas*) From the East Central Florida Coast: Evidence From mtDNA Markers. Herpetologica, 56(3):357-367.

Bjorndal, K.A. 1982. The Consequences of Herbivory for Life History Pattern of the Caribbean Green Turtle, *Chelonia Mydas*. Pages 111-116 *in* Biology and Conservation of Sea Turtles. Smithsonian Institution, Washington, D.C.

Bjorndal, K.A. 1997. Foraging Ecology and Nutrition of Sea Turtles. Pages 199-231 *in* The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Bjorndal, K.A., and A.B. Bolten. 2002. Proceedings of a Workshop on Assessing Abundance and Trends for In-Water Sea Turtle Populations. NOAA Technical Memorandum NMFS-SEFSC-445.

Bjorndal, K.A., A.B. Bolten, and M.Y. Chaloupka. 2005. Evaluating Trends in Abundance of Immature Green Turtles, *Chelonia Mydas*, in the Greater Caribbean. Ecological Applications, 15(1):304-314.

Bjorndal, K.A., A.B. Bolten, T. Dellinger, C. Delgado, and H.R. Martins. 2003. Compensatory Growth in Oceanic Loggerhead Sea Turtles: Response to a Stochastic Environment. Ecology, 84(5):1237-1249.

Bjorndal, K.A., J.A. Wetherall, A.B. Bolten, and J.A. Mortimer. 1999. Twenty-Six Years of Green Turtle Nesting at Tortuguero, Costa-Rica: An Encouraging Trend. Conservation Biology, 13(1):126-134.

Bolten, A.B., K.A. Bjorndal, and H.R. Martins. 1994. Life History Model for the Loggerhead Sea Turtle (*Caretta Caretta*) Populations in the Atlantic: Potential Impacts of a Longline Fishery. Pages 48-55 *in* G.J. Balazs and S.G. Pooley, editors. Research Plan to Assess Marine Turtle Hooking Mortality, Volume Technical Memorandum NMFS-SEFSC-201. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Bolten, A.B., K.A. Bjorndal, H.R. Martins, T. Dellinger, M.J. Biscoito, S.E. Encalada, and B.W. Bowen. 1998. Transatlantic Developmental Migrations of Loggerhead Sea Turtles Demonstrated by mtDNA Sequence Analysis. Ecological Applications, 8(1):1-7.

Bolten, A.B., and B.E. Witherington. 2003. Loggerhead Sea Turtles. Smithsonian Books, Washington, D.C.

Bouchard, S., K. Moran, M. Tiwari, D. Wood, A. Bolten, P. Eliazar, and K. Bjorndal. 1998. Effects of Exposed Pilings on Sea Turtle Nesting Activity at Melbourne Beach, Florida. Journal of Coastal Research, 14(4):1343-1347.

Bowen, B.W., A.B. Meylan, J.P. Ross, C.J. Limpus, G.H. Balazs, and J.C. Avise. 1992. Global Population Structure and Natural History of the Green Turtle (*Chelonia Mydas*) in Terms of Matriarchal Phylogeny. Evolution, 46(4):865-881.

Bowen, B.W., and W.N. Witzell. 1996. Proceedings of the International Symposium on Sea Turtle Conservation Genetics, Miami, Florida. NOAA Technical Memorandum NMFS-SEFSC-396. 177 pp.

Brame, A.B., T.R. Wiley, J.K. Carlson, S.V. Fordham, R.D. Grubbs, J. Osborne, R.M. Scharer, D.M. Bethea, and G.R. Poulakis. 2019. Biology, Ecology, and Status of the Smalltooth Sawfish *Pristis Pectinata* in the USA. Endangered Species Research, 39:9-23.

Brand, L.E. and A. Compton. 2007. Long-Term Increase in *Karenia Brevis* Abundance Along the Southwest Florida Coast. Harmful Algae, 6:232-252.

Brautigam, A., and K.L. Eckert. 2006. Turning the Tide: Exploitation, Trade and Management of Marine Turtles in the Lesser Antilles, Central America, Columbia and Venezuela. TRAFFIC International, Cambridge, United Kingdom.

Bresette, M., R.A. Scarpino, D.A. Singewald, and E.P. de Maye. 2006. Recruitment of Post-Pelagic Green Turtles (*Chelonia Mydas*) to Nearshore Reefs on Florida's Southeast Coast. Page 288 *in* M. Frick, A. Panagopoulou, A.F. Rees, and K. Williams, editors. Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Broderick, A.C., B.J. Godley, S. Reece, and J.R. Downie. 2000. Incubation Periods and Sex Ratios of Green Turtles: Highly Female Biased Hatchling Production in the Eastern Mediterranean. Marine Ecology Progress Series, 202:273-281.

Brodeur, R.D., C.E. Mills, J.E. Overland, G.E. Walters, and J.D. Schumacher. 1999. Evidence for a Substantial Increase in Gelatinous Zooplankton in the Bering Sea, With Possible Links to Climate Change. Fisheries Oceanography, 8(4): 296-306.

Caldwell, D.K., and A. Carr. 1957. Status of the Sea Turtle Fishery in Florida. Pages 457-463 *in* J.B. Trefethen, editor. Twenty-Second North American Wildlife Conference. Wildlife Management Institute, Statler Hotel, Washington, D.C.

Campell, C.L., and C.J. Lagueux. 2005. Survival Probability Estimates for Large Juvenile and Adult Green Turtles (*Chelonia Mydas*) Exposed to an Artisanal Marine Turtle Fishery in the Western Caribbean. Herpetologica, 61(2):91-103.

Carballo, J.L., C. Olabarria, and T.G. Osuna. 2002. Analysis of Four Macroalgal Assemblages Along the Pacific Mexican Coast During and After the 1997-98 El Niño. Ecosystems, 5(8):749-760.

Carr, A.F. 1986. New Perspectives on the Pelagic Stage of Sea Turtle Development. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Ceriani, S.A., P. Casale, M. Brost, E.H. Leone, and B.E. Witherington. 2019. Conservation Implications of Sea Turtle Nesting Trends: Elusive Recovery of a Globally Important Loggerhead Population. Ecosphere, 10(11):e02936.

Chaloupka, M.Y., K.A. Bjorndal, G.H. Balazs, A.B. Bolten, L.M. Ehrhart, C.J. Limpus, H. Suganuma, S. Troëng, and M. Yamaguchi. 2007. Encouraging Outlook for Recovery of a Once Severely Exploited Marine Megaherbivore. Global Ecology and Biogeography, 17(2):297-304.

Chaloupka, M.Y., and C.J. Limpus. 2005. Estimates of Sex- and Age-Class-Specific Survival Probabilities for a Southern Great Barrier Reef Green Sea Turtle Population. Marine Biology, 146(6):1251-1261.

Chaloupka, M.Y., C.J. Limpus, and J. Miller. 2004. Green Turtle Somatic Growth Dynamics in a Spatially Disjunct Great Barrier Reef Metapopulation. Coral Reefs, 23(3):325-335.

Chaloupka, M.Y., and J.A. Musick. 1997. Age Growth and Population Dynamics. Pages 233-276 *in* P.L. Lutz and J.A. Musick, editors. The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Chaloupka, M.Y., T.M. Work, G.H. Balazs, S.K.K. Murakawa, and R. Morris. 2008. Cause-Specific Temporal and Spatial Trends in Green Sea Turtle Strandings in the Hawaiian Archipelago (1982-2003). Marine Biology, 154(5):887-898.

Colburn, T., D. Dumanoski, and J.P. Myers. 1996. Our Stolen Future. Dutton/Penguin Books, New York, New York.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead Sea Turtle (*Caretta Caretta*) 2009 Status Review Under the U.S. Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Coyne, M.S. 2000. Population Sex Ratio of the Kemp's Ridley Sea Turtle (*Lepidochelys Kempii*): Problems in Population Modeling. Unpublished Ph.D. Dissertation. Texas A&M University, College Station, Texas.

Coyne, M.S., and A.M. Landry Jr. 2007. Population Sex Ratio and Its Impact on Population Models. Pages 191-211 *in* P.T. Plotkin, editor. Biology and Conservation of Ridley Sea Turtles. Johns Hopkins University Press, Baltimore, Maryland.

Crabbe, M.J. 2008. Climate Change, Global Warming and Coral Reefs: Modelling the Effects of Temperature. Computational Biology and Chemistry, 32(5):311-314.

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A Stage-Based Population Model for Loggerhead Sea Turtles and Implications for Conservation. Ecology, 68(5):1412-1423.

Crowder, L.B., D.T. Crouse, S.S. Heppell, and T.H. Martin. 1994. Predicting the Impact of Turtle Excluder Devices on Loggerhead Sea Turtle Populations. Ecological Applications, 4(3):437-445.

D'Ilio, S., D. Mattei, M.F. Blasi, A. Alimonti, and S. Bogialli. 2011. The Occurrence of Chemical Elements and POPs in Loggerhead Turtles (*Caretta Caretta*): An Overview. Marine Pollution Bulletin, 62(8):1606-1615.

Dangendorf, S., Hendricks, N., Sun, Q., Klinck, J., Ezer, T., Frederikse, T., Calafat, F.M., Wahl, T., Törnqvist, T.E. 2023. Acceleration of U.S. Southeast and Gulf coast sea-level rise amplified by internal climate variability. Nature Communications, 14 (1) DOI: 10.1038/s41467-023-37649–9.

Daniels, R.C., T.W. White, and K.K. Chapman. 1993. Sea-Level Rise - Destruction of Threatened and Endangered Species Habitat in South Carolina. Environmental Management, 17(3):373-385.

Davenport, J. 1997. Temperature and the Life-History Strategies of Sea Turtles. Journal of Thermal Biology, 22(6): 479-488.

Dewald, J.R., and D.A. Pike. 2014. Geographical Variation in Hurricane Impacts Among Sea Turtle Populations. Journal of Biogeography, 41(2):307-316.

Dickerson, D. 2005. Observed Takes of Sturgeon and Turtles From Dredging Operations Along the Atlantic Coast. Presentation given at the Western Dredging Association Twenty-Fifth Technical Conference and Thirty-Seventh Texas A&M Dredging Seminar. CDS Report No. 507, New Orleans, Louisiana.

Dickerson, D. 2013. Observed Takes of Sturgeon from Dredging Operations Along the Atlantic and Gulf Coasts. U.S. Army Corps of Engineers Research and Development Center Environmental Laboratory, Vicksburg, Mississippi.

Dixon, L.K., G. Kirkpatrick, E. Hall, and A. Nissanka. 2014. Nitrogen, Phosphorous and Silica on the West Florida Shelf: Patterns and Relationships with Karenia spp. Occurrence. Harmful Algae, 38:8-19.

Dodd Jr., C.K. 1988. Synopsis of the Biological Data on the Loggerhead Sea Turtle *Caretta Caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service, 88(14).

Doughty, R.W. 1984. Sea Turtles in Texas: A Forgotten Commerce. Southwestern Historical Quarterly, 88:43-70.

Duarte, C.M. 2002. The Future of Seagrass Meadows. Environmental Conservation, 29(2):192-206.

Dutton, P.H., V. Pease, and D. Shaver. 2006. Characterization of MtDNA Variation Among Kemp’s Ridleys Nesting on Padre Island With Reference to Rancho Nuevo Genetic Stock. Page 189 *in* In M. Frick, A. Panagopoulou, A.F. Rees, and K. Williams, compilers. Proceedings of the 26th Annual Symposium on Sea Turtle Biology and Conservation, Athens, Greece.

DWH Trustees. 2016. Deepwater Horizon Oil Spill: Draft Programmatic Damage Assessment and Restoration Plan and Draft Programmatic Environmental Impact Statement. Retrieved from http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan/.

Eckert, K.L., J.A. Overing, and B.B. Lettsome. 1992. Sea Turtle Recovery Action Plan for the British Virgin Islands. UNEP Caribbean Environment Programme, Wider Caribbean Sea Turtle Recovery Team and Conservation Network, Kingston, Jamaica.

Ehrhart, L.M. 1983. Marine Turtles of the Indian River Lagoon System. Florida Scientist, 46(3/4):337-346.

Ehrhart, L.M., W.E. Redfoot, and D.A. Bagley. 2007. Marine Turtles of the Central Region of the Indian River Lagoon System, Florida. Florida Scientist, 70(4):415-434.

Ehrhart, L.M., W.E. Redfoot, D.A. Bagley, and K. Mansfield. 2014. Long-Term Trends in Loggerhead (*Caretta Caretta*) Nesting and Reproductive Success at an Important Western Atlantic Rookery. Chelonian Conservation and Biology, 13(2):173-181.

Ehrhart, L.M., and R.G. Yoder. 1978. Marine Turtles of Merritt Island National Wildlife Refuge, Kennedy Space Centre, Florida. Florida Marine Research Publications, 33:25-30.

Epperly, S.P., J. Braun, A.Chester, F. Cross, J.Merriner, P. Tester, and J. Churchill. 1996. Beach Strandings as an Indicator of At Sea Mortality of Sea Turtles. Bulletin of Marine Science, 59(2):289-297.

Epperly, S.P., J. Braun-McNeill, and P.M. Richards. 2007. Trends in Catch Rates of Sea Turtles in North Carolina, USA. Endangered Species Research, 3(3):283-293.

Fish, M.R., I.M. Cote, J.A. Gill, A.P. Jones, S. Renshoff, and A.R. Watkinson. 2005. Predicting the Impact of Sea-Level Rise on Caribbean Sea Turtle Nesting Habitat. Conservation Biology, 19(2):482-491.

FitzSimmons, N.N., L.W. Farrington, M.J. McCann, C.J. Limpus, and C. Moritz. 2006. Green Turtle Populations in the Indo-Pacific: A (Genetic) View from Microsatellites. Page 111 *in* N. Pilcher, editor. Twenty-Third Annual Symposium on Sea Turtle Biology and Conservation.

Fleming, E.H. 2001. Swimming Against the Tide: Recent Surveys of Exploitation, Trade, And Management of Marine Turtles In the Northern Caribbean. TRAFFIC North America, Washington, D.C.

Foley, A.M., B.A. Schroeder, and S.L. MacPherson. 2008. Post-Nesting Migrations and Resident Areas of Florida Loggerheads (*Caretta Caretta*). Pages 75-76 *in* H.J. Kalb, A.S. Rhode, K. Gayheart, and K. Shanker, editors. Twenty-Fifth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Department of Commerce, Savannah, Georgia.

Foley, A.M., B.A. Schroeder, A.E. Redlow, K.J. Fick-Child, and W.G. Teas. 2005. Fibropapillomatosis in Stranded Green Turtles (*Chelonia Mydas*) from the Eastern United States (1980-98): Trends and Associations with Environmental Factors. Journal of Wildlife Diseases, 41(1):29-41.

Foley, A.M., K.E. Singel, P.H. Dutton, T.M. Summers, A.E. Redlow, and J. Lessman. 2007. Characteristics of a Green Turtle (*Chelonia Mydas*) Assemblage in Northwestern Florida Determined During a Hypothermic Stunning Event. Gulf of Mexico Science, 25(2):131-143.

Foley, A.M., B.A. Stacy, P. Schueller, L.J. Flewelling, B. Schroeder, K. Minch, D.A. Fauquier, J.J. Foote, C.A. Manire, K.E. Atwood, A.A. Granholm, and J.H. Landsberg. 2019. Assessing *Karenia Brevis* Red Tide as a Mortality Factor of Sea Turtles in Florida, USA. Diseases of Aquatic Organisms, 132:109-124.

Frazer, N.B., and L.M. Ehrhart. 1985. Preliminary Growth Models for Green (*Chelonia Mydas*) and Loggerhead (*Caretta Caretta*) Turtles in the Wild. Copeia, 1985(1):73-79.

Fretey, J. 2001. Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa. CMS Technical Series Publication No. 6, UNEP/CMS Secretariat, Bonn, Germany. 429 pp.

Fuentes, M.M.P.B., A.J. Allstadt, S.A. Ceriani, M.H. Godfrey, C. Gredzens, D. Helmers, D. Ingram, M. Pate, V.C. Radeloff, D.J. Shaver, N. Wildermann, L. Taylor, and B.L. Bateman. 2020. Potential Adaptability of Marine Turtles to Climate Change May Be Hindered By Coastal Development in the USA. Regional Environmental Change, 20(3):104.

Fuentes, M.M.P.B., D.A. Pike, A. Dimatteo, and B.P. Wallace. 2013. Resilience of Marine Turtle Regional Management Units to Climate Change. Global Change Biology, 19(5):1399-1406.

Galloway, B.J., W. Gazey, C.W. Caillouet Jr, P.T. Plotkin, F.A. Abreu Grobois, A.F. Amos, P.M. Burchfield, R.R. Carthy, M.A. Castro Martinez, J.G. Cole, A.T. Coleman, M. Cook, S.F. DiMarco, S.P. Epperly, M. Fujiwara, D.G. Gamez, G.L. Graham, W.L. Griffin, F. Illescas Martinez, M.M. Lamont, R.L. Lewison, K.J. Lohmann, J.M. Nance, J. Pitchford, N.F. Putman, S.W. Raborn, J.K. Rester, J.J. Rudloe, L. Sarti Martinez, M. Schexnayder, J.R. Schmid, D.J. Shaver, C. Slay, A.D. Tucker, M. Tumlin, T. Wibbels, and B.M. Zapata Najera.

2016. Development of a Kemp's Ridley Sea Turtle Stock Assessment Model. Gulf of Mexico Science, 33(2):138-157.

Garrett, C. 2004. Priority Substances of Interest in the Georgia Basin - Profiles and Background Information on Current Toxics Issues. Canadian Toxics Work Group Puget Sound, Georgia Basin International Task Force, GBAP Publication No. EC/GB/04/79.

Gavilan, F.M. 2001. Status and Distribution of the Loggerhead Turtle, *Caretta Caretta*, in the Wider Caribbean Region. Pages 36-40 *in* K.L. Eckert and F.A. Abreu Grobois, editors. Marine Turtle Conservation in the Wider Caribbean Region—A Dialogue for Effective Regional Management, Santo Domingo, Dominican Republic.

Geraci, J.R. 1990. Physiologic and Toxic Effects on Cetaceans. Pages 167-197 *in* J.R. Geraci and D.J.S. Aubin, editors. Sea Mammals and Oil: Confronting the Risks. Academic Press, San Diego, California.

Girard, C., A.D. Tucker, and B. Calmettes. 2009. Post-Nesting Migrations of Loggerhead Sea Turtles in the Gulf of Mexico: Dispersal in Highly Dynamic Conditions. Marine Biology, 156(9):1827-1839.

Gladys Porter Zoo. 2017. Gladys Porter Zoo's Preliminary Annual Report on the Mexico/United States of America Population Restoration Project for the Kemp's Ridley Sea Turtle, *Lepidochelys Kempii*, on the Coasts of Tamaulipas, Mexico, 2017.

Grant, S.C.H., and P.S. Ross. 2002. Southern Resident Killer Whales at Risk: Toxic Chemicals in the British Columbia and Washington Environment. Department of Fisheries and Oceans Canada, Sidney, B.C., Canada.

Green, D. 1993. Growth Rates of Wild Immature Green Turtles in the Galápagos Islands, Ecuador. Journal of Herpetology, 27(3):338-341.

Greene, C.H., A.J. Pershing, T.M. Cronin, and N. Ceci. 2008. Arctic Climate Change and Its Impacts on the Ecology of the North Atlantic. Ecology, 89(sp11):S24-S38.

Griffin, L.P., C.R. Griffin, J.T. Finn, R.L. Prescott, M. Faherty, B.M. Still, and A.J. Danylchuk. 2019. Warming Seas Increase Cold-Stunning Events for Kemp's Ridley Sea Turtles in the Northwest Atlantic. PLOS ONE, 14(1):e0211503.

Groombridge, B. 1982. Kemp's Ridley or Atlantic Ridley, *Lepidochelys Kempii* (Garman 1980). The IUCN Amphibia, Reptilia Red Data Book, pp. 201-208.

Guseman, J.L., and L.M. Ehrhart. 1992. Ecological Geography of Western Atlantic Loggerheads and Green Turtles: Evidence from Remote Tag Recoveries. Page 50 *in* M. Salmon and J. Wyneken, editors. Eleventh Annual Workshop on Sea Turtle Biology and Conservation. U.S. Department of Commerce, Jekyll Island, Georgia.

Hart, K.M., M.M. Lamont, I. Fujisaki, A.D. Tucker, and R.R. Carthy. 2012. Common Coastal Foraging Areas for Loggerheads in the Gulf of Mexico: Opportunities for Marine Conservation. Biological Conservation, 145:185-194.

Hart, K.M., P. Mooreside, and L.B. Crowder. 2006. Interpreting the spatio-temporal patterns of sea turtle strandings: going with the flow. Biological Conservation, 129(2):283–290.

Hartwell, S.I. 2004. Distribution of DDT in Sediments off the Central California Coast. Marine Pollution Bulletin, 49(4):299-305.

Hausfather Z. and G.P. Peters. 2020. Emissions: The 'Business as Usual' Approach is Misleading. Nature, 577:618-620

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the Potential Impacts of Climate Change on a Marine Turtle Population. Global Change Biology, 13:1-10.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2009. Climate Change and Marine Turtles. Endangered Species Research, 7: 137-154.

Hays, G.C., A.C. Broderick, F. Glen, and B.J. Godley. 2003. Climate Change and Sea Turtles: a 150-Year Reconstruction of Incubation Temperatures at a Major Marine Turtle Rookery. Global Change Biology, 9(4): 642-646.

Hays, G.C., S. Åkesson, A.C. Broderick, F. Glen, B.J. Godley, P. Luschi, C. Martin, J.D. Metcalfe, and F. Papi. 2001. The Diving Behavior of Green Turtles Undertaking Oceanic Migration to and from Ascension Island: Dive Durations, Dive Profiles, and Depth Distribution. Journal of Experimental Biology, 204:4093-4098.

Hays, G.C., A.C. Broderick, F. Glen, B.J. Godley, J.D.R. Houghton, and J.D. Metcalfe. 2002. Water Temperature and Internesting Intervals for Loggerhead (*Caretta Caretta*) and Green (*Chelonia Mydas*) Sea Turtles. Journal of Thermal Biology, 27(5):429-432.

Hazel J., and E. Gyuris. 2006. Vessel-Related Mortality of Sea Turtles in Queensland, Australia. Wildlife Research, 33:149-154.

Heil, C.A., L.K. Dixon, E. Hall, M. Garrett, J. Lenes, J.M. O'Neil, B.M. Walsh, D.A. Bronk, L. Killberg-Thoreson, G.L. Hitchcock, K.A. Meyer, M.R. Mulholland, L. Procise, G. J. Kirkpatrick, J.J. Walsh, R.W. Weisberg. 2014. Blooms of Karenia Brevis on the West Florida Shelf: Nutrient Sources and Potential Management Strategies Based on a Multi-Year Regional Study. Harmful Algae, 38:127-140.

Heppell, S.S., D.T. Crouse, L.B. Crowder, S.P. Epperly, W. Gabriel, T. Henwood, R. Márquez, and N.B. Thompson. 2005. A Population Model to Estimate Recovery Time, Population Size, and Management Impacts on Kemp's Ridley Sea Turtles. Chelonian Conservation and Biology, 4(4):767-773.

Heppell, S.S., L.B. Crowder, D.T. Crouse, S.P. Epperly, and N.B. Frazer. 2003. Population Models for Atlantic Loggerheads: Past, Present, and Future. Pages 255-273 *in* A. Bolten and B. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books, Washington, D.C.

Herbst, L.H. 1994. Fibropapillomatosis of Marine Turtles. Annual Review of Fish Diseases, 4:389-425.

Herbst, L.H., E.R. Jacobson, R. Moretti, T. Brown, J.P. Sundberg, and P.A. Klein. 1995. An Infectious Etiology for Green Turtle Fibropapillomatosis. Proceedings of the American Association for Cancer Research Annual Meeting, 36:117.

Hildebrand, H.H. 1963. *Hallazgo del Area de Anidacion de la Tortuga Marina "Lora", Lepidochelys Kempi* (Garman), *en la Costa Occidental del Golfo de Mexico*. *Ciencia* (Mexico), 22:105-112.

Hildebrand, H.H. 1982. A Historical Review of the Status of Sea Turtle Populations in the Western Gulf of Mexico. Pages 447-453 *in* K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Hirth, H.F. 1971. Synopsis of Biological Data on the Green Turtle *Chelonia Mydas* (Linnaeus) 1758. Food and Agriculture Organization, Fisheries Synopsis.

Hirth, H.F. 1997. Synopsis of the Biological Data on the Green Turtle *Chelonia Mydas* (Linnaeus 1758). U.S. Fish and Wildlife Service, Washington, D.C. Biological Report 97(1):120.

Hulin, V., and J.M. Guillon. 2007. Female Philopatry in a Heterogeneous Environment: Ordinary Conditions Leading to Extraordinary ESS Sex Ratios. BMC Evolutionary Biology, 7(1):13.

Hulme, P.E. 2005. Adapting to Climate Change: Is There Scope for Ecological Management in the Face of a Global Threat? Journal of Applied Ecology, 42(5):784-794.

IPCC. 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, editors. Cambridge University Press, Cambridge, United Kingdom. 996 pp.

IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. *In* Core Writing Team, R.K. Pachauri, and L.A. Meyer, L.A., editors. 151. IPCC, Geneva, Switzerland. Available from http://www.ipcc.ch.

IPCC. 2021. Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou, editors. In Press

Iwata, H., S. Tanabe, N. Sakai, and R. Tatsukawa. 1993. Distribution of Persistent Organochlorines in the Oceanic Air and Surface Seawater and the Role of Ocean on Their Global Transport and Fate. Environmental Science and Technology, 27(6):1080-1098.

Jacobson, E.R. 1990. An Update on Green Turtle Fibropapilloma. Marine Turtle Newsletter, 49:7-8.

Jacobson, E.R., J.L. Mansell, J.P. Sundberg, L. Hajjar, M.E. Reichmann, L.M. Ehrhart, M. Walsh, and F. Murru. 1989. Cutaneous Fibropapillomas of Green Turtles (*Chelonia Mydas*). Journal Comparative Pathology, 101:39-52.

Jacobson, E.R., S.B. Simpson Jr., and J.P. Sundberg. 1991. Fibropapillomas in Green Turtles. Pages 99-100 *in* G.H. Balazs, and S.G. Pooley, editors. Research Plan for Marine Turtle Fibropapilloma. NOAA Technical Memorandum NMFS-SWFSC-156.

Jensen M.P., N.N. FitzSimmons, and P.H. Dutton. 2013. Molecular Genetics of Sea Turtles *in* J. Wyneken, K.J. Lohmann, and J.A. Musick editors. The Biology of Sea Turtles, Vol. 3. Boca Raton, FL: CRC Press, 135–154.

Johnson, S.A., and L.M. Ehrhart. 1994. Nest-Site Fidelity of the Florida Green Turtle. Page 83 *in* B.A. Schroeder and B.E. Witherington, editors. Thirteenth Annual Symposium on Sea Turtle Biology and Conservation.

Johnson, S.A., and L.M. Ehrhart. 1996. Reproductive Ecology of the Florida Green Turtle: Clutch Frequency. Journal of Herpetology, 30(3):407-410.

Lagueux, C.J. 2001. Status and Distribution of the Green Turtle, *Chelonia Mydas*, in the Wider Caribbean Region. Pages 32-35 *in* K.L. Eckert and F.A. Abreu Grobois, editors. Marine Turtle Conservation in the Wider Caribbean Region—A Dialogue for Effective Regional Management, Santo Domingo, Dominican Republic.

Laloë, J.-O., J.-O. Cozens, B. Renom, A. Taxonera, and G.C. Hays. 2014. Effects of Rising Temperature on the Viability of an Important Sea Turtle Rookery. Nature Climate Change, 4:513-518.

Laloë, J.-O., N. Esteban, J. Berkel, and G.C. Hays. 2016. Sand Temperatures for Nesting Sea Turtles in the Caribbean: Implications for Hatchling Sex Ratios in the Face of Climate Change. Journal of Experimental Marine Biology and Ecology, 474:92-99.

Landsberg, J. 2002. The Effects of Harmful Algal Blooms on Aquatic Organisms. Reviews in Fisheries Science 10:113-390.

Laurent, L., P. Casale, M.N. Bradai, B.J. Godley, G. Gerosa, A.C. Broderick, W. Schroth, B. Schierwater, A.M. Levy, D. Freggi, E.M.A. El-Mawla, D.A. Hadoud, H.E. Gomati, M. Domingo, M. Hadjichristophorou, L. Kornaraky, F. Demirayak, and C.H. Gautier. 1998. Molecular Resolution of Marine Turtle Stock Composition in Fishery By-Catch: A Case Study in the Mediterranean. Molecular Ecology, 7:1529-1542.

Law, R.J., C.F. Fileman, A.D. Hopkins, J.R. Baker, J. Harwood, D.B. Jackson, S. Kennedy, A.R. Martin, and R.J. Morris. 1991. Concentrations of Trace Metals in the Livers of Marine Mammals (Seals, Porpoises and Dolphins) from Waters Around the British Isles. Marine Pollution Bulletin, 22(4):183-191.

Lolavar, A., and J. Wyneken. 2015. The Effect of Rainfall on Loggerhead Turtle Nest Temperatures, Sand Temperatures and Hatchling Sex. Endangered Species Research, 28.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human Impacts on Sea Turtle Survival. Pages 387-409 *in* P. Lutz and J.A. Musick, editors. The Biology of Sea Turtles, Volume 1. CRC Press, Boca Raton, Florida.

Mackay, A.L. 2006. 2005 Sea Turtle Monitoring Program the East End Beaches (Jack’s, Isaac’s, and East End Bay) St. Croix, U.S. Virgin Islands. Nature Conservancy.

Márquez M., R. 1990. Sea Turtles of the World. An Annotated and Illustrated Catalogue of Sea Turtle Species Known to Date. FAO Fisheries Synopsis No. 125. Rome, Italy. 81 pp.

Márquez M., R. 1994. Synopsis of Biological Data on the Kemp’s Ridley Sea Turtle, *Lepidochelys Kempii* (Garman, 1880). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Matkin, C.O., and E. Saulitis. 1997. Restoration Notebook: Killer Whale (*Orcinus Orca*). Exxon Valdez Oil Spill Trustee Council, Anchorage, Alaska.

McMahon, C.R., and G.C. Hays. 2006. Thermal Niche, Large-Scale Movements and Implications of Climate Change for a Critically Endangered Marine Vertebrate. Global Change Biology, 12(7):1330-1338.

McMichael, E., R.R. Carthy, and J.A. Seminoff. 2003. Evidence of Homing Behavior in Juvenile Green Turtles in the Northeastern Gulf of Mexico. Pages 223-224 *in* J.A. Seminoff, editor. Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation.

McPherson, B.F., Miller, R.L. 1990. Nutrient Distribution and Variability in the Charlotte Harbor Estuarine System, Florida. Journal of American Water Resources Association, 26:67–80.

Medina, M., R. Huffaker, J.W. Jawitz, and R. Munoz-Carpena. 2020. Seasonal Dynamics of Terrestrially Sourced Nitrogen Influenced *Karenia Brevis* Blooms off Florida's Southern Gulf Coast. Harmful Algae 99 101900. 11 pg.

Medina, M., D. Kaplan, E.C. Milbrandt, D. Tomasko, R. Huffaker, and C. Angelini. 2022. Nitrogen-enriched Discharges from a Highly Managed Watershed Intensify Red Tide (Karenia Brevis) Blooms in Southwest Florida. Science of the Total Environment, 827. http://dx.doi.org/10.1016/j.scitotenv.2022.154149

Meylan, A.B. 1982. Estimation of Population Size in Sea Turtles. Pages 135-138 in K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D.C.

Meylan, A.B., B.A. Schroeder, and A. Mosier. 1994. Marine Turtle Nesting Activity in the State of Florida, 1979-1992. Page 83 *in* K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.

Meylan, A.B., B.A. Schroeder, and A. Mosier. 1995. Sea Turtle Nesting Activity in the State of Florida, 1979-1992. Florida Department of Environmental Protection, (52):63.

Meylan, A.B., B.E. Witherington, B. Brost, R. Rivero, and P.S. Kubilis. 2006. Sea Turtle Nesting in Florida, USA: Assessments of Abundance and Trends for Regionally Significant Populations of *Caretta*, *Chelonia*, and *Dermochelys*. Pages 306-307 *in* M. Frick, A. Penagopoulou, A.F. Rees, K. and Williams. Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation.

Milliken, T., and H. Tokunaga. 1987. The Japanese Sea Turtle Trade, 1970-1986. TRAFFIC (JAPAN), Center for Environmental Education, Washington, D.C.

Milton, S.L., and P.L. Lutz. 2003. Physiological and Genetic Responses to Environmental Stress. Pages 163-197 *in* P.L. Lutz, J.A. Musick, and J. Wyneken, editors. The Biology of Sea Turtles, Volume II. CRC Press, Boca Raton, Florida.

Mo, C.L. 1988. Effect of Bacterial and Fungal Infection on Hatching Success of Olive Ridley Sea Turtle Eggs. World Wildlife Fund-U.S.

Moncada, F., A. Abreu-Grobois, D. Bagley, K.A. Bjorndal, A.B. Bolten, J.A. Caminas, L. Ehrhart, A. Muhlia-Melo, G. Nodarse, B.A. Schroeder, J. Zurita, and L.A. Hawkes. 2010. Movement Patterns of Loggerhead Turtles *Caretta Caretta* in Cuban Waters Inferred from Flipper Tag Recaptures. Endangered Species Research, 11(1):61-68.

Montero, N., S.A. Ceriani, K. Graham, and M.M.P.B. Fuentes. 2018. Influences of the Local Climate on Loggerhead Hatchling Production in North Florida: Implications From Climate Change. Frontiers in Marine Science, 5:262.

Montero, N., P.S. Tomillo, V.S. Saba, M.A.G. dei Marcovaldi, M. López-Mendilaharsu, A.S. Santos, and M.M.P.B. Fuentes. 2019. Effects of Local Climate on Loggerhead Hatchling Production in Brazil: Implications From Climate Change. Scientific Reports, 9(1).

Monzón-Argüello, C., L.F. López-Jurado, C. Rico, A. Marco, P. López, G.C. Hays, and P.L.M. Lee. 2010. Evidence From Genetic and Lagrangian Drifter Data for Transatlantic Transport of Small Juvenile Green Turtles. Journal of Biogeography, 37(9):1752-1766.

Morreale, S.J., and E. Standora. 2005. Western North Atlantic Waters: Crucial Developmental Habitat for Kemp's Ridley and Loggerhead Sea Turtles. Chelonian Conservation and Biology, 4(4):872-882.

Mortimer, J.A., M. Day, and D. Broderick. 2002. Sea Turtle Populations of the Chagos Archipelago, British Indian Ocean Territory. Pages 47-49 *in* A. Mosier, A. Foley, and B. Brost, editors. Twentieth Annual Symposium on Sea Turtle Biology and Conservation, Orlando, Florida.

Murdoch, P.S., J.S. Baron, and T.L. Miller. 2000. Potential Effects of Climate Change of Surface Water Quality in North America. Journal of the American Water Resources Association, 36(2):347-366.

Murphy, T.M., and S.R. Hopkins. 1984. Aerial and Ground Surveys of Marine Turtle Nesting Beaches in the Southeast Region. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center, Miami, Florida.

Musick, J.A., and C.J. Limpus. 1997. Habitat Utilization and Migration in Juvenile Sea Turtles. Pages 137-163 *in* P.L. Lutz and J.A. Musick, editors. The Biology of Sea Turtles. CRC Press, New York, New York.

NAST. 2000. Climate Change Impacts on the United States: the Potential Consequences of Climate Variability and Change. National Assessment Synthesis Team, U.S. Global Change Research Program, Washington D.C.

Nelms, S.E., E.M. Duncan, A.C. Broderick, T.S. Galloway, M.H. Godfrey, M. Hamann, P.K. Lindeque, and B.J. Godley. 2016. Plastic and Marine Turtles: a Review and Call for Research. ICES Journal of Marine Science, 73(2):165-181.

NMFS. 2001. Stock Assessments of Loggerhead and Leatherback Sea Turtles and an Assessment of the Impact of the Pelagic Longline Fishery on the Loggerhead and Leatherback Sea Turtles of the Western North Atlantic. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

NMFS. 2002. ESA Section 7 Consultation on Shrimp Trawling in the Southeastern United States Under the Sea Turtle Conservation Regulations and as Managed by the Fishery Management Plans for Shrimp in the South Atlantic and Gulf of Mexico. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2003. ESA Section 7 Consultation on the Fishery Management Plan for the Dolphin and Wahoo Fishery of the Atlantic. Biological Opinion F/SER/2002/01305. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2005. ESA Section 7 Consultation on the Continued Authorization of Reef Fish Fishing under the Gulf of Mexico Reef Fish Fishery Management Plan and Proposed Amendment 23. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2007a. ESA Section 7 Consultation on the on the Continued Authorization of the Fishery Management Plan for Coastal Migratory Pelagic Resources in the Atlantic and Gulf of Mexico under the Magnuson-Stevens Fishery Management and Conservation Act. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2007b. ESA Section 7 Consultation on the ESA Section 7 Consultation on the Dredging of Gulf of Mexico Navigation Channels and Sand Mining (“Borrow”) Areas Using Hopper Dredges by USACE Galveston, New Orleans, Mobile, and Jacksonville Districts. Second Revised Biological Opinion, November 19, 2003. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3), St. Petersburg, Florida.

NMFS. 2008. Endangered Species Act Section 7 Consultation on the Continued Authorization of Shark Fisheries (Commercial Shark Bottom Longline, Commercial Shark Gillnet and Recreational Shark Handgear Fisheries) as Managed under the Consolidated Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks (Consolidated HMS FMP), including Amendment 2 to the Consolidated HMS FMP. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3), St. Petersburg, Florida.

NMFS. 2009a. An Assessment of Loggerhead Sea turtles to Estimate Impacts of Mortality on Population Dynamics. U.S. Department of Commerce, National Oceanic and Atmospheric

Administration, National Marine Fisheries Service, Southeast Fisheries Science Center Contribution PRD-08/09-14.

NMFS. 2009b. The Continued Authorization of Reef Fish Fishing Under the Gulf of Mexico Reef Fish Fishery Management Plan, Including Amendment 31, and a Rulemaking to Reduce Sea Turtle Bycatch in the Eastern Gulf Bottom Longline Component of the Fishery. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2009c. ESA Section 7 Consultation on the Continued Authorization of Fishing under the Fishery Management Plan for Spiny Lobster in the South Atlantic and Gulf of Mexico. Biological Opinion F/SER/2005/07518. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2009d. ESA Section 7 Consultation on the Continued Authorization of Fishing under the Fishery Management Plan for the Stone Crab Fishery of the Gulf of Mexico. Biological Opinion F/SER/2005/07541. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2009e. An Assessment of Loggerhead Sea Turtles to Estimate Impacts of Mortality Reductions on Population Dynamics. NMFS-SEFSC Contribution PRD-08/09-14. National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

NMFS. 2011a. Preliminary Summer 2010 Regional Abundance Estimate of Loggerhead Turtles (*Caretta Caretta*) in Northwestern Atlantic Ocean Continental Shelf Waters. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 11-03.

NMFS. 2011b. The Continued Authorization of Reef Fish Fishing under the Gulf of Mexico Reef Fish Fishery Management Plan. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2012a. Reinitiation of Endangered Species Act (ESA) Section 7 Consultation on the Continued Implementation of the Sea Turtle Conservation Regulations, as Proposed to be Amended, and the Continued Authorization of the Southeast U.S. Shrimp Fisheries in Federal Waters under the Magnuson-Stevens Act. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3) and Sustainable Fisheries Division (F/SER2), St. Petersburg, Florida.

NMFS. 2012b. ESA Section 7 Consultation on the Continued Authorization of the Atlantic Shark Fisheries *via* the Consolidated HMS Fishery Management Plan as Amended by Amendments 3 and 4 and the Federal Authorization of a Smoothhound Fishery. Biological Opinion. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3), St. Petersburg, Florida.

NMFS. 2020a. South Atlantic Regional Biological Opinion for Dredging and Material Placement Activities in the Southeast United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3), St. Petersburg, Florida.

NMFS. 2020b. Endangered Species Act Section 7 Consultation On the Operation of the HMS Fisheries (Excluding Pelagic Longline) Under the Consolidated Atlantic HMS Fishery Management Plan. Biological Opinion F/SER/2015/16974. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (F/SER3), St. Petersburg, Florida.

NMFS and USFWS. 1991. Recovery Plan for U.S. Population of the Atlantic Green Turtle (*Chelonia Mydas*). National Marine Fisheries Service, Washington, D.C.

NMFS and USFWS. 1992. Recovery Plan for Leatherback Turtles *Dermochelys Coriacea* in the U.S. Carribean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

NMFS and USFWS. 2007a. Kemp's Ridley Sea Turtle (*Lepidochelys Kempii*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS and USFWS. 2007b. Loggerhead Sea Turtle (*Caretta Caretta*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS and USFWS. 2007c. Green Sea Turtle (*Chelonia Mydas*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS and USFWS. 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta Caretta*), Second Revision. National Marine Fisheries Service, Silver Spring, Maryland.

NMFS, USFWS, and SEMARNAT. 2011. Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys Kempii*), Second Revision. National Marine Fisheries Service, Silver Spring, Maryland.

NOAA. 2023. Sea Turtle Stranding and Salvage Network. URL: https://www.fisheries.noaa.gov/national/marine-life-distress/sea-turtle-stranding-and-salvage-network. Accessed March 1, 2023.

NPS. 2020. Review of the Sea Turtle Science and Recovery Program, Padre Island National Seashore. National Park Service, Denver, Colorado. Retrieved from: https://www.nps.gov/pais/learn/management/sea-turtle-review.htm.

NRC. 1990. Decline of the Sea Turtles: Causes and Prevention. National Research Council, Washington, D.C.

Ogren, L.H. 1989. Distribution of Juvenile and Subadult Kemp's Ridley Sea Turtles: Preliminary Results From 1984-1987 Surveys. Pages 116-123 *in* C.W. Caillouet Jr. and A.M. Landry Jr., editors. First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University, Sea Grant College, Galveston, Texas.

Palmer, M.A., C.A. Reidy Liermann, C. Nilsson, M. Flörke, J. Alcamo, P.S. Lake, and N. Bond. 2008. Climate Change and the World's River Basins: Anticipating Management Options. Frontiers in Ecology and the Environment, 6(2):81-89.

Patino-Martinez, J., A. Marco, L. Quiñones, and L.A. Hawkes. 2012. A potential Tool to Mitigate the Impacts of Climate Change to the Caribbean Leatherback Sea Turtle. Global Change Biology, 18:401-411.

Patino-Martinez, J., A. Marco, L. Quiñones, and L.A. Hawkes. 2014. The Potential Future Influence of Sea Level Rise on Leatherback Turtle Nests. Journal of Experimental Marine Biology and Ecology, 461:116- 123.

Pike, D.A. 2013. Forecasting Range Expansion Into Ecological Traps: Climate-Mediated Shifts in Sea Turtle Nesting Beaches and Human Development. Global Change Biology, 19(10):3082-3092.

Pike, D.A. 2014. Forecasting the Viability of Sea Turtle Eggs in a Warming World. Global Change Biology, 20(1):7-15.

Pike, D.A., R.L. Antworth, and J.C. Stiner. 2006. Earlier Nesting Contributes to Shorter Nesting Seasons for the Loggerhead Sea Turtle, *Caretta Caretta*. Journal of Herpetology, 40(1):91-94.

Pike, D.A., E.A. Roznik, and I. Bell. 2015. Nest Inundation From Sea-Level Rise Threatens Sea Turtle Population Viability. Royal Society Open Science, 2(7):150127.

Plotkin, P.T. 2003. Adult Migrations and Habitat Use. Pages 225-241 *in* P.L. Lutz, J.A. Musick, and J. Wyneken, editors. The Biology of Sea Turtles, Volume 2. CRC Press, Boca Raton, Florida.

Plotkin, P.T., and A.F. Amos. 1988. Entanglement in and Ingestion of Marine Debris by Sea Turtles Stranded Along the South Texas Coast. Pages 79-82 *in* B.A. Schroeder, editor. Proceedings of the Eighth Annual Workship on Sea Turtle Biology and Conservation, Fort Fisher, North Carolina. NOAA Technical Memorandum NMF-SEFSC-214.

Plotkin, P.T., and A.F. Amos. 1990. Effects of Anthropogenic Debris on Sea Turtles in the Northwestern Gulf of Mexico. Pages 736-743 *in* R.S. Shoumura and M.L. Godfrey, editors. Proceedings of the Second Internntional Conference on Marine Debris, Honolulu, Hawaii. NOAA Technical Memorandum NMFS SWFSC-154.

Poloczanska, E.S., C.J. Limpus, and G.C. Hays. 2009. Chapter 2: Vulnerability of Marine Turtles to Climate Change. Pages 151-211 *in* D.W. Sims, editor. Advances in Marine Biology, Volume 56. Academic Press. 420 pp.

Poulakis, G.R., P.W. Stevens, A.A. Timmers, T.R. Wiley, and C.A. Simpfendorfer. 2011. Abiotic Affinities and Spatiotemporal Distribution of the Endangered Smalltooth Sawfish, *Pristis Pectinata*, in a Southwestern Florida Nursery. Marine and Freshwater Research, 62:1165-1177.

Pritchard, P.C.H. 1969. The Survival Status of Ridley Sea Turtles in America. Biological Conservation, 2(1):13-17.

Pritchard, P.C.H., P. Bacon, F.H. Berry, A. Carr, J. Feltemyer, R.M. Gallagher, S. Hopkins, R. Lankford, M.R. Marquez, L.H. Ogren, W. Pringle Jr., H. Reichart, and R. Witham. 1983. Manual of Sea Turtle Research and Conservation Techniques, Second Edition. Center for Environmental Education, Washington, D.C.

Purcell, J. 2005. Climate Effects on Formation of Jellyfish and Ctenophore Blooms: A Review. Journal of the Marine Biological Association of the United Kingdom, 85:461-476.

Rafferty, A.R., C.P. Johnstone, J.A. Garner, and R.D. Reina. 2017. A 20-Year Investigation of Declining Leatherback Hatching Success: Implications of Climate Variation. Royal Society Open Science, 4(10):170196.

Rebel, T.P. 1974. Sea Turtles and the Turtle Industry of the West Indies, Florida, and the Gulf of Mexico. University of Miami Press, Coral Gables, Florida.

Reece, J., D. Passeri, L. Ehrhart, S. Hagen, A. Hays, C. Long, R. Noss, M. Bilskie, C. Sanchez, M. Schwoerer, B. Von Holle, J. Weishampel, and S. Wolf. 2013. Sea Level Rise, Land Use, and Climate Change Influence the Distribution of Loggerhead Turtle Nests at the Largest USA Rookery (Melbourne Beach, Florida). Marine Ecology Progress Series, 493:259-274.

Richards, P.M., S.P. Epperly, S.S. Heppell, R.T. King, C.R. Sasso, F. Moncada, G. Nodarse, D.J. Shaver, Y. Medina, and J. Zurita. 2011. Sea Turtle Population Estimates Incorporating Uncertainty: A New Approach Applied to Western North Atlantic Loggerheads *Caretta Caretta*. Endangered Species Research, 15:151-158.

Richardson, A.J., A. Bakun, G.C. Hays, and M.J. Gibbons. 2009. The Jellyfish Joyride: Causes, Consequences and Management Responses to a More Gelatinous Future. Trends in Ecology and Evolution, 24(6):312-322.

Robinson, R.A., H.Q.P. Crick, J.A. Learmonth, I.M.D. Maclean, C.D. Thomas, F. Bairlein, M.C. Forchhammer, C.M. Francis, J.A. Gill, B.J. Godley, J. Harwood, G.C. Hays, B. Huntley, A.M. Hutson, G.J. Pierce, M.M. Rehfisch, D.W. Sims, B.M. Santos, T.H. Sparks, D.A. Stroud, and M.E. Visser. 2009. Travelling Through a Warming World: Climate Change and Migratory Species. Endangered Species Research, 7(2):87-99.

Ross, J.P. 1996. Caution Urged in the Interpretation of Trends at Nesting Beaches. Marine Turtle Newsletter, 74:9-10.

Sallenger, A.H., K.S. Doran, and P.A. Howd. 2012. Hotspot of Accelerated Sea-Level Rise on the Atlantic Coast of North America. Nature Climate Change, 2(12):884-888.

Saunders, M.I., J. Leon, S.R. Phinn, D.P. Callaghan, K.R. O'Brien, C.M. Roelfsema, C.E. Lovelock, M.B. Lyons, and P.J. Mumby. 2013. Coastal Retreat and Improved Water Quality Mitigate Losses of Seagrass From Sea Level Rise. Global Change Biology, 19(8):2569-2583.

Schmid, J.R., and J.A. Barichivich. 2006. *Lepidochelys Kempii*–Kemp's Ridley. Pages 128-141 *in* P.A. Meylan, editor. Biology and Conservation of Florida Turtles. Chelonian Research Monographs, Volume 3.

Schmid, J.R., and A. Woodhead. 2000. Von Bertalanffy Growth Models for Wild Kemp's Ridley Turtles: Analysis of the NMFS Miami Laboratory Tagging Database. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Schroeder, B.A., and A.M. Foley. 1995. Population Studies of Marine Turtles in Florida Bay. J.I. Richardson and T.H. Richardson, editors. Twelfth Annual Workshop on Sea Turtle Biology and Conservation.

Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz, E.E. Seney, K.S. Van Houtan, and R.S. Waples. 2015. Status Review of the Green Turtle (*Chelonia Mydas*) Under the Endangered Species Act. NOAA Technical Memorandum, NMFS-SWFSC-539.

Shamblin B.M., B.E. Witherington, S. Hirama, R.F. Hardy, and C.J. Nairn. 2018. Mixed Stock Analyses Indicate Population-scale Connectivity Effects of Active Dispersal by Surface-pelagic Green Turtles. Marine Ecology Progress Series, 601:215-226.

Shamblin B.M., P.H. Dutton, D.J. Shaver, D.A. Bagley, N.F. Putman, K.L. Mansfield, L.M. Ehrhart, L.J. Peña, and C.J. Nairn. 2016. Mexican Origins for the Texas Green Turtle Foraging Aggregation: A Cautionary Tale of Incomplete Baselines and Poor Marker Resolution. Journal of Experimental Marine Biology and Ecology, 488:111–120.

Shaver, D.J. 1994. Relative Abundance, Temporal Patterns, and Growth of Sea Turtles at the Mansfield Channel, Texas. Journal of Herpetology, 28(4):491-497.

Short, F.T., and H.A. Neckles. 1999. The Effects of Global Climate Change on Seagrasses. Aquatic Botany, 63(34):169-196.

Simpfendorfer, C.A., B.G. Yeiser, T.R. Wiley, G.R. Poulakis, P.W. Stevens, and M.R. Heupel. 2011. Environmental Influences on the Spatial Ecology of Juvenile Smalltooth Sawfish (*Pristis Pectinata*): Results From Acoustic Monitoring. PLOS ONE, 6(2):e16918.

Snover, M.L. 2002. Growth and Ontogeny of Sea Turtles Using Skeletochronology: Methods, Validation and Application to Conservation. PhD Dissertation, Duke University.

Spotila, J.R. 2004. Sea Turtles: A Complete Guide to their Biology, Behavior, and Conservation. Johns Hopkins University Press, Baltimore, Maryland.

Steidinger, K.A., Haddad, K., 1981. Biologic and Hydrologic Aspects of Red Tides. Bioscience, 31:814–819.

Storelli, M.M., G. Barone, A. Storelli, and G.O. Marcotrigiano. 2008. Total and Subcellular Distribution of Trace Elements (Cd, Cu and Zn) in the Liver and Kidney of Green Turtles (*Chelonia Mydas*) from the Mediterranean Sea. Chemosphere, 70(5):908-913.

TEWG. 1998. An Assessment of the Kemp's Ridley (*Lepidochelys Kempii*) and Loggerhead (*Caretta Caretta*) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409. 96 pp.

TEWG. 2000. Assessment Update for the Kemp's Ridley and Loggerhead Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444. 115 pp.

TEWG. 2007. An Assessment of the Leatherback Turtle Population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555. 116 pp.

TEWG. 2009. An Assessment of the Loggerhead Turtle Population in the Western North Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-575.

Titus, J.G., and V.K. Narayanan. 1995. The Probability of Sea Level Rise. U.S. Environmental Protection Agency, Washington, D.C.

Troëng, S., and E. Rankin. 2005. Long-Term Conservation Efforts Contribute to Positive Green Turtle *Chelonia Mydas* Nesting Trend at Tortuguero, Costa Rica. Biological Conservation, 121:111-116.

Tucker, A.D. 2010. Nest Site Fidelity and Clutch Frequency of Loggerhead Turtles are Better Elucidated by Satellite Telemetry than by Nocturnal Tagging Efforts: Implications for Stock Estimation. Journal of Experimental Marine Biology and Ecology, 383(1):48-55.

USFWS and NMFS. 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act.

Van Houtan, K.S., and J.M. Halley. 2011. Long-Term Climate Forcing Loggerhead Sea Turtle Nesting. PLOS ONE, 6(4).

Vargo, G.A., C.A. Heil, K.A. Fanning, L.K. Dixon, M.B. Neely, K. Lester, D. Ault, S. Murasko, J. Havens, J. Walsh, and S. Bell. 2008. Nutrient availability in support of Karenia brevis blooms on the central West Florida Shelf: What keeps *Karenia* blooming? Continental Shelf Research 28(1): 73-98.

Wallace, B.P., and T.T. Jones. 2008. What Makes Marine Turtles Go: A Review of Metabolic Rates and Their Consequences. Journal of Experimental Marine Biology and Ecology, 356(1):8-24.

Weisberg, R., Y. Liu, C. Lembke, C. Hu, K. Hubbard., and M. Garrett. 2019. The Coastal Ocean Circulation Influence on the 2018 West Florida Shelf *K. Brevis* Red Tide Bloom. Journal of Geophysical Research: Oceans, 124:2501–2512.

Weishampel, J.F., D.A. Bagley, and L.M. Ehrhart. 2004. Earlier Nesting by Loggerhead Sea Turtles Following Sea Surface Warming. Global Change Biology, 10:1424-1427.

Weishampel, J.F., D.A. Bagley, L.M. Ehrhart, and B.L. Rodenbeck. 2003. Spatiotemporal Patterns of Annual Sea Turtle Nesting Behaviors Along an East Central Florida Beach. Biological Conservation, 110(2):295-303.

Wershoven, J.L., and R.W. Wershoven. 1992. Juvenile Green Turtles in Their Nearshore Habitat of Broward County, Florida: A Five-Year Review. Pages 121-123 *in* M. Salmon and J. Wyneken, editors. Eleventh Annual Workshop on Sea Turtle Biology and Conservation.

Wibbels, T. 2003. Critical Approaches to Sex Determination in Sea Turtle Biology and Conservation. Pages 103-134 *in* P. Lutz, J.A. Musick, J. Wyneken, editors. Biology of Sea Turtles, Volume 2. CRC Press, Boca Raton, Florida.

Wibbels, T., and E. Bevan. 2019. *Lepidochelys Kempii*. The IUCN Red List of Threatened Species 2019. International Union for Conservation of Nature and Natural Resources.

Wilcox, J.R., J.R. Bouska, J. Gorham, B. Peery, and M. Bressette. 1998. Knee Deep in Green Turtles: Recent Trends in Capture Rates at the St. Lucie Nuclear Power Plant. Pages 147-148 in R. Byles and Y. Fernandesz, compilers. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation, Hilton Head, South Carolina. NOAA Technical Memorandum NMFS-SEFSC-412.

Wilkinson, C. 2004. Status of Coral Reefs of the World: 2004. Australian Institute of Marine Science, ISSN 1447-6185.

Witherington, B.E. 1992. Behavioral Responses of Nesting Sea Turtles to Artificial Lighting. Herpetologica 48(1):31-39.

Witherington, B.E. 2002. Ecology of Neonate Loggerhead Turtles Inhabiting Lines of Downwelling Near a Gulf Stream Front. Marine Biology, 140(4):843-853.

Witherington, B.E., and K.A. Bjorndal. 1991. Influences of Artificial Lighting on the Seaward Orientation of Hatchling Loggerhead Turtles *Caretta Caretta*. Biological Conservation 55(2):139-149.

Witherington, B.E., M. Bresette, and R. Herren. 2006. *Chelonia Mydas*—Green Turtle. Chelonian Research Monographs, 3:90-104.

Witherington, B.E., and L.M. Ehrhart. 1989a. Hypothermic Stunning and Mortality of Marine Turtles in the Indian River Lagoon System, Florida. Copeia, 1989(3):696-703.

Witherington, B.E., and L.M. Ehrhart. 1989b. Status and Reproductive Characteristics of Green Turtles (*Chelonia Mydas*) Nesting in Florida. Pages 351-352 *in* L. Ogren *et al.*, editors. Second Western Atlantic Turtle Symposium.

Witherington, B.E., S. Hirama, and A. Moiser. 2003. Effects of Beach Armoring Structures on Marine Turtle Nesting. U.S. Fish and Wildlife Service.

Witherington, B.E., S. Hirama, and A. Moiser. 2007. Changes to Armoring and Other Barriers to Sea Turtle Nesting Following Severe Hurricanes Striking Florida Beaches. U.S. Fish and Wildlife Service.

Witt, M.J., L.A. Hawkes, H. Godfrey, B.J. Godley, and A.C. Broderick. 2010. Predicting the Impacts of Climate Change on a Globally Distributed Species: The Case of the Loggerhead Turtle. The Journal of Experimental Biology, 213:901-911.

Witzell, W.N. 2002. Immature Atlantic Loggerhead Turtles (*Caretta Caretta*): Suggested Changes to the Life History Model. Herpetological Review, 33(4):266-269.

Wynne, T.T., A. Meredith, T. Briggs and W. Litaker. 2018. Harmful Algal Bloom Forecasting Branch Ocean Color Satellite Imagery Processing Guidelines. NOAA Technical Memorandum NOS NCCOS 296, 48 pp. DOI: 10.25923/606t-m243

Zug, G.R., and R.E. Glor. 1998. Estimates of Age and Growth in a Population of Green Sea Turtles (*Chelonia Mydas*) from the Indian River Lagoon System, Florida: A Skeletochronological Analysis. Canadian Journal of Zoology, 76(8):1497-1506.

Zurita, J.C., R. Herrera, A. Arenas, M.E. Torres, C. Calderón, L. Gómez, J.C. Alvarado, and R. Villavicencia. 2003. Nesting Loggerhead and Green Sea Turtles in Quintana Roo, Mexico. Pages 25-127 *in* J. A. Seminoff, editor. Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation, Miami, Florida.

Zwinenberg, A.J. 1977. Kemp’s Ridley, *Lepidochelys Kempii* (Garman, 1880), Undoubtedly the Most Endangered Marine Turtle Today (With Notes on the Current Status of *Lepidochelys Olivacea*). Bulletin Maryland Herpetological Society, 13(3):170-192.

Appendix A. Table of summary statistics for estimated lethal and non-lethal take of sea turtle species associated with LOSOM operations, as simulated across 1000 bootstrap runs. The scenario used to generate take estimates, using Lake Okeechobee total nitrogen levels and overall changes in annual flows as a proxy for LOSOM contributions to red tide enhancement, is presented in bold. Note approach accounts for only 10 to 20% of strandings being observed.

			Lethal			Non-lethal		
Species	**Area**	**Effect**	**median**	**min**	**max**	**median**	**min**	**max**
Green	CRE	noeffectN	4.14	0.01	24.17	1.80	0.03	4.95
Green	CRE	noeffectP	3.22	0.01	18.80	1.40	0.02	3.85
Green	CRE	flowsN	3.98	0.01	23.20	1.73	0.03	4.75
Green	CRE	flowsP	3.09	0.01	18.04	1.34	0.02	3.70
Green	CRE	peakflowsN	3.19	0.01	18.61	1.38	0.02	3.81
Green	CRE	peakflowsP	2.48	0.01	14.47	1.08	0.02	2.97
Green	CRE	AugDec_flowsN	4.52	0.01	26.34	1.96	0.03	5.40
Green	CRE	AugDec_flowsP	3.51	0.01	20.49	1.52	0.02	4.20
Green	SLE	noeffectN	0.04	0.00	0.23			
Green	SLE	noeffectP	0.03	0.00	0.15			
Green	SLE	flowsN	0.02	0.00	0.14			
Green	SLE	flowsP	0.02	0.00	0.09			
Green	SLE	peakflowsN	0.01	0.00	0.08			
Green	SLE	peakflowsP	0.01	0.00	0.05			
Green	SLE	AugDec_flowsN	0.04	0.00	0.20			
Green	SLE	AugDec_flowsP	0.02	0.00	0.13			
Kemps Ridley	CRE	noeffectN	6.55	0.01	36.83	1.12	0.02	3.08
Kemps Ridley	CRE	noeffectP	5.10	0.01	28.65	0.87	0.01	2.40
Kemps Ridley	CRE	flowsN	6.29	0.01	35.36	1.07	0.02	2.96
Kemps Ridley	CRE	flowsP	4.89	0.01	27.50	0.84	0.01	2.30
Kemps Ridley	CRE	peakflowsN	5.05	0.01	28.36	0.86	0.01	2.37
Kemps Ridley	CRE	peakflowsP	3.92	0.01	22.06	0.67	0.01	1.85
Kemps Ridley	CRE	AugDec_flowsN	7.14	0.01	40.14	1.22	0.02	3.36
Kemps Ridley	CRE	AugDec_flowsP	5.56	0.01	31.22	0.95	0.01	2.61
Loggerhead	CRE	noeffectN	5.28	0.01	43.73	0.92	0.01	2.53
Loggerhead	CRE	noeffectP	4.11	0.00	34.01	0.71	0.01	1.97
Loggerhead	CRE	flowsN	5.07	0.01	41.98	0.88	0.01	2.43
Loggerhead	CRE	flowsP	3.95	0.00	32.65	0.69	0.01	1.89
Loggerhead	CRE	peakflowsN	4.07	0.00	33.67	0.71	0.01	1.95
Loggerhead	CRE	peakflowsP	3.16	0.00	26.19	0.55	0.01	1.52
Loggerhead	CRE	AugDec_flowsN	5.76	0.01	47.67	1.00	0.02	2.76
Loggerhead	CRE	AugDec_flowsP	4.48	0.00	37.07	0.78	0.01	2.15
Loggerhead	SLE	noeffectN	0.05	0.00	0.28			

Loggerhead	SLE	noeffectP	0.03	0.00	0.18			
Loggerhead	SLE	flowsN	0.03	0.00	0.17			
Loggerhead	SLE	flowsP	0.02	0.00	0.11			
Loggerhead	SLE	peakflowsN	0.02	0.00	0.10			
Loggerhead	SLE	peakflowsP	0.01	0.00	0.06			
Loggerhead	SLE	AugDec_flowsN	0.04	0.00	0.25			
Loggerhead	SLE	AugDec_flowsP	0.03	0.00	0.16			

*Effect: Scenario used for evaluating LOSOM contributions to red tide enhancement: "*noeffectN*" - no changes to contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution; "*noeffectP*" - no changes to contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution; "*flowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on annual reduction in flow; "*flowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on annual reduction in flow; "*peakflowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on high harmful algal bloom months reduction in flow; "*peakflowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on high harmful algal bloom months reduction in flow; "*AugDec_flowsN*" - reduction in contribution from LORS08 using proportional Nitrogen loading as a proxy for attribution based on high nearshore red tide months reduction in flow; "*AugDec_flowsP*" - reduction in contribution from LORS08 using proportional Phosphorous loading as a proxy for attribution based on high nearshore red tide months reduction in flow. Q90 denotes upper 90th percentile quartile.