UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

AUG - 2 2016

Ms. Joanne Benante
Water Quality Planning Branch
U.S. Environmental Protection Agency
Region 4
Atlanta Federal Center
61 Forsyth Street
Atlanta, Georgia 30303

Dear Ms. Benante:

Enclosed is the National Marine Fisheries Service's (NMFS) biological opinion (opinion) on the Environmental Protection Agency's (EPA) approval of water quality standards under section 303(c) of the Clean Water Act. The specific standards for which consultation was requested are site specific numeric criteria for total nitrogen, total phosphorus, and chlorophyll-a, region specific criteria for dissolved oxygen, and turbidity limits for permits issued under Florida's Joint Coastal Permit. Our opinion was prepared pursuant to section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 USC 1531 *et seq.*). In our opinion, we conclude that EPA's approval of these standards is not likely to jeopardize any ESA-listed species under NMFS' jurisdiction that occur in Florida: North Atlantic right whale, green, hawksbill, Kemp's ridley, Leatherback, or loggerhead sea turtle, smalltooth sawfish, shortnose or Atlantic sturgeon, Atlantic sturgeon, Nassau grouper, elkhorn, staghorn, rough cactus, pillar, lobed star, mountainous star, or boulder star coral, or Johnson's seagrass. We also conclude that EPA's approval of these standards is not likely to destroy or adversely modify designated critical habitat under NMFS' jurisdiction that occurs within Florida: for the North Atlantic right whale, smalltooth sawfish, loggerhead sea turtle, elkhorn or staghorn coral, or Johnson's seagrass.

We based our conclusion on the following analyses that are found in the opinion:

- Performance of the numeric nutrient criteria in preventing elevated chlorophyll-a levels indicative of eutrophic conditions,
- Florida's integration of recommendations from EPA's Science Advisory Board review of coastal chlorophyll–a criteria methodology,
- Implications of dissolved oxygen conditions under the regional dissolved oxygen criteria for ESA-listed species under NMFS' jurisdiction,
- ESA section 7 consultations with the U.S. Army Corps of Engineers that will occur on Joint Coastal Permit actions that may affect ESA-listed species under NMFS' jurisdiction, and
- Potential for aggregate impacts of Joint Coastal Permit actions that may affect ESA-listed species under NMFS jurisdiction.

To arrive at our conclusion, these analyses were integrated with the current status of ESA-listed species under NMFS' jurisdiction, baseline conditions in Florida waters where these species and their designated critical habitat occur, and the cumulative effects of future State or private activities that are reasonably certain to occur within the action area.

This concludes formal consultation on this action. Consultation on this issue must be reinitiated if: (1) new information reveals effects of the action that may affect endangered or threatened species under NMFS' jurisdiction or to designated critical habitat in a manner or to an extent not considered in this opinion; (2) the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat not considered in this opinion; (3) a new species is listed or critical habitat designated that may be affected by the action; or (4) the amount or extent of take specified in the incidental take statement is exceeded.

If you have any questions, please contact Pat Shaw-Allen, consultation biologist, at (301) 427-8473, or by e-mail at pat.shaw-allen@noaa.gov, Cathy Tortorici, Chief, Interagency Cooperation Division at (301) 427-8495 or by e-mail at cathy.tortorici@noaa.gov, or myself.

Sincerely,

for

Donna S. Wieting
Director, Office of Protected Resources

NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION

Action Agency: Environmental Protection Agency, Region 4, Atlanta, Georgia

Activity Considered: Approval of Florida Numeric Nutrient Criteria for Total Phosphorus, Total Nitrogen, and Chlorophyll-a, Dissolved Oxygen Criteria, and Turbidity Limits under section 303(c) of the Clean Water Act

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

Approved: for

Donna S. Wieting
Director, Office of Protected Resources

Date: 7/29/16

Public Consultation Tracking System (PCTS) number: FPR-2015-9234

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ACRONYMS AND ABBREVIATIONS

BE – Biological Evaluation
CCC – Chronic Criterion Concentration
Chl–a – Chlorophyll a
CMC – Criterion Maximum Concentration
CWA – Clean Water Act
DO – Dissolved Oxygen
DPS – Distinct Population Segment
ECOTOX – ECOTOXicology database
EPA – Environmental Protection Agency
ESA – Endangered Species Act
FAV – Final Acute Value
FDEP – Florida Department of Environmental Protection
FP – Fibropapillomatosis
FFWCC – Fish and Wildlife Conservation Commission
HABs – Harmful Algal Blooms
ICWW – Intracoastal Waterway
IPCC – Intergovernmental Panel on Climate Change
ISED – International Sawfish Encounter Database
ITS – Incidental Take Statement
JCP – Joint Coastal Permit
LC50 – Concentration at which 50 percent of exposed organisms die
LOEC – Lowest Observed Effect Concentration
NH_3 – Unionized ammonia
NH_4^+ – Ionized Ammonia
NLAA – Not Likely to Adversely Affect
NMFS – National Marine Fisheries Service
NNC – Numeric Nutrient Criteria
NOAA – National Oceanic and Atmospheric Administration
NOEC – No Observed Effect Concentration
NPDES – National Pollutant Discharge Elimination System
PCBs – Polychlorinated Biphenyls
RPM – Reasonable and Prudent Measure
SAB – Science Advisory Board
SCI – Stream Condition Index
SSAC – Site Specific Alternative Criteria
STORET – STOrage and RETrieval database
TAN – Total Ammonia Nitrogen
TL – Total Length
TMDL – Total Maximum Daily Load
TN – Total Nitrogen
TP – Total Phosphorus
TSS – Total Suspended Solids
USACE – U.S. Army Corps of Engineers
USFWS – U.S. Fish and Wildlife Service
WQC – Water Quality Criteria
WQS – Water Quality Standard

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 USC. 1531 et seq.; ESA) requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. The definition of species in the Endangered. Species Act "… includes any subspecies of fish or wildlife or plants, or any distinct population segment (DPS)." When a Federal agency's action "may affect" a protected species, that agency is required to consult with The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14 (a)). Federal agencies must engage in formal consultation if their actions are likely to adversely affect listed species or designated critical habitat. If Federal agencies have concluded that an action "may affect, but is not likely to adversely affect" (i.e., NLAA) endangered species, threatened species, or designated critical habitat, they may alternatively engage in "informal consultation" and request NMFS and/or USFWS concurrence with that conclusion (50 CFR §402.14(b).

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

In this case, the action is the Environmental Protection Agency's (EPA) approval of Water Quality Standards (WQS - numeric criteria and narrative criteria) applied by the state of Florida (hereinafter referred to as the "State" or "Florida") in its 305(b)/303(d) water quality assessment program to identify waters currently in or approaching impaired conditions.

NMFS prepared this biological opinion (opinion) and ITS in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This document represents NMFS' final opinion on the effects of these actions on endangered and threatened species and designated critical habitat that has been designated for those species.

In this opinion, we evaluate whether the EPA approval of certain water quality criteria and limits on the mixing zones for discharges of sediment to waters of the U.S. is likely to jeopardize endangered and threatened species or destroy or adversely modify designated critical habitat. An endangered species is defined by the ESA as a species in danger of extinction throughout all or a significant portion of its range; a threatened species is defined as a species likely to become an endangered species throughout all or a significant portion of its range in the foreseeable future. The continued existence of a population is determined by the fate of the individuals within it and the continued existence of a species is determined by the fate of its populations. Populations grow or decline as its individuals live, die, grow, mature, migrate, and reproduce, or fail to do so. Designated critical habitat is defined as the specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features that are essential to the conservation of the species, and which may require special management considerations or protection. Designated critical habitat can also include specific areas outside the geographical area occupied by the species at the time it is listed that are determined by the Secretary to be essential for the conservation of the species[1]. Destruction or adverse modification means a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features. These include, but are not limited to:

- space for individual and population growth, and for normal behavior;
- nutritional or physiological requirements (e.g., food, water, air, light, minerals);
- cover or shelter;
- sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and
- habitats that are protected from disturbance or are representative of the historic, geographic and ecological distributions of a species.

This opinion and ITS were prepared by the ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This opinion complies with the Data Quality Act (44 USC. 3504(d)(1) et seq.) and underwent pre-dissemination review. This document represents NMFS' opinion on the effects of these actions on endangered and threatened species and designated critical habitat that has been designated for those species. A complete record of this consultation is on file at NMFS' Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The Florida Wildlife Federation (FWF) filed a lawsuit in 2008 seeking to require EPA to promulgate water quality criteria (WQC) for nutrients in Florida waters. On January 14, 2009, the EPA determined that numeric nutrient WQC in the State of Florida were necessary to meet the requirements of the Clean Water Act (CWA). In August 2009, the EPA entered into a Consent Decree with FWF to settle the 2008 litigation, setting dates for promulgation of NNC. The consent decree provided that, if Florida submits and the EPA approves State NNC for the relevant waters before any of the above dates, the EPA would no longer be under obligation with respect to promulgating such criteria.

[1] Sections 3 (5), (6) and (20), 16 USC. 1532 (5), (6) and (20)

On June 13, 2012, the Florida Department of Environmental Protection submitted new and revised WQS for review by the U.S. Environmental Protection Agency pursuant to section 303(c) of the CWA.

1.2 Consultation History

- On December 20, 2012, EPA Region 4 transmitted a letter to the NMFS Southeast Region Office requesting informal review of its BE for its approval of new and revised WQS.
- EPA initiated informal consultation with representatives from the Fish and Wildlife Service and NMFS Southeast Region Office (the Services) on July 24, 2013, via a conference call.
- On October 18, 2013, EPA Region 4 transmitted a letter to the NMFS Southeast Region Office requesting informal review of its BE for its approval of new saturation-based criteria for oxygen dissolved in water.
- On October 25, 2013, EPA Region 4 transmitted a letter to the NMFS Southeast Region Office requesting informal review of its BE for its approval of new saturation-based criteria for and nutrient criteria for Florida's Panhandle and estuaries evaluated in the 2013 assessment cycle.
- On May 7, 2014, EPA Region 4 transmitted a letter to the NMFS Southeast Region Office requesting informal review of its BE for its approval of new turbidity mixing zone limits for dredging of beach-quality sand from inlets and related channels, or restoration/nourishment of beaches and the use of offshore borrow areas, a water quality criterion for the pesticide lindane, and nutrient criteria for the Tidal segment of the Peace River within the Charlotte Harbor Estuary.
- On September 4, 2014, the NMFS Southeast Region Office notified EPA Region 4 that help from NMFS headquarters ESA Interagency Cooperation Division will be needed to work through EPA's consultation requests.
- On September 12, 2014, EPA Region 4 provided NMFS with an updated list of actions with pending NMFS consultation responses.
- Between September 21, 2014 and August 21, 2015, EPA and the ESA Interagency Cooperation Division engaged in informal ESA section 7 consultation and held multiple conference calls.
- On August 21, 2015, EPA Region 4 requested formal consultation or written concurrence on its approval of specific provisions of the Florida WQS. The EPA's request was accompanied by a BE Supplement analysis was developed to support the evaluation of the biological effects of three revisions made to Florida's WQC for nutrients, oxygen saturation, approved in various CWA 303(c) actions taken by the EPA. The corresponding original transmittals of BEs to NMFS were provided by letters dated December 20, 2012, October 18, 2013, October 25, 2013, and May 7, 2014.

- Between August 21 and December 3, 2015, EPA and the ESA Interagency Cooperation Division engaged in formal ESA section 7 consultation and held multiple conference calls.
    - On October 16, 2015, ESA Interagency Cooperation Division provided EPA Region 4 with a draft description of the action.
    - On November 24, 2015, EPA Region 4 provided edits and comments on the description of the action.
    - On December 3, 2015, EPA and the ESA Interagency Cooperation Division finalized edits to the description of the action.
- On January 29th, 2016, the ESA Interagency Cooperation Division requested an extension to consultation.
- On March 8, 2016, the ESA Interagency Cooperation Division notified that Tidal Peace River NNC appeared to promote eutrophication.
- On March 8, 2016, EPA transmitted a copy of the document Florida relied on to derive the nutrient criteria for Tidal Peace River.
- On March 14, 2016, the ESA Interagency Cooperation Division requested an extension to consultation.
- On May 2, 2016, EPA conducted a conference a call with the ESA Interagency Cooperation Division and representatives of Florida Department of Environmental Protection to discuss issues found with the development of Tidal Peace River nutrient criteria and the possibility of an expedited Total Maximum Daily Load (TMDL).
- On June 8, 2016, EPA and the ESA Interagency Cooperation Division agreed that the criteria approved for lindane in the BE transmitted to the ESA Interagency Cooperation Division on May 7, 2014 would be folded into EPAs upcoming 303(c) action for Florida's triennial addressing pesticides criteria.
- On June 16, 2016, the ESA Interagency Cooperation Division requested an extension to consultation.
- On July 6, 2016, the EPA recommended an extension to consultation to address terms and conditions.
- On August 2, 2016, NMFS transmitted its opinion to EPA.

2 DESCRIPTION OF THE ACTION

Under Section 7(a)(2) of the ESA "Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas. The action agency for this consultation is Region 4 of the EPA. The action is EPA Region 4's approval of revisions to Florida's 303(c) WQS To ensure that the opinion is consistent with the agency's action, the following *Description of the Action* was reviewed in draft form by EPA Region 4 and revised according to their edits. EPA was notified of, and concurred with, necessary edits made to the description of the action during the development of this opinion.

EPA Region 4 approved new and revised WQS in Rules 62-302, 62-303, and 62-4 of the Florida Administrative Code. The EPA's statutory authority for the review and approval of state WQS falls under Section 303(c) of the CWA, which establishes the basic structure for regulating discharges of pollutants into and regulating quality standards for the waters of the United States. Under section 303(c), states are required to adopt WQS to restore and maintain the chemical, physical, and biological integrity of the nation's waters. An overview of the CWA and the role of water quality criteria and standards in protecting protect the Nation's waters is provided in Appendix A. EPA is required to review these changes to ensure revisions in designated water uses are consistent with the CWA and that new or revised standards protect the designated water uses. Approval must be granted by EPA within 60 days or EPA must respond within 90 days if it disapproves of the standards. Specifically the federal WQS regulations at 40 CFR § l31.21 state, in part, that when EPA disapproves a state's WQS, EPA shall specify changes that are needed to ensure compliance with the requirements of Section 303(c) of the CWA and federal WQS. The adoption, review, and approval of state WQS satisfy the goals and policies of the CWA (33 USC §§1251).

Section 7(d) of the ESA prohibits an action agency engaged in ESA section 7(a)(2) consultation from making an irreversible or irretrievable commitment of resources that would have the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures that would avoid violation of section 7(a)(2). Although EPA has already approved Florida's WQS, EPA has determined that its approval does not violate section 7(d) of the ESA, stating: *"it does not foreclose either the formulation by the Services, or the implementation by the EPA, of any alternatives that might be determined in the consultation to be needed to comply with section 7(a)(2)."* This determination is expressed within the Biological Evaluations (BEs) provided to the ESA Interagency Cooperation Division, EPA decision documents, and EPA Region 4 memos to file. EPA's decision documents explicitly state that the approval is "subject to the results of consultation under section 7(a)(2) of the ESA." EPA states that it retains its discretion to take the full range of options available under section 303(c) for ensuring WQS are environmentally protective if the consultation identifies deficiencies in the standards. The decisional documents EPA transmitted to the State and included with its BEs state that it can, for example, work with the State to ensure that the State revises its standards as needed to ensure listed species' protection, such as by initiating rulemaking under section 303(c)(4)(B) of the CWA to promulgate federal standards to supersede the State standards. EPA states in its BEs that its 7(d) determinations allow them to accommodate the approval deadlines specified under the CWA and enter into consultation with the services in order to meet its obligations under the ESA.

In its initiation letter, EPA requested NMFS concurrence on its determination that its approval of Numeric Nutrient Criteria and turbidity standards was NLAA for ESA-listed species. In addition, EPA requested formal consultation on its approval of DO standards. These requests are addressed together in this document. EPA's decision to approve Florida's standards comprise the actions under consideration in this opinion.

EPA's analysis and conclusions are outlined in the BE documents, associated decision documents, and guidance described in five BE documents which are summarized below. The NNC described in these BEs include concentration and load-based criteria that were derived through different strategies determined by the quantity and comprehensiveness of available data, and, in some cases, the complexity of the system to be protected. The estuary segment-specific NNC derived under these differing strategies for the waters addressed in this action are provided in Appendix B.

2.1 Biological Evaluation (BE) for Hierarchical Numeric Nutrient Criteria (NNC) for Total Phosphorus (TP), Total Nitrogen (TN), and Chlorophyll a (Chl-a)

On December 20, 2012, EPA submitted the Biological Evaluation for the EPA's approval of new and revised WQS in Florida Administrative Code Chapters 62-302 and 62-303 62-4 and several documents regarding the hierarchical NNC. The BE evaluates the ESA implications of EPA's decision to approve Florida's amendments to Florida's Rule 62-302 and 62-303. This BE and its associated decisional document will be referred to as the hierarchical approach. In particular, EPA's decision was to approve Florida's hierarchical approach to the derivation of NNC and resulting NNC for springs, lakes, streams, certain estuaries, and a procedure for developing alternative NNC.

Under the hierarchical approach, hierarchy 1 is the preferred numeric criterion and is obtained through a site-specific analysis such as a TMDL, site-specific alternative criterion derivation (SSAC), water quality based effluent limitation, or other Florida Department of Environmental Protection (FDEP) approved action that numerically interprets the narrative criterion of "no imbalance in natural populations of aquatic flora or fauna." That is to say, if that surface water meets the concentrations of TN, TP, and Chl-a specified by numeric criteria, there will be no imbalance in natural populations of aquatic flora or fauna (i.e., the presence and abundance of species indicative of a healthy ecosystem). If these site-specific analyses have already been developed or as they become developed in the future, they are considered the numeric interpretation of the narrative standards under hierarchy 1 and are the applicable criteria for the specific waterbody.

If a hierarchy 1 interpretation is not available, the Rule's hierarchical approach then gives preference to hierarchy 2 criteria, which are nutrient concentrations based on quantifiable stressor-response relationships between nutrients and biological response. If no quantifiable stressor-response relationship has been established, such as is the case for Florida streams, hierarchy 3 standards apply.

Hierarchy 3 standards use biological information from suitably matched reference areas to identify the nutrient levels at which no imbalance in natural populations of aquatic flora or fauna is expected to occur. For those waters without a numeric interpretation under any of these approaches, the narrative standards continue to apply to the waterbody.

2.1.1 Springs and Lakes

The EPA approved hierarchy 2 NNC for springs and lakes that lack a TMDL, SSAC, Water Quality Based Effluent Limitation, or other FDEP approved action that numerically interprets the narrative criterion. ESA-listed species under NMFS' jurisdiction do not occupy spring vents or lakes, so the standards approved by EPA for these waters are not evaluated in this document.

2.1.2 Streams

Site-specific analysis (hierarchy 1) standards are only available for a subset of Florida streams and quantifiable stressor-response relationships between nutrients and biological responses (hierarchy 2) are not available for the remaining Florida streams. Florida proposed, and EPA approved, hierarchy 3 NNC standards for those streams lacking hierarchy 1 or 2 standards. The hierarchy 3 standards are based on an evaluation of stream water chemistry and biological community data to determine if a stream's nutrient concentrations are protective of balanced flora and fauna. FDEP-based its approach on the belief that the nutrient indicators, TN and TP, in streams are only a problem when at high enough concentrations to stimulate excess plant or algal growth to the extent that adverse effects occur in aquatic animals. Excess plant or algal growth impacts aquatic animals by smothering their habitat, disturbing the food webs, or when decomposed, by depleting the available oxygen in the water. Biological indicators, such as excessive algal mats, excess water column chlorophyll, excess nuisance vascular plant growth, and/or failing health scores for faunal communities signal an imbalance of aquatic flora and/or fauna due to excess nutrients. FDEP has derived metrics[2] for biological indicators that support the State's recreation and aquatic life use: "recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife." These metrics are included in the technical support documents submitted as part of the Rule package EPA approved and are specifically referenced in the Rule itself.

FDEP used metrics directly relatable to excess nutrients to detect floral imbalance. These metrics are Chl-a levels, the presence of nuisance macrophyte growth, algal mats or blooms, and changes

[2] Metrics are quantitative measures of biological indicators that are used to score and evaluate the condition of a community relative to some reference condition.

in algal species composition. If any one of the floral measures indicates an imbalance, then the stream does not attain the NNC. Faunal imbalance is evaluated using the Stream Condition Index (SCI). The SCI integrates data on the diversity and abundance of benthic macroinvertebrate species to indicate the degree to which flowing fresh waters support a healthy, well-balanced biological community. Attainment of the SCI threshold is an indication that the faunal community of the stream is not impaired to the extent that there is a loss in designated use due to any stressor, including excess nutrients. Since there are other stressors, besides excess nutrient loading, that affect SCI attainment, failure of the SCI metric does not necessarily mean that the loss of designated use is caused by nutrients.

EPA also approved Florida's narrative standards for the protection of downstream waters stating that "The loading of nutrients from a waterbody shall be limited as necessary to provide for the attainment and maintenance of WQS in downstream waters."

2.1.3 **Estuaries**

Hierarchy 1 estuary-specific numeric interpretations of the narrative standards were derived for estuaries along the South and Southwest Coast of Florida to protect recreation and a healthy, well-balanced population of fish and wildlife. These waters include: Tampa Bay, Clearwater Harbor, Sarasota Bay, Charlotte Harbor, Clam Bay, and the marine waters of South Florida.

The Tampa Bay, Clearwater Harbor, Sarasota Bay and Charlotte Harbor NNCs are based on the collaborative research, data, and work of the National Estuary Programs in an effort to improve and restore seagrass. The Tampa Bay standards are expressed as delivery ratios while the remaining southwest estuary standards are expressed as concentrations not to be exceeded more than once in three consecutive years.

A "maintain healthy conditions" approach was applied to the southernmost marine waters of Florida after grouping these waters geographically into four large systems (Tidal Cocohatchee River/Ten Thousand Islands, Florida Bay, the Florida Keys, and Biscayne Bay). Important biological communities, water quality conditions, and nutrient sources were evaluated in each system to establish the status and determine if a system, or part of a system, is meeting its designated use. Using statistics with a prediction interval, FDEP calculated standards that reflect healthy conditions in the waterbody while shielding against a statistically false positive result (that is, identification of a healthy waterbody as impaired).

2.1.4 **Site-Specific Alternative Standards (SSACs)**

EPA approved Florida's approach to developing nutrient SSACs using water quality and biological data to characterize existing nutrient concentrations and aquatic health. Type I SSACs are established to reflect natural background conditions, such as lower DO levels than the statewide default standards. Type II SSACs are established for situations other than natural background conditions. Type III SSACs are specific to nutrients and use biological health assessments (evaluating both flora and fauna) to demonstrate full aquatic life use support. A Type III SSAC is established at levels representative of an existing associated nutrient regime in a water achieving its designated use. The approach for nutrient SSACs is detailed in the guidance: *Development of Type III Site Specific Alternative Standards for Nutrients*. Future applications of this process that result in alternative standards will be subject to EPA review and subsequent ESA consultation. This opinion will evaluate the approach itself and those standards approved by EPA.

2.1.5 **Impaired Waters Rule**

EPA also approved FDEP changes to Florida's Impaired Waters Rule. The changes include trend analysis and processes to determine if waterbodies (or waterbody segments) should be placed on the verified list and CWA 303(d) list of impaired waterbodies for subsequent TMDL development. The listings are made in accordance with evaluation thresholds, data sufficiency and data quality requirements in the Impaired Waters Rule. The results of the assessment are used to identify waters in each basin for which TMDLs will be developed. The Impaired Waters Rule also includes the provision for the new "study list," which is also a part of the CWA 303(d) list.

2.2 BE for Dissolved Oxygen (DO) and Nutrient Related Revisions (NNC for Tidal Peace River)

The *BE for the EPA's Approval of DO and Nutrient Related Revisions to Florida's 62-302 and 62-303 Rules*, dated September 2013, evaluates DO revisions for fresh and marine waters throughout the state, nutrient related provisions for the tidal Peace River, and provides that NNC will be applied over an area consistent with derivation of those standards statewide.

2.2.1 **Florida's DO Criteria**

Florida's prior DO criteria are as follows:

- Class I waters shall not be less than 5 mg/L and seasonal fluctuations above this level shall be maintained.
- Class II waters shall not average less than 5 mg/L in a 24 hour period and shall never be less than 4.0 and normal daily and seasonal fluctuations above this level shall be maintained.
- Class III and III-limited predominantly fresh waters shall not average less than 5 mg/L in a 24 hour period and shall never be less than 4.0 and normal daily and seasonal fluctuations above this level shall be maintained.

Revisions to Florida's DO criteria described above include incorporation of a guidance document for the determination of natural DO levels based on oxygen saturation: *Technical Support Document: Derivation of DO Standards to Protect Aquatic Life in Florida's Fresh and Marine Waters*. This Technical Support Document's section on *Consideration of Threatened and Endangered Species* discusses smalltooth sawfish and shortnose and Gulf sturgeon, but does not address Atlantic sturgeon, corals, or Johnson's seagrass. Appendix I of the document

"Protection of Threatened and Endangered Species in Portions of the Suwannee, Withlacoochee, Santa Fe, New, and St. Johns Rivers" addresses Atlantic and shortnose surgeon. See Figure 1 and Table 1 for a summary of these standards.

The revisions apply an alternative criterion of 0.1 mg/L below the DO concentration associated with the natural background DO saturation level for freshwater waterbodies found to have natural background DO saturation levels that do not meet applicable DO criterion. In its BE, EPA-supports taking into account the natural DO regime. Applications of this provision will still be subject to future EPA review and ESA consultation.

For predominantly marine waters, the revisions allow for a decrease in magnitude, of up to 10 percent from natural background condition, if it is demonstrated that sensitive resident aquatic species will not be adversely affected based on a model referenced in the Technical Support Document. The *USEPA Natural Background Larval Recruitment Model* is a spreadsheet model used to determine the allowable deviation from natural background DO levels (up to 10 percent) that would result in a less than 5 percent additional loss in fish larval recruitment (Tetra-Tech, 2005).

Florida's rule also requires that ambient DO levels above the minimum standards be maintained. Ambient DO levels will be considered to have declined if a waterbody segment is shown to have a statistically significant decreasing trend in DO percent saturation or an increasing trend in the range of daily DO fluctuations. Such water segments will be placed on the verified list for DO impairment. To guard against listing as impaired those water segments with a DO regime attributable to natural background levels, water segments would only be placed on the verified list after a pollutant causing DO impairment is identified. Before a pollutant is identified, the water would still be placed on the study list, which is part of the state's 303(d) list.

Table 1. Summary of Florida's Regional DO Criteria.

Location	**No more than 10 percent of daily average DO saturation values shall be below the following:**	**Estimated DO range (from Figure 1)**
Panhandle West Bioregion	67%	4.9-8.2
Peninsula and Everglades Bioregions	38%	2.9-4.5
Northeast and Big Bend Bioregions	34%	2.5-4.2
Marine waters	42% 51% weekly 56% monthly	2.9-4.5 3.6-5.6 3.8-6.2
Water body-specific Florida's DO criteria		
Suwannee, Withlacoochee (North), and Santa Fe Rivers used by the Gulf Sturgeon	DO shall not be lowered below the baseline distribution of the water[1]	
St. Johns River used by the Shortnose or Atlantic Sturgeon	DO shall not be below 53 percent saturation during February and March and standards for the pertinent bioregions apply for the remainder of the year	

Technical Support Document, Appendix I, Table 3 indicates median saturation levels at 53.6 to 78.2 percent.

EPA reviewed Florida's approach to development of regional Florida's DO criteria based on the regression relationship between the average SCI score and daily average DO concentration in minimally disturbed sites and the 90th percentile of DO saturation in reference streams and determined these to be scientifically sound. Each adoption of a revised criterion using the natural background provisions will be reviewed by the EPA and will be considered for future consultation. In the case where a deviation is allowed, the presence of threatened or endangered species should be considered such that only an insignificant effect occurs.

EPA determined in the BE that the approach to Florida's DO criteria revision will have an insignificant effect on threatened and endangered species or their designated critical habitat because any alternative levels adopted would be related to natural background and would be presumed to be protective of all species present in the given waterbody. EPA determined that the standards are beneficial to ESA-listed species because they are based on updated science that takes ESA-listed species into consideration. EPA also concluded that the requirement to maintain conditions in waters with DO levels above the minimum standards would be beneficial because it provides an additional layer of protection for existing levels of ambient water quality consistent with the State's antidegradation procedures.

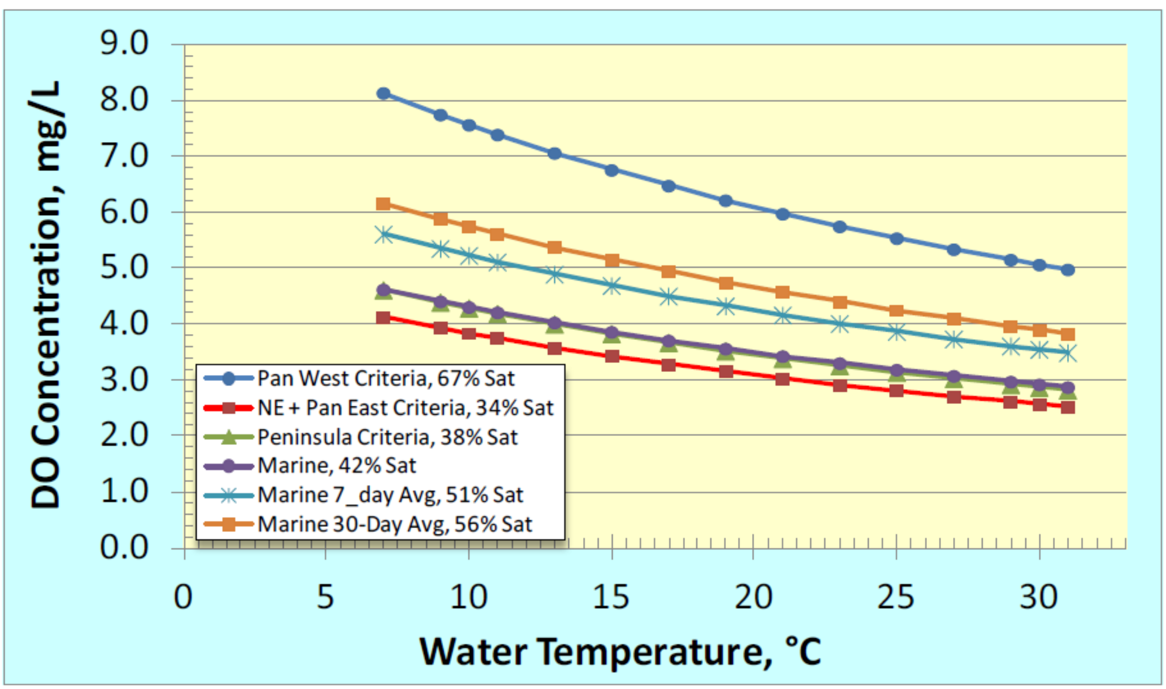

Figure 1. Relationship Between DO Concentration and Water Temperature for Florida's DO Criteria (from Technical Support Document, Figure 35).

2.2.2 Tidal Peace River NNC

The concentration-based estuary NNC are for open water, area-wide averages at annual arithmetic mean values. For waters within the Charlotte Harbor/Estero Bay estuary, these are not to exceed NNC more than once in a three year period. For the Tidal Peace River, the annual arithmetic mean values for TP and TN are 0.5 and 1.08 mg/L, respectively, and for Chl-a is 12.6 µg/L.

EPA made the determination that this revision protects the designated uses of the tidal reaches of the Peace River and provides protection for the estuarine waters by updating the specific spatial coverage where the standards apply. EPA stated that it expects that implementation of these standards will reduce eutrophication and is wholly beneficial and is therefore NLAA for ESA-listed species or their habitat.

2.3 Estuary NNC

The BE for the EPAs Approval of Amendments to Florida's Rule 62-302.532, F.A.C. Numeric Nutrient Standards for Florida's Panhandle and 2013 Estuaries) and Chapter 2013-71, Laws of Florida (Senate Bill 1808), dated September 2013, evaluates NNC for estuaries on the Florida panhandle, and on the east and west coast of Florida, and NNC for coastal offshore waters. The NNC for near-coastal waters are based on satellite data for detected chlorophyll-a. Several of the estuary NNC were revised after EPA produced this BE, and EPA withdrew these waters from its request for consultation. The opinion will evaluate NNC only for those estuaries having revised NNC more protective or unchanged relative to the original TN, TP and Chl-a NNC the BE was based on.

2.3.1 Coastal Waters

Florida's coastal waters were classified into three segments for the development of NNC: the Florida Panhandle, West Florida Shelf, and Atlantic Coast. The NNC for these waters are based on satellite remote sensing data for chlorophyll-a collected between 1998 and 2009, which were validated using available field observations. Coastal waters adjacent to impaired estuaries and data obtained during harmful algal bloom events were excluded from the dataset prior to calculating standards. Standards for each segment are the 90th percentiles of the annual geometric means of chlorophyll-a levels in the reference dataset. Sufficient field monitoring data for TP and TN were not available, so only chlorophyll-a standards were established for coastal waters. As more data become available relevant to these coastal waters, the EPA will encourage the State to derive numeric standards for those additional parameters. EPA determined that the NNC were protective of designated uses and therefore were NLAA for ESA-listed species.

2.3.2 Estuaries

The FDEP sub divided each Florida estuarine system into segments based on physical factors and long-term average salinity gradients before evaluating each segment to determine whether the current conditions were protecting the most sensitive designated uses. Most estuary standards are based on distributional statistics applied to data for reference conditions. However, TMDLs were submitted as site-specific standards for those segments that were currently or had been previously identified on the state's 303(d) impaired waters list as impaired for nutrients or DO. The reference condition approach was applied to some segments which had been previously been identified as impaired by nutrients or DO, but had since attained designated uses. In these cases, data from years when the segment was impaired or from specific impaired portions of the segment were excluded from the calculation.

The FDEP determined reference conditions using biological endpoint data from currently unimpaired segments or data from the period of time when a segment was unimpaired. Endpoints used in this determination included DO concentration and/or percent saturation, chlorophyll-a concentration, and the seagrass indicators: colonization depth, water clarity, coverage, and extent. Specifically, achievement of 20 percent of the surface light at the bottom of the water column is considered to be protective of seagrass communities and a chlorophyll-a concentration of 20 μg/L, not to be exceeded more than 10 percent of the time, is considered to be indicative of balanced algal populations. Taken with spatial attributes of seagrass indicators and Florida's DO criteria previously approved by EPA and applied by FDEP, EPA concluded that these endpoints are expected to indicate the health of the system as a whole and, at reference levels, represent conditions that protect aquatic life and recreation uses.

EPA determined that the reference condition approach applied reliable, vetted and representative data in calculating is estuarine standards. The EPA concluded that because the established NNC are associated with nutrient levels that are necessary to protect designated uses from harmful nutrient concentrations, the NNC approved by the EPA are NLAA for ESA-listed species or their designated critical habitat. The adoption of these standards and the EPA' s subsequent approval of them provide numeric levels that can be used in assessment and permitting.

2.4 BE for Turbidity limits under Florida's Joint Coastal Permit (JCP)

EPA's BE for NMFS in Regards to the Triennial Review Revisions to Rules 62-302, 62-303, and 62-4, F.A.C., dated April 2014 arrived at an NLAA determination for dredging of beach-quality sand from inlets and related channels, or restoration or nourishment of beaches and the use of offshore borrow areas (hereafter referred to as beach nourishment). The limits:

- Establish that the boundary of a mixing zone for such activities shall not be more than 1000 meters from the point of discharge into the waterbody.
- Additional standards for determining the appropriate size of a turbidity mixing zone for sediment plumes resulting from beach nourishment. These standards include:
    - Minimize the magnitude and duration of turbidity to the maximum extent practicable
    - Mixing zones shall be kept to the minimum size necessary to meet the turbidity standard
    - Mixing zones shall not encompass hard bottom communities, coral resources, or submerged aquatic vegetation beds outside of the authorized impact sites unless those areas are also evaluated as impact sites.

The original mixing zone standard specified in Subsection 62-4.244 (5) was specific to dredge and fill permits. It originally read: "*In no case shall the boundary of a dredge and fill mixing zone be more than 150 meters downstream in flowing streams or 150 meters in radius in other bodies of water*." Prior to the revision, no mixing zone limits had been identified by name for JCP-authorized beach nourishment at all and provisions for the protection of sensitive substrates were absent from the regulations at 62-304, F.A.C. However, with the current revisions and based on the supporting information provided by the State, EPA interpreted the revision as an expansion of the maximum allowable mixing zone distance to allow mixing zones greater than 150 meters in the case of beach nourishment, in addition to codifying the requirements necessary for protection of sensitive substrates.

In addition to these limits, the *Turbidity BE* evaluates approvals for Florida's clarifications that the water transparency standard reflects an annual mean not to be reduced more than 10 percent below natural background, clarification of the process for using biological assessment results (i.e., evaluate benthic macroinvertebrate community to determine ecological health) for removing a water from the verified list of impaired waters and a standard for the pesticide lindane. The lindane approval will be addressed in an upcoming triennial consultation and the clarifications of how existing standards would be implemented were determined to be "no effect."

Editorial changes such as that WQS apply to waters outside of mixing zones, were determined to have "no effect" on ESA-listed species. EPA has also not requested consultation on other EPA approvals where EPA's position is that it lacks discretionary involvement or control. These include those changes affecting anti-degradation and human health provisions for microbes and carcinogens.

2.5 The Coral Supplement

The *Supplement to Biological Evaluations for Florida 303(c) WQS actions Prepared for NMFS,* dated August 2015 evaluates EPA's extrapolation of conclusions regarding the effects of DO, turbidity, and nutrients on staghorn and elkhorn corals to effects on the five newly listed coral species found in Florida's waters. The opinion will refer to this BE as the Coral Supplement.

EPA's transmittal letter accompanying the Coral Supplement BE requested formal consultation with the ESA Interagency Cooperation Division with respect to the Likely to Adversely Affect determination for Florida's DO WQC revision and written concurrence from NMFS for its NLAA findings for the nutrient and turbidity provisions. Under the 2001 Memorandum of Agreement between EPA, USFWS, and NMFS, if the consulting agency concurs with EPA's determination, a concurrence letter will be transmitted within 30 days of its receipt of the EPA's NLAA determination. The ESA Interagency Cooperation Division' response reflected the intention to address the approvals together as a batched formal consultation. The batched consultation affords a clear and complete administrative record integrating EPA's BEs into a consolidated description of the approval and analysis of effects to ESA-listed species and designated critical habitat under NMFS' jurisdiction.

2.6 Action Area

The action area is defined 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). The action area would encompass the waters of the entire state of Florida and coastal waters for which standards have been approved in the action under consideration. EPA retracted a subset of estuary standards from the consultation (Table 2, yellow segments in Figure 2) as the state revised these standards to values allowing for higher TN, TP, or Chl-a concentrations than those originally approved.

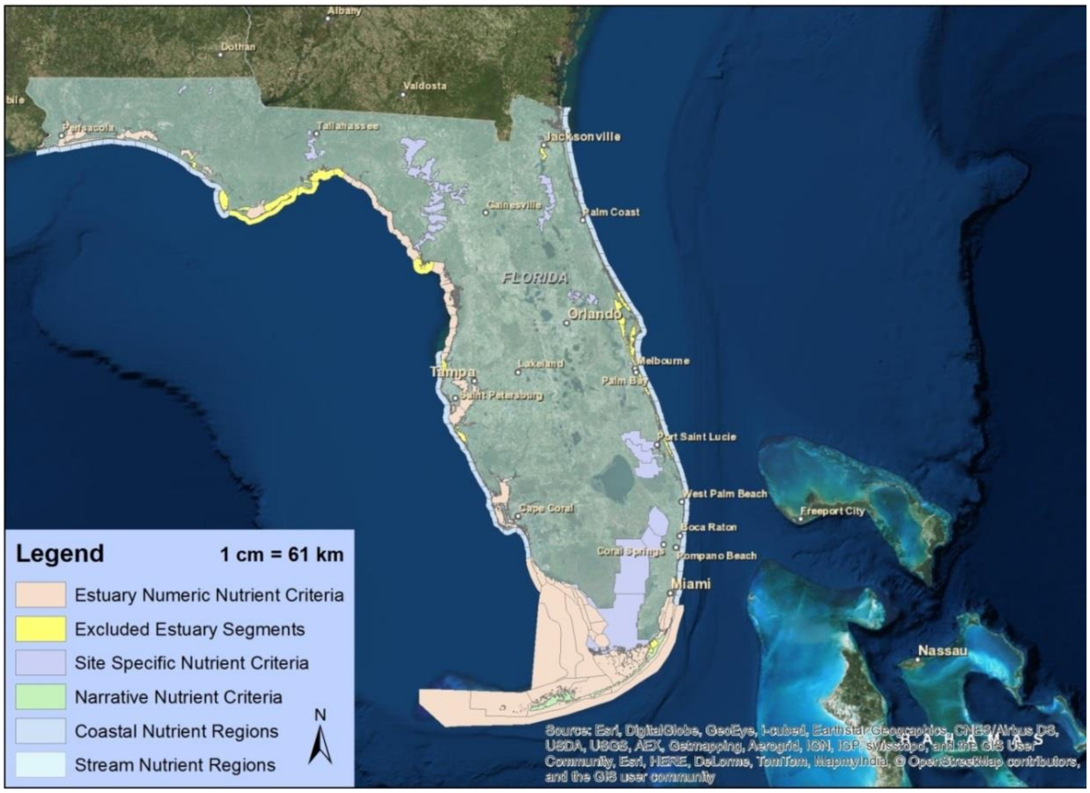

Figure 2. Extent of EPA's Action Area for the Approval of Florida Water Quality Standards.

During consultation, FDEP revised a number of the estuary NNCs and those that were made less conservative (i.e., allowing higher nutrient and Chl-a concentrations) were withdrawn from consultation pending EPA's determination on the effects of the revised criteria on ESA-listed species and designated critical habitat under NMFS' jurisdiction. The estuary segments excluded from the analysis are listed in Table 2. Importantly, the St. Johns and St. Marys Rivers that may be used by shortnose sturgeon and Atlantic sturgeon are among the excluded estuaries.

Table 2. Estuary Segments Excluded from the Analysis after Florida Department of Environmental Protection Revised NNC to Higher TN, TP, and/or Chl-a Concentrations.

St. Joseph Bay	
Alligator Harbor	Apalachicola Offshore
Big Bend and Apalachee Bay	
Aucilla Offshore	Steinhatchee River Estuary
Aucilla River Estuary	Ochlockonee River Estuary
Econfina River Estuary	Ochlockonee/Alligator Harbor Offshore
Fenholloway River Estuary	
Indian River Lagoon, Banana River Lagoon, and Mosquito Lagoon	
Banana River Lagoon	Mosquito Lagoon: Oak Hill to the Southern
Central Indian River Lagoon	Mosquito Lagoon: Ponce de Leon to Edgewater
Indian River Lagoon from Ft. Pierce Inlet to Indian River County Line	Mosquito Lagoon: Edgewater to Oak Hill
Indian River Lagoon from St. Lucie Estuary to Ft. Pierce Inlet	Newfound Harbor
Sykes Creek Estuary	North Indian River Lagoon
Indian River Lagoon	Sebastian River Estuary
Intracoastal Waterway	
Intracoastal Waterway Palm Coast	Intracoastal Waterway Palm Beach County
Lower St. Johns River and Tributaries (predominantly marine)	
St. Marys River	
Lower St. Marys River	Upper St. Marys River
Middle St. Marys River	
Loxahatchee River Estuary	
Loxahatchee River Estuary (Southwest Fork)	
St. Lucie Estuary	
St. Lucie Estuary proper	Upper North Fork St. Lucie River
Lower North Fork St. Lucie River	Upper South Fork St. Lucie River
Lower South Fork St. Lucie River"	Manatee Creek
St. Marks River Estuary	
St. Marks River Estuary proper	St. Marks Offshore (includes Dickerson Bay and Oyster Bay)

2.7 Interrelated and Interdependent Actions

The NMFS has not identified any additional interdependent or interrelated actions for EPA's approval of Florida's NNC, DO criteria, or Turbidity Limits.

3 OVERVIEW OF THE ASSESSMENT FRAMEWORK

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

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

Section 7 assessment involves the following steps:

1) We identify the proposed action and those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on the physical, chemical, and biotic environment within the action area, including the spatial and temporal extent of those stressors.

2) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time.

3) We describe the environmental baseline in the action area including: past and present impacts of Federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation, impacts of state or private actions that are contemporaneous with the consultation in process.

4) We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. We also consider whether the action "may affect" designated critical habitat. This is our exposure analysis.

5) We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.

6) We assess the consequences of the responses of individuals that are likely to be exposed to the populations or subpopulations those individuals represent. We also consider how the action may affect designated critical habitat. This is our risk analysis.

7) The adverse modification analysis considers whether the action causes "direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." 50 C.F.R. § 402.02.

8) We describe any cumulative effects of the proposed action in the action area. Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of

future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

9) We integrate and synthesize the above factors by considering the effects of the action within the action area on populations or subpopulations when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

    1) Reduce appreciably the likelihood of survival or recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or

    2) Appreciably diminish the value of designated critical habitat for the conservation of a listed species. These assessments are made in full consideration of the status of the species and designated critical habitat.

10) We state our conclusions regarding jeopardy and the destruction or adverse modification of designated critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives. See 50 C.F.R. § 402.14.

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of ISI Web of Science, Medline, and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. We also collected monitoring data and mapping layers from the NOAA, FDEP, International Union for Conservation of Nature, and Florida Fish and Wildlife Conservation Commission (FFWCC) websites. These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions about the likely risks to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3.1 Applying a Risk Assessment Framework to the Assessment in this Consultation

The action this opinion addresses is EPA's approval of NNC, DO criteria, and turbidity limits proposed by the State of Florida. This opinion integrates elements of EPA's ecological risk assessment framework (ERA-Framework, USEPA 1998) into NMFS' assessment approach. The assessment is organized in three phases:

1) Problem formulation: Examines the stressors of the action, the environmental baseline, and the status of the species in order to formulate risk hypotheses on how species may be affected by the action,

2) Analysis of exposure and response: For each risk hypotheses, the analysis of exposure and response determines whether the stressor exposure would result in adverse responses in individuals of ESA-listed species, and
3) Risk characterization: For those species and designated critical habitats with outcomes indicating one or more adverse responses, the risk characterization includes population-level effect analyses to determine if adverse responses of individuals are sufficiently large to affect population parameters (e.g., recruitment, reproductive rate), and analyses of effects to the physical and biological features of designated critical habitat. The risk characterization also characterizes the uncertainty in these determinations.

The *Environmental Baseline* and *Status of Listed Resources* formed the foundation of the *Problem Formulation* that framed the analyses. These two sections are again used for the *Integration and Synthesis*, which places the Risk *Characterization* in context of conditions represented by the *Environmental Baseline* and *Status of the Species*, then adds the *Cumulative Effects* of any state or private action to determine if the anticipated future conditions would jeopardize the continued existence of ESA-listed species or adversely modify designated critical habitat. See Figure 3 and the narrative that follows.

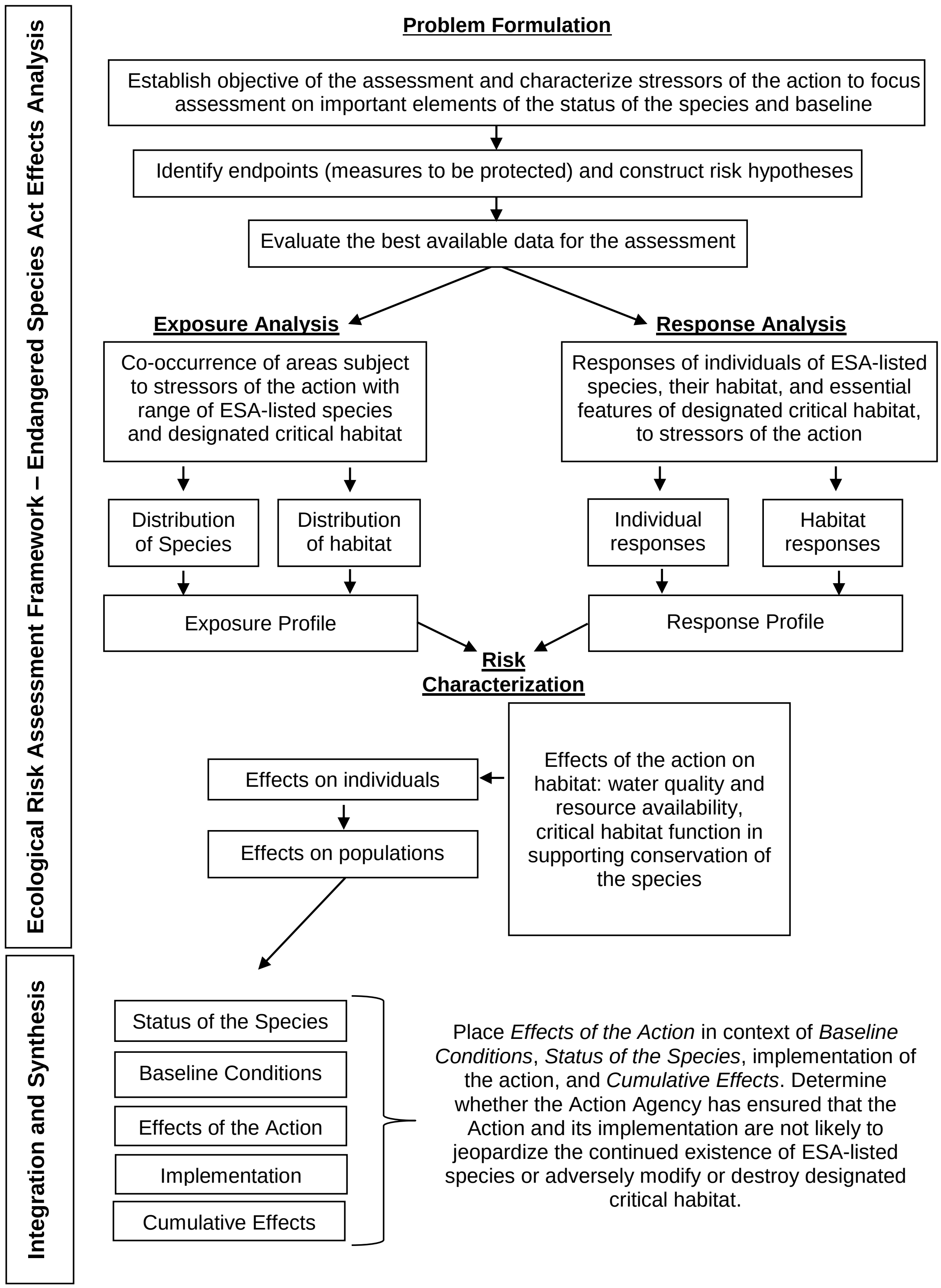

Figure 3. Process Diagram for the Ecological Risk Assessment – Endangered Species Act Effects Analysis Framework and Integration and Synthesis Used in this Opinion (adapted from USEPA 1998, USFWS and NMFS, 1998).

The actions that most ESA section 7 consultations consider involve the direct introduction of stressors, such as toxicants or disturbance activities. For these actions, identifying those species for which the action is NLAA due to lack of exposure occurs when the assessment establishes the overlap between the action area and the range and designated critical habitat for ESA-listed species. One portion of the action considered in this consultation, the approval of NNC, does not directly introduce stressors. The nitrogen, phosphorous, and algae the TN, TP, and Chl-a criteria are applied to are not directly harmful. These NNC, if inadequate, promote eutrophication, thus indirectly introduce stressors associated with eutrophy.

For eutrophication, the assessment must first identify areas with NNC that are anticipated to promote eutrophy before identifying which species will be exposed adverse effects caused by inadequate NNC. The TN, TP, and Chl-a NNC are intended to prevent or discourage eutrophication, and therefore the stressors that are associated with eutrophic conditions (see Section 4.1.1, Figure 5 and narrative). In order to determine whether the NNC adversely affect ESA-listed species, the exposure analysis must first determine whether any of the site-specific NNC support or promote eutrophication. Identifying those NNC that favor eutrophic conditions focuses subsequent analyses on areas at risk of eutrophication under their NNC and the ESA-listed species and designated critical habitat that occur in those areas. Due to the tiered analysis necessary to assess the NNC, all ESA-listed species that occur in Florida are carried forward in the NNC assessment until it is clear that they are not exposed to the adverse cascading effects of eutrophication.

For the turbidity limits, the exposure analysis first determines whether effects of individual actions on ESA-listed species will be addressed in section 7 consultation requested by the agency ultimately authorizing the actions, the USACE. The analysis must also determine whether ESA-listed species are anticipated to be exposed to aggregate impacts of multiple actions authorized by the USACE that would not be captured in site-level USACE consultations.

3.1.1 Effects Analysis

PROBLEM FORMULATION

Problem formulation provides an early identification of key factors to be considered, which in turn will produce a more scientifically sound assessment. It includes the first three steps in the NMFS *Approach to the Assessment*: identifying the scope of the action, its associated stressors, and aspects of the species and their environment that influence their vulnerability to stressors of the action. Problem formulation applies a planning and scoping process that establishes the goals, breadth, and focus of the assessment.

As a consultation on EPA's approval of state WQS, the stressors of the action, Nutrients, DO, and turbidity, are initially identified in the *Description of the Action* of this opinion. The scope of the action assessed and any associated policy and regulatory objectives are also defined within the *Description of the Action* (Section 2) identifying the areas to which the criteria are applied. The problem formulation in this opinion focuses the assessment by first characterizing how nutrients, DO, and turbidity limits affect organisms and water quality. This information is then combined with information on the environmental baseline and the status of ESA-listed species and their designated critical habitat that may be influenced by these water quality characteristics.

Once the stressors of the action are understood and how they adversely affect ESA-listed species and the environment in which they live, risk hypotheses may be formed. Risk hypotheses are statements that describe the relationships among stressor, exposure, and the assessment endpoint. For example, a risk hypothesis statement could be: The action will result in stressor x at exposure intensities resulting in reduced reproduction of species y. To test this hypothesis, the assessment might compare the concentrations of stressor x expected under the action to concentrations that affect the number of eggs produced by species y, or an appropriate surrogate species, if data specific to species y are not available.

This systematic planning phase is helpful in developing opinions that address the risks of multiple stressors to many species as well as risks to communities and ecosystems. This is particularly important for stressors that elicit adverse effects through multiple pathways (e.g., direct effects on mortality and growth and indirect effects such as decreased food supply or habitat compression).

Exposure and Response Analyses

The exposure and response analyses align with the fourth step of the *Approach to the Assessment*. For water quality, the duration and intensity of exposures associated with an action are central to an exposure analysis. The exposure analysis identifies the listed species and associated designated critical habitat that may occur in the same space and at the same time as the effects of the action.

The action area for this opinion encompasses the waters of the U.S. to which FDEP will apply the NNC and DO criteria, the turbidity limits. The TN, TP, and Chl-a nutrient criteria are estuary-specific indicators for eutrophication. Our exposure analysis will first determine whether these criteria support or promote eutrophication and its associated stressors and then focus the analysis on those at-risk areas and the ESA-listed species that occur in those areas. The water quality parameter DO is a direct stressor and will be evaluated in all areas where ESA-listed species under NMFS' jurisdiction occur. These analyses try to estimate the nature of co-occurrence through identifying the developmental stages of individuals that are likely to be exposed and the populations or subpopulations those individuals represent.

Unlike the NNC and Florida's DO criteria, the action related to turbidity that is the subject of this opinion does not specify acceptable ambient concentrations. Instead, EPA approved of limits for beach nourishment under Florida's JCP, along with additional protective measures to mitigate the effects of such activities. These permits are bundled by FDEP and submitted as a group to the USACE for authorization. Because the actual mixing zone and turbidity limits applied to these activities are determined by site-specific conditions and background levels, EPA's approval is not relatable to a stressor intensity that can be evaluated through risk hypotheses.

The JCP itself is a permitting program implemented by the State, and EPA's action approved only a portion of the requirements implemented for the beach nourishment. These are evaluated and authorized by the USACE. The exposure assessment will first identify whether and how projects to which the limits will apply are addressed in ESA section 7 consultations between NMFS and USACE when ESA-listed species under NMFS' jurisdiction are potentially affected. The exposure analysis will also evaluate the potential for exposures to aggregate impacts from iterative beach nourishment (i.e., periodically occurring in the same location) and impacts that may overlap (i.e., occurring nearby one another).

Following the exposure analysis, the response analysis evaluates how ESA-listed species are likely to respond given their probable exposure. The response analysis for the nutrient criteria will evaluate the relationship between stressors caused by eutrophication and anticipated responses of exposed individuals of ESA-listed species. The response analyses for the direct stressor DO will evaluate the relationship between the criteria and response thresholds in exposed individuals of ESA-listed species. If exposure to aggregate impacts of beach nourishment are expected, the response analysis for the turbidity limits would evaluate implications of EPA's mixing zone approval on ESA-listed species with respect to aggregate impacts of actions to which those standards are applied.

Use of Toxicity Data and EPA Water Quality Guidelines in this Biological Opinion

Data from toxicity tests and EPA's water quality guidelines for the protection of aquatic life (i.e., acceptable ambient stressor concentrations in surface waters recommended by EPA as protective of aquatic ecosystems) can be used to evaluate the implications of expected concentrations of stressors resulting from an action. These must be applied thoughtfully in an opinion because toxicity data do not necessarily reflect conditions in nature and the water quality guidelines for the protection of aquatic life are derived using a methodology intended to protect most aquatic ecosystems under most circumstances (Stephen et al. 1985). The guidance for the derivation of water quality guidelines states:

> "*Because aquatic ecosystems can tolerate some stress and occasional adverse effects, protection of all species at all times and places it is not deemed necessary for the derivation of a standard. If acceptable data are available for a large number of appropriate taxa from an appropriate variety of taxonomic and functional groups, a reasonable level of protection will probably be provided if all except a small fraction of the taxa are protected, unless a commercially or recreationally important species is very sensitive.*"

EPA's water quality guidelines, and state water quality criteria based on those guidelines, cannot be assumed to be protective of lethal and sublethal effects to threatened and endangered species. A number of studies proposed adjustment factors based on the sensitivity of threatened and endangered species relative to common laboratory species (Sappington et al. 2001, Besser et al. 2005, Dwyer et al. 2005a, Dwyer et al. 2005b). As generic adjustment factors, they do not account for how the loss of one individual of a particular ESA-listed species affects the persistence of the population it belongs to. For example, the implications of adjustment factors for ESA-listed corals differ from implications for Atlantic sturgeon.

In addition, laboratory studies used to derive the guidelines do not address many sublethal responses that are important to survival of individuals in the wild such as swimming speed, predator/prey detection, and predator avoidance. Most chronic toxicity data studies were designed to identify the tested concentration that does not differ significantly from the control (i.e., NOEC), and the lowest tested concentration that does differ significantly from the control (i.e., LOEC). The resulting chronic values and their biological relevance are highly dependent on the statistical resolution provided by the study design. A study with few exposure concentrations and few replicates may only have the statistical power to result in a NOEC reflecting a 30 percent decline in reproduction or growth in the tested species. As a result, a relatively high underlying “level of effect” may be associated with NOECs, LOECs, and the associated "Minimum Acceptable Toxicant Concentration" which are the geometric mean of the NOECs and LOECs. For example, Suter et al. (1987) reported that the calculated Minimum Acceptable Toxicant Concentrations for fish fecundity, on average, corresponded to a 42 percent level of adverse effect. Some workers addressed these shortcomings by using regression to calculate point estimates, such as the EC10, where such data are suitable. This approach must be used with caution because, if applied to a dataset with few exposure concentrations and a high amount of variability, the estimate will be bounded by a large confidence interval that must also be taken into consideration when evaluating effects.

For reasons stated above, toxicity data and EPA water quality guidelines must be applied carefully in this opinion. Where they can be applied, they are useful for:

- For toxicity data: Evaluating effects on ESA-listed species using toxicity data for taxonomically related surrogate species, taking into consideration the magnitude of effect reported by the study and the implications of such responses in the wild.
- For water quality guidelines: Evaluating indirect effects to ESA-listed species through effects to prey species and species providing habitat, provided data produced after a guideline's development do not suggest the guideline need adjustment; and
- For toxicity data and water quality guidelines: Identifying exposures that would be harmful to most exposed species. For example, when the anticipated exposure exceeds a water quality guideline by orders of magnitude or exceeds exposures where significant effects were observed in multiple laboratory tests.

RISK CHARACTERIZATION

Risk Characterization integrates the exposure and response analyses to assess the risk to listed species and their designated critical habitat from the stressors or stressful conditions associated with the action. This aligns with the sixth and seventh step of the NMFS *Approach to the Assessment*: assess the implications of these responses on exposed populations or subpopulations and the impacts of the proposed action on the designated critical habitat features and conservation value of designated critical habitat. The purpose of risk characterization is to determine whether effects to a population or subpopulation are anticipated based on the principle that the growth, decline, or stability is determined by the fate of the individuals that comprise them. Populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). The risk characterization is ultimately a qualitative assessment that draws on the best available quantitative and qualitative evidence from the exposure and effects analyses, taking the uncertainties, assumptions, and strengths and limitations of these analyses into consideration.

Risk characterization for this opinion starts by evaluating whether water quality conditions resulting from the TN, TP, Chl-a, DO, and the turbidity limits for the beach nourishment approved by EPA are likely to influence the survival or fitness of individuals of species that are listed as threatened or endangered under the ESA. If we determine that individuals of listed species are *not* likely to experience reductions in their fitness, we would conclude our assessment of jeopardy, because an action that is not likely to affect the fitness of individuals is not likely to jeopardize the continued existence of listed species. If, however, we determine that individuals of listed species are likely to experience reductions in their fitness, we then need to determine if those fitness reductions are likely to be sufficient to reduce the viability of the populations those individuals represent. This is evaluated by estimating anticipated changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks.

Risk characterization for species' designated critical habitat focuses on the effects of the action on the physical and biological features that are essential to the conservation of the species. Designated critical habitat designations frequently include prey availability and suitability, substrate, and water quality among primary characteristics to be protected. This includes measured and anticipated responses within aquatic communities responding to WQS limits (i.e., at the allowable level under the WQS). For example, in the absence of other stressors contributing to a biological impairment, instances of biologically impaired water bodies meeting WQS would suggest the WQS are not protective.

CUMULATIVE EFFECTS

Cumulative effects, the seventh step in the NMFS *Approach to the Assessment* include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

3.1.2 Integration and Synthesis

Integration and synthesis of risk posed by the *Effects of the Action* with current (i.e., *Environmental Baseline* and *Status of Listed Resources*) and anticipated conditions (i.e., *Cumulative Effects*) is used to determine whether the action and its implementation is likely to jeopardize the continued existence of endangered or threatened species or destroy or adversely modify designated critical habitat. Approval of Florida's Criteria for DO and NNC and Turbidity Limits by EPA results in actionable thresholds that the state uses to maintain water quality conditions by determining pollutant discharge permit limits and identifying conditions that require intervention in order to restore or maintain water quality that supports aquatic life. Integration and synthesis of risks in this opinion evaluates whether these standards are protective of ESA-listed species and designated critical habitat, taking into consideration how FDEP will be implementing the standards.

4 EFFECTS ANALYSIS

4.1 Problem Formulation

As described in the *Approach to the Assessment*, the problem formulation in this opinion first characterizes potential stressor pathways for the water quality parameters for which EPA has approved standards. Problem formulation then uses this information to focus the assessment on those aspects of the status of the species and their designated critical habitat and baseline conditions (e.g., natural and human influenced biogeochemistry of Florida ecosystems) that may be affected by the implementation of these standards. Taken together, this information is used to identify appropriate endpoints for the response analysis and construct risk hypotheses that will integrate exposure and response during risk characterization.

4.1.1 Stressors of the Action

The water quality criteria and turbidity limits developed by Florida, and approved by EPA, are for natural constituents of surface waters that, when higher or lower than natural levels, can introduce stress and alter aquatic communities. The NNC and DO criteria are intended to prevent adverse water quality conditions in order to support natural populations of aquatic flora and fauna. TP and TN encompass all forms of nitrogen and phosphorus that may be present in a water body. Plants and microbes require nitrogen and phosphorus for growth and reproduction. The nutrient criteria approved by EPA are expressed as TP and TN, which may include dissolved organic, dissolved inorganic, or particulate forms of nitrogen and phosphorus. Transformations among these forms depend on environmental conditions such as pH, temperature, and DO.

Aquatic organisms require DO to generate the energy needed for life processes and DO is consumed during decomposition of organic detritus. Florida's DO criteria are expressed in terms of percent saturation, which is the amount of oxygen actually dissolved in water relative to the amount of oxygen potentially dissolved in water, given ambient conditions. Florida's DO criteria are expressed as percent saturation rather than milligrams per liter to reflect anticipated DO variability and lower acceptable limits under fluctuating reference conditions on a regional and waterbody-specific basis. Consumption of DO, expressed as biological oxygen demand or chemical oxygen demand, is used as an index of water pollution and wastewater treatment efficiency. The solubility of oxygen in water is affected by temperature, salinity, turbulence, and pressure (i.e., depth). Seasonal fluctuations in water temperatures also influence pH and the capacity of water to retain DO, with colder temperatures increasing these values. DO can also be expressed as mg/L without regard to factors influencing oxygen solubility.

Turbidity is a measure of the ability of light to penetrate the water column. The turbidity limits apply to the beach nourishment and are set relative to background turbidity. The Specifically, water transparency is not to be reduced more than 10 percent below natural background as annual means. The amount of total suspended solids (TSS), that is to say, suspended inorganic and organic particles (i.e., sediment), algae, and microbes, is the primary source of turbidity. Suspended and bedded sediment naturally occur in aquatic systems. Sediment provides substrate for aquatic plants and sediment-dwelling (benthic) animals, plankton and organic particles are consumed by filter feeders, and sediments act as both reservoir and source for nutrients and minerals in biogeochemical cycles. Degree of eutrophy, inputs from land, water turbulence, and erosivity influence the amount of material suspended in the water column. Turbidity measures can also express water clarity in terms of depth of visibility for a secchi disc or light transmission as measured in nephelometric or similar units depending on the meter used. These measures are not readily interconvertible and none of these measures identify the actual components contributing to the turbidity.

The following models and narratives describe fundamental ecological principles of how adverse nutrient, DO, and turbidity conditions can affect aquatic life. The information is adapted from two sources, Dodds (2002) and the stressor profiles found on EPA's Causal Analysis Decision/Diagnostic Information System (http://www3.epa.gov/caddis/ssr_definitions_str.html). The models follow a schema that relates the pathway to adverse biological responses through modes of action, intermediate states, and proximate stressors. Modes of action for these models are processes, such as photosynthesis or sedimentation, that result in a change in environmental state. Intermediate states are the conditions, such as increased plant biomass or bedded sediment, resulting from such processes. Proximate stressors are the actual toxicants, physiological stressors, or resource limitations most directly linked to a biological response. The models share a section reflecting the interdependence of species (generalized in Figure 4). Conditions that directly affect organism survival and lifecycle processes (i.e., effects to growth, fecundity, and recruitment) can also affect the survival and lifecycle processes of prey species and the quality of the non-biological habitat properties (e.g., suitable temperature, substrate, water clarity).

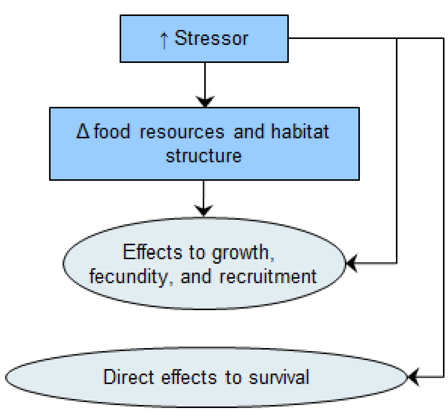

Figure 4. Direct and Indirect Effects of Stressors Due to the Interdependence of Species.

The discussion of how these water quality characteristics affect organisms and their habitat begins with nutrients. Because DO and turbidity are influenced by nutrients, these are initially discussed in context of nutrients in order to fully describe the pathways for this important aquatic cycle. Separate, more detailed discussions of DO and turbidity follow the discussion of nutrients.

NUTRIENTS

Under natural conditions, essential nutrients contribute to the proper structure and function of healthy ecosystems. However, in excessive quantities, nutrients can have adverse effects on ecosystems, and nutrient enrichment, which leads to eutrophication, often ranks as one of the top causes of water resource impairment (Bricker et al. 2008, USEPA 2014).

Eutrophication alters the composition and species diversity of aquatic communities through intensifying competition by those species, native or invasive, that are better adapted to eutrophic environments (Nordin 1985, Welch et al. 1988, Carpenter et al. 1998, Smith 1998, Smith et al. 1999). In some cases, it may result in ESA-listed species experiencing increased mortality from competitors. Thus, eutrophication can have cascading effects that change ecosystem structure at numerous trophic levels. Nuisance levels of algae, as indicated by Chl-a levels, and other aquatic vegetation (macrophytes) can develop rapidly in freshwater and marine habitats in response to nutrient enrichment when other factors (e.g., light, temperature) are not limiting. The relationship between nuisance algal growth and nutrient enrichment has been well-documented (e.g., Welch et al. 1992, VanNieuwenhuyse and Jones 1996, Dodds et al. 1997, Chetelat et al. 1999). In addition to outcompeting native aquatic plants for space and light, the proliferation of nuisance algae can lead to the occurrence of harmful algal blooms (e.g., brown tides, toxic *Pfiesteria piscida* outbreaks, some types of red tides) which contain microalgae that produce potent toxins. Symptoms from toxin exposure range from neurological impairment to gastrointestinal upset to respiratory irritation, and sometimes result in severe illness and death (Lopez et al. 2008). In marine systems, algal toxins have caused massive fish kills, along with deaths of whales, sea lions, dolphins, manatees, sea turtles, birds, and wild and cultured fish and invertebrates (Landsberg 2002, Shumway et al. 2003). Eutrophication is believed to be a likely contributor to the increased occurrence of harmful algal blooms (Heisler et al. 2008). In addition to its association with harmful algal blooms and algal toxins, eutrophication has also been linked to increases in bacteria biomass (Carr et al. 2005). Bacteria have been associated with mortality among fish, turtles, and alligators (Shotts et al. 1972). There has been an increase in the number of unusual marine mammal mortality events reported in the U.S. and this is believed to be associated with the increasing occurrence of harmful algal blooms. The timing of the blooms and strandings of marine mammals suggests that species that forage both inshore and offshore can be affected. NOAA’s Marine Mammal Health and Stranding Response Program is finding more mammal stranding events to be linked to biotoxins (Gulland and Hall 2007, de la Riva et al. 2009).

The accumulation of algal biomass through excessive productivity can reduce available habitat, and the decay of this organic matter may lead to reductions in DO in the water, which in turn can cause problems such as fish kills and release of toxic substances or phosphates that were previously bound to oxidized sediments (Chorus and Bartram 1999). High biomass blooms of toxic and nontoxic algae resulting from excess nutrients or eutrophication is a common type of event that can cause hypoxia or anoxia (low or no DO), which suffocates fish and bottom-dwelling organisms and can sometimes lead to hydrogen sulfide poisoning (Lopez et al. 2008). Hypoxia can cause habitat loss, long-term weakening of species, change in species dynamics and even fish kills. Because hypoxia often occurs in estuaries or near shore areas where the water is poorly mixed, nursery habitat for fish and shellfish is often affected. Without nursery grounds the young animals cannot find the food or habitat they need to reach adulthood. This causes years of weak recruitment to adult populations and can result in an overall reduction or destabilization of important stocks. High biomass blooms can also directly inhibit growth of beneficial vegetation by blocking sunlight penetration into the water column (Onuf 1996). For example, an excessive accumulation of filamentous benthic algae or other macrophytes during the peak summer growing season can alter stream flow as well as the availability of benthic habitat for stream invertebrates and vertebrates (Welch et al. 1989, Chessman et al. 1992). Macroalgal blooms reduce sunlight penetration and can overgrow or displace seagrasses and corals as well as foul beaches (Valiela et al. 1997). Bloom-inflicted mortalities can degrade habitat quality indirectly through altered food webs or hypoxic events caused by the decay of dead animals (Lopez et al. 2008).

The stressor-to-response pathways for the direct and indirect effects of excess nutrients are described in Figure 5. Excess nutrients accelerate the production and turnover of plant and algal biomass and alter plant species composition. Aquatic plants and microbes require N and P for growth and reproduction. Given adequate light, photosynthesis converts carbon dioxide into biomass growth of macrophytes, periphyton, and phytoplankton. The consumption of carbon dioxide also generates oxygen and increases water pH. The breakdown of plant and algal biomass is mediated by microbes which consume oxygen during respiration and release carbon dioxide, lowering pH. Plants also respire and consume oxygen, but photosynthesis during the day generates more oxygen than consumed. When photosynthesis pauses at night time, plant respiration and microbial decay continues, resulting in a diurnal cycle of peak DO and pH during daylight hours and lowest DO concentrations and pH observed pre-dawn. In addition, direct toxic effects can occur in waters with elevated nitrogen in the form of ammonia, with the more toxic form ammonium more prevalent at high pH. In addition to the potential for ammonia toxicity under high nutrient loadings, toxins may also be produced by some algae that thrive in eutrophic conditions. Accumulation and increased turnover of algal and plant biomass (i.e., death, decay, nutrient release) generates suspended solids in the form of organic particulates and phytoplankton, contributing to turbidity from natural and human-caused erosion and sediment resuspension. Increased turbidity affects light penetration into the water column and the ability of aquatic plants to photosynthesize and survive and the effectiveness of sight-dependent behaviors such as foraging by sight feeders, reproductive displays, and predator evasion. This, in turn, affects the degree of coverage of the substrate by plants and benthic organisms that are reliant on plants. Suspended organic matter can eventually accumulate upon and smother plants, animals, and benthic habitat surfaces. Increases in plant and microbial biomass or productivity may result in negative ecological effects by:

- altering food resources: the amount and type of food resources or their palatability (e.g., changes in algal cell size affects filter-feeding animals);
- increased microbial infection of invertebrates or fish;
- altering habitat: light penetration, diurnal DO cycle, changes in benthic interstitial space, availability of macrophytes as habitat;
- stimulating generation of toxins: some algae that thrive in eutrophic conditions can be toxic to fish and invertebrates;
- increasing mortality through favoring nitrogen pathways increasing the formation of toxic unionized ammonia; and
- changes in community structure, even without overall increases in primary producers, due to alterations of nutrient availability ratios.

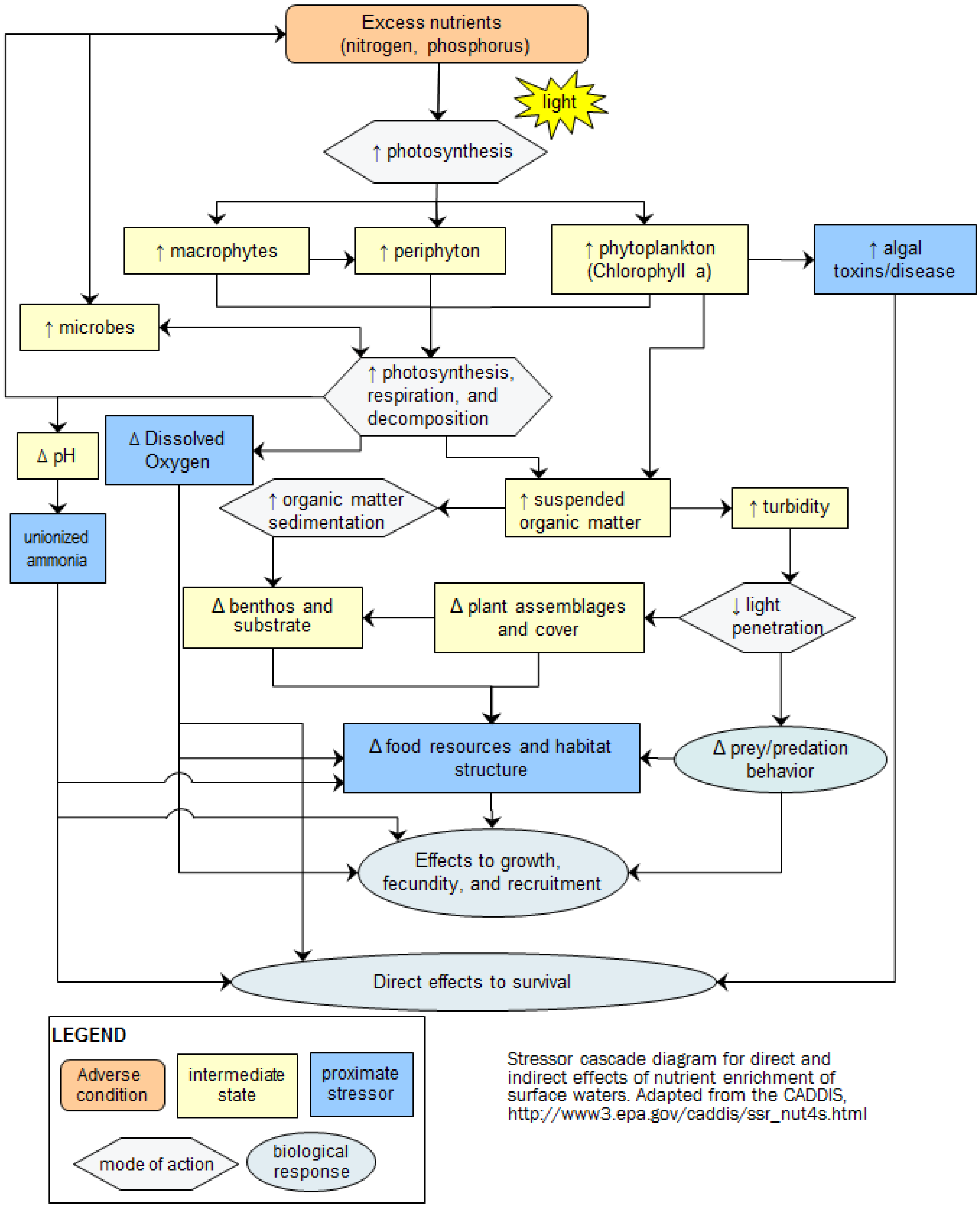

Figure 5. Direct and Indirect Effects of Excess Nutrients on Biological Responses.

DO

Oxygen is essential in aerobic organisms for the electron transport system of mitochondria. Oxygen insufficiency at the mitochondria results in reduction in cellular energy and a subsequent loss of ion balance in cellular and circulatory fluids (USEPA 2000). If oxygen insufficiency persists, death will ultimately occur, although some aerobic animals also possess anaerobic metabolic pathways, which can delay lethality for short time periods (minutes to days). Anaerobiosis is well developed in some benthic animals, such as bivalve mollusks and polychaetes, but not in other groups, like fish and crustaceans (Hammen, 1976 after EPA 2000).

Elevated loadings of organic material can increase levels of oxygen-demanding substances in receiving waters thus lowering DO in the water. Chemical oxygen demand is a measure of the oxygen-consuming capacity of inorganic and organic matter present in wastewater. Microbes aerobically break down the organic compounds. Elevated oxygen demand can lower DO levels in surface water, leading to several of the impacts associated with nutrient- derived or organic chemical caused oxygen depletion discussed previously. If DO concentrations are reduced sufficiently, pollutants such as phosphorus, aluminum and iron are released from sediments in the streambed (Kim et al. 2003). Excess phosphorus in the water column can cause algal blooms, developing an oxygen-depleting cycle that can cause harm to fish. Conversely, accelerated photosynthesis or extreme turbulence and subsequent aeration of water can supersaturate water with DO. Fish in water supersaturated with oxygen can suffer from gas bubble disease, which involves tissue embolism and disruptions in buoyancy.

The stressor-to-response pathways for direct and indirect effects of oxygen imbalance are described in Figure 6. Most aquatic organisms are dependent upon oxygen dissolved in the water column for survival. Oxygen depletion may be caused by biomass turnover, inputs of oxygen demanding substances, or inflow of oxygen-depleted groundwater. Oxygen depletion affects organisms through respiratory stress due to insufficient oxygen. If organisms cannot move and avoid unfavorable DO conditions, direct mortality can result. Avoidance behaviors can influence growth, fecundity and recruitment as organisms expend energy seeking more favorable environments and under circumstances where the amount of habitable space is reduced. Adverse DO conditions affecting food resources in an area, through direct mortality or avoidance by prey affects growth, fecundity, and recruitment.

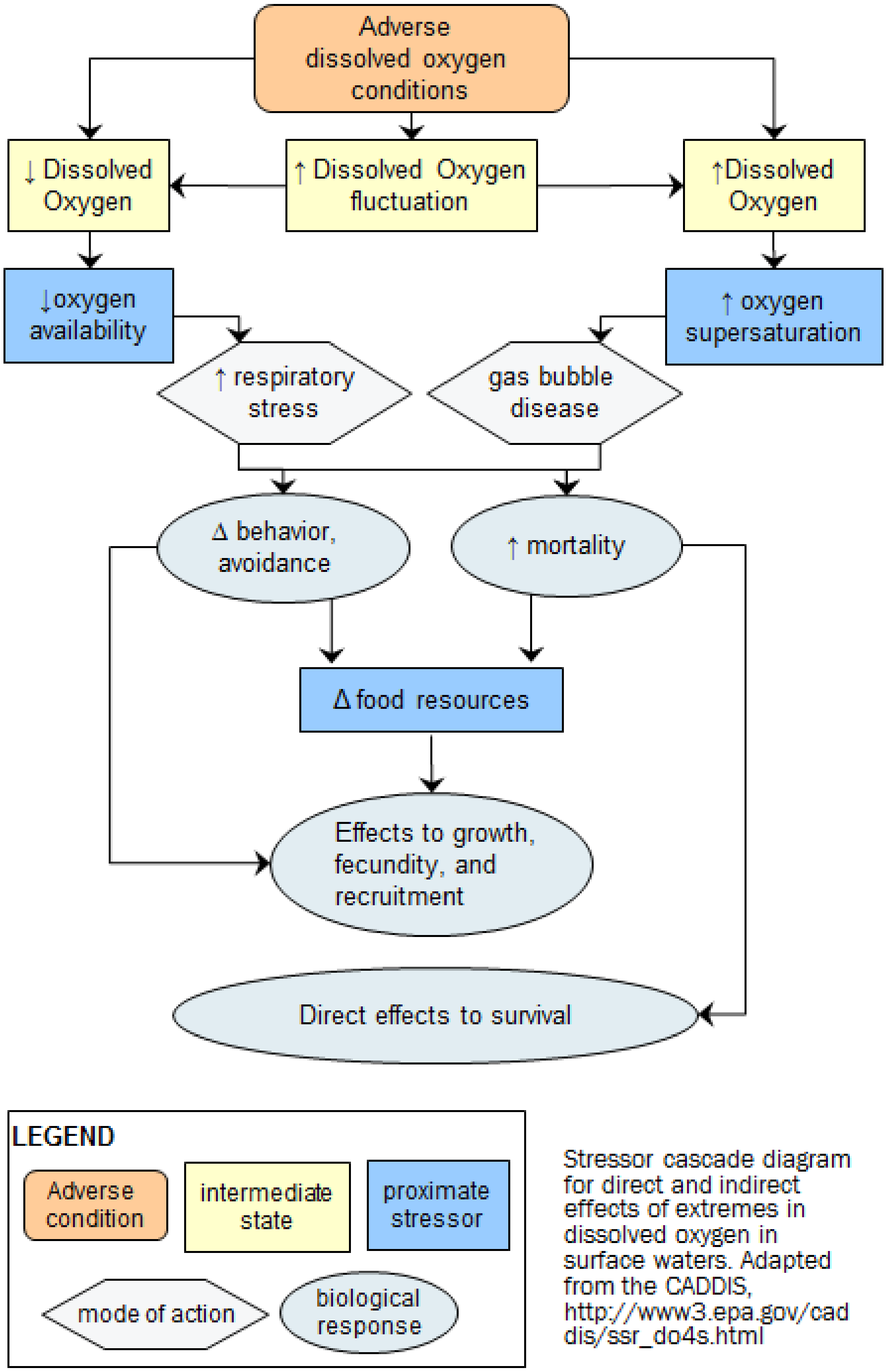

Figure 6. Direct and Indirect Effects of Adverse DO Conditions on Biological Responses.

TURBIDITY

As described previously, turbidity is a measure of the ability of light to penetrate the water column. The stressor-to-response pathways for the direct and indirect effects of turbidity are summarized in Figure 7. The amount of TSS, that is to say, suspended inorganic and organic particles (i.e., sediment), algae, and microbes, is the primary determinant of turbidity. Suspended and bedded sediment naturally occur in aquatic systems, sediment provides substrate for aquatic plants and sediment-dwelling animals, serves as a food source for filter feeders, and acts as both reservoir and source for nutrients and minerals in natural biogeochemical cycles. Excess amounts of suspended sediments affect the survival of fish, freshwater mussels, and other benthic organisms. In a frequently cited review paper prepared by Newcombe and Jensen (1996), sublethal effects (e.g. increased respiration rate) were observed in eggs and larvae of fish when exposed to TSS concentrations as low as 55 mg/L for one hour. Increased turbidity can reduce primary productivity of algae as well as growth and reproduction of submerged vegetation (Jha and Swietlik 2003). TSS influence macrophytes and algae primarily through affecting the amount of light penetrating through the water column (Bilotta and Brazier 2008). The reduction in light penetration through the water column will restrict the rate at which periphyton and emergent and submersed macrophytes can assimilate energy through photosynthesis, which could impact primary consumers. Excessive amounts of suspended sediment that settles onto substrate will smother benthic organisms. In addition, once in the system, sediment resuspension and deposition can "recycle" sediments so that they exert water column and benthic effects repeatedly over time and in multiple locations.

Sediment particles themselves act as proximate stressors through clogging the intake and filtering organs of filter feeders and through abrading and damaging the gills and filter feeding structures (Lowe et al. 2015). Depending on severity, abrasion and tissue damage by suspended sediment particles can directly affect survival or impair an organism's ability to fulfill lifecycle processes (e.g., recruit, grow, reproduce). Lifecycle processes require organisms to have adequate food intake. Turbidity effects on filter feeding and predation, whether though tissue damage or altered behavior and efficiency, affects both organisms and their food base. In the wild, mobile organisms are expected to avoid entering or remaining in areas with turbidity levels causing such effects.

Suspended sediment and sediment deposition act to limit coral growth, feeding patterns, photosynthesis, recruitment, and survivorship. Reductions in long-term water clarity can also reduce the coral photosynthesis to respiration ratio. Telesnicki and Goldberg (1995) and Yentsch et al. (2002) found that elevated turbidity levels did not affect gross photosynthetic oxygen production, but did lead to increased respiration that consumed the products of photosynthesis with little remaining for coral growth. Excessive sedimentation can smother corals and increased nutrient availability promotes algal growth on corals, leading to light blockage to zooxanthellae and death of corals (*Acropora* Biological Review Team 2005).

In summary, high suspended sediment concentrations, whether resulting from construction activities, agricultural activities, stormwater erosion, shoreline and bank erosion, or other stressors can adversely affect aquatic organisms through:

- impairment of filter feeding, by filter clogging or reduction of food quality;
- reduction of light penetration and visibility, affecting foraging ability of visually-cued predators and prey, and reducing photosynthesis, growth, and survival of submerged aquatic plants, phytoplankton, and periphyton;
- physical abrasion by sediments, which may scour food sources (e.g., algae) or directly abrade exposed surfaces (e.g., gills) of fishes and invertebrates; and
- increased heat absorption, leading to increased water temperatures.

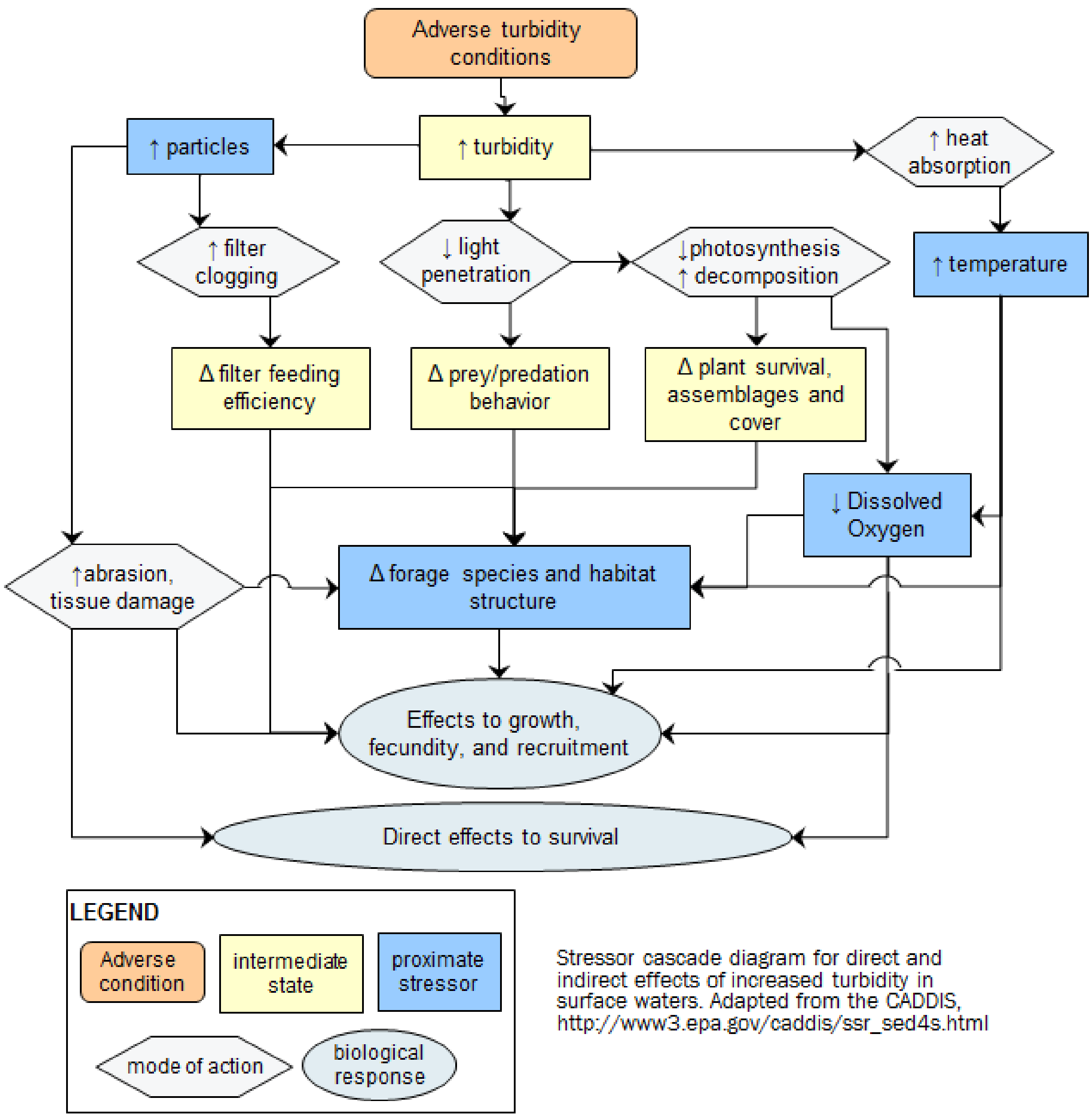

Figure 7. Direct and Indirect Effects of Adverse Turbidity Conditions on Biological Responses.

4.1.2 Status of Species Listed as Endangered or Threatened under the Endangered Species Act (ESA) and Designated Critical Habitats in the Action Area and Under the Jurisdiction of the National Marine Fisheries Service (NMFS)

One cetacean, five sea turtle species, five species of fish, seven coral species, and one plant species inhabiting Florida waters that are listed as threatened or endangered are under NMFS' jurisdiction (Table 3). Designated critical habitat for four of these species (north Atlantic right whale, loggerhead sea turtle, smalltooth sawfish, and Johnson's seagrass) occurs in Florida waters.

Table 3. Endangered and Threatened Species and Designated Critical Habitat Under NMFS' Jurisdiction that Occur in Florida Waters.

Species	ESA Status	Designated critical habitat	Recovery Plan
Cetacean			
North Atlantic right whale (*Eubalaena glacialis*)	E – 35 FR 18319 & 73 FR 12024	63 FR 46693	70 FR 32293
Sea Turtles			
Green Turtle (*Chelonia mydas*)	E – 43 FR 32800	63 FR 46693	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	75 FR 12496
Leatherback Turtle (*Dermochelys coriacea*)	E – 61 FR 17	44 FR 17710	63 FR 28359
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic DPS	E – 76 FR 58868	78 FR 39856	63 FR 28359
Fish			
Smalltooth sawfish (*Pristis pectinata*)	E – 68 FR 15674	74 FR 45353*	74 FR 3566
Shortnose sturgeon (*Acipenser brevirostrum*)	E – 32 FR4001	-- --	63 FR 69613
Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) South Atlantic DPS	E – 77 FR 5914	-- --	81 FR 36077 (proposed)
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	T – 56 FR 49653	68 FR 13370	1995
Nassau grouper (*Epinephelus striatus*)	T – 81 FR 42268	-- --	biological report
Corals			
Elkhorn Coral (*Acropora palmata*)	T – 71 FR 26852	73 FR 72210	-- --
Staghorn Coral (*Acropora cervicornis*)	T – 71 FR 26852		-- --
Rough Cactus Coral *(Mycetophyllia ferox)*	T – 79 FR 54122	-- --	-- --
Pillar Coral (*Dendrogyra cylindrus)*	T – 79 FR 54122	-- --	-- --
Lobed Star Coral *(Orbicella annularis)*	T – 79 FR 54122	-- --	-- --
Mountainous Star Coral (*Orbicella faveolata)*	T – 79 FR 54122	-- --	-- --
Boulder Star Coral (*Orbicella franksi)*	T – 79 FR 54122	-- --	-- --
Marine Plant			
Johnson's Seagrass (*Halophila johnsonii*)	T – 63 FR 49035	65 FR 17786*	2002

*Designated critical habitat occurs in Florida

The status for each species is discussed in the sections that follow with particular emphasis on aspects that may be influenced by Florida's water quality criteria for nutrients, DO, and turbidity. Greater detail on species life history and status are available in the recovery plans and status reports for each species through the NMFS' Office of Protected Resources website: http://www.nmfs.noaa.gov/pr/species/esa/listed.htm. This opinion applied the most recent recovery plans and status reports available at the time it was written. Note that recovery plans and status reports are periodically updated, so this content is not readily transferable to future assessments. While the following discussions focus on the use of Florida waters by these species, consideration was also given to the status of populations outside of the action area, which is important for evaluating how the risk to affected population (s) impacts the status of the species as a whole.

CETACEAN: NORTH ATLANTIC RIGHT WHALE

Description. The north Atlantic right whale is a stocky black bodied baleen whale. They weigh to up to 70 tons (140,000 lbs; 63,500 kg) with a length of about 50 feet (15 m). Calves are about 14 feet (4.2 m) at birth. The limited data available suggests that the life span of right whales is about 50 years.

Status. The Northern right whale was originally listed as endangered in 1970 (35 FR 18319).The western North Atlantic minimum stock size is based on a direct count of individual whales identified using photo-identification. The 25 October 2013 review of the photo-ID recapture database identified 465 individually recognized whales that were known to be alive during 2011. This number represents a minimum population size. The minimum population size calculated from the sightings database for the years 1990-2010 suggests a positive and slowly accelerating increase in population size.

Use of Florida Waters. North Atlantic right whale calving occurs from December through March in the coastal waters off Georgia and northern Florida. After calving, the adult females and calves migrate to northern feeding areas off the northeast U.S. and Canada. Most of the population, particularly the males and non-pregnant females, are not found in the calving area and may not follow this pattern (Morano et al. 2012). This species fasts during the winter and feeds during the summer, so the action is not expected to affect forage for this species.

Threats. Shark predation has been repeatedly documented on right whale calves along the southeastern U.S., some of which may be fatal (Taylor et al. 2013). Mortality or debilitation from infection or disease and red tide events are not known, but have the potential to be significant problems in the recovery of right whales because of their small population size. Historically, whaling was responsible for listing right whales as an endangered species. Currently, ship strikes and entanglement in commercial fishing gear pose the greatest threat to North Atlantic Right Whales. Infection of entanglement wounds can compromise health. Three quarters of 447 individuals examined between 1980 and 2002 showed scarring from fishing gear (Waring et al. 2013). Deaths of females are especially deleterious to the ability of the North Atlantic right whale population to recover. For instance, in 2005, ship strike mortalities included six adult females, three of which were carrying near-term fetuses and four of which were just starting to bear calves, thereby representing a lost reproductive potential of as many as 21 individuals over the short term (Kraus et al. 2005).

Climate-change associated shifts in calving intervals with sea surface temperature have already been documented for southern right whales (Leaper et al. 2006). The contribution of climate change to increased frequency of algal blooms was associated with the annual Southern right whale calf deaths. The calf deaths began in 2005 and strongly correlated with Harmful Algal Blooms (HABs). Calf death rates jumped from fewer than six per year prior to 2005 up to an average of 65 per year between 2005 and 2014. Exposure to algal toxins potentially occurred during gestation, by maternal transfer in milk or direct feeding. (Wilson et al. 2015). The NNC under review in this opinion that may influence the exposure of the North Atlantic right whale to HABs are the coastal Chl-a standards.

North Atlantic right whales are exposed to toxic pollutants in their environment. Levels of chromium in North Atlantic right whale tissues are sufficient to be mutagenic and cause cell death in lung, skin, or testicular tissues (Wise et al. 2008, Chen et al. 2009). Flame retardants such as polybrominated diphenyl ethers (known to be carcinogenic) have also been detected in North Atlantic right whales (Montie et al. 2010). Mean PCB levels in North Atlantic right whales are greater than any other baleen whale species thus far measured (Van Scheppingen et al. 1996, Gauthier et al. 1997). Persistent pesticides and pesticide metabolites have been isolated from blubber samples (Woodley et al. 1991). The implication of these substances on the health and fitness of individuals is uncertain. Pesticides, although variable in concentration by season, do not appear to threaten North Atlantic right whale health and recovery (Weisbrod et al. 2000).

Designated critical habitat. In June of 1994, three designated critical habitat areas were designated for North Atlantic right whale feeding and calving (59 FR 28805). The designated critical habitats for feeding cover portions of the Great South Channel (east of Cape Cod), Massachusetts Bay and Cape Cod Bay, and Stellwagen Bank. The designated critical habitat area protecting calving and breeding grounds is along Georgia and northeastern Florida coasts (Figure 8). These whales calve and breed in shallow coastal waters. This designated critical habitat has generally fared better than northern designated critical habitat and significant degradation has not been clearly identified (Keller et al. 2012).

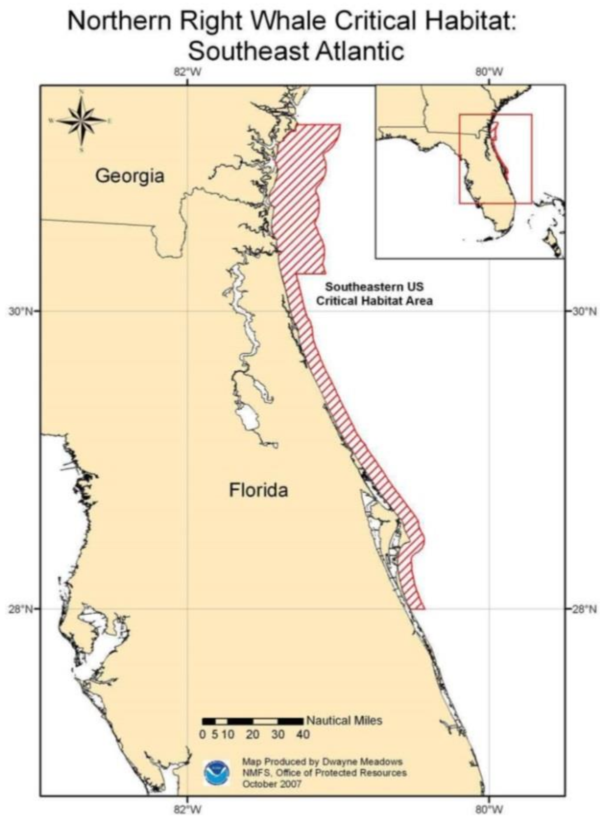

Figure 8. North Atlantic Right Whale Designated Critical Habitat along Georgia and Northeastern Florida Coasts.

SEA TURTLES

A number of threats are common to all sea turtles.[3] Predation is a primary natural threat. While cold stunning is not a major concern for leatherback sea turtles, which can tolerate low water temperatures, it is considered a major natural threat to other sea turtle species. Disease is also a factor in sea turtle survival. Fibropapillomatosis (FP) tumors are a major threat to green turtles in some areas of the world and is particularly associated with degraded coastal habitat. Scientists have also documented FP in populations of loggerhead, olive ridley, and flatback turtles, but reports in green turtles are more common. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness. FP was first described in green turtles in the Florida Keys in the 1930s. Since then it has been recorded in many green turtle populations around the world. The effects of FP at the population level are not well understood. The sand-borne fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* capable of killing greater than 90 percent of sea turtle embryos they infect, threatening nesting productivity under some conditions. These pathogens can survive on decaying organic matter

[3] See http://www.nmfs.noaa.gov/pr/species/turtles/threats.htm, updated June 16, 2014

and embryo mortality rates attributed to fusarium were associated with clay/silt nesting areas compared to sandy areas (Sarmiento-Ramırez et al. 2014).

Fishing is the primary anthropogenic threat to sea turtles in the ocean. Fishing gear entanglement potentially drowns or seriously injures sea turtles. Fishing dredges can crush and entrap turtles, causing death and serious injury. Infection of entanglement wounds can compromise health. The development and operation of marinas and docks in inshore waters can negatively impact nearshore habitats. Turtles swimming or feeding at or just beneath the surface of the water are particularly vulnerable to boat and vessel strikes, which can result in serious propeller injuries and death.

Ingestion or entanglement in marine debris is a cause of morbidity and mortality for sea turtles in the pelagic (open ocean) environment (Stamper et al. 2009). Consumption of non-nutritive debris also reduces the amount of nutritive food ingested, which then may decrease somatic growth and reproduction (McCauley and Bjorndal 1999). Marine debris is especially problematic for turtles that spend all or significant portions of their life cycle in the pelagic environment (e.g., leatherbacks, juvenile loggerheads, and juvenile green turtles).

Sea turtle nesting and marine environments are facing increasing impacts through structural modifications, sand nourishment, and sand extraction to support widespread development and tourism (Lutcavage et al. 1997, Bouchard et al. 1998, Hamann et al. 2006, Maison 2006, Hernandez et al. 2007, Santidrián Tomillo et al. 2007, Patino-Martinez 2013). These factors decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings through direct loss of and indirect (e.g., altered temperatures, erosion) mechanisms (Ackerman 1997, Witherington et al. 2003, 2007). Lights from developments alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Witherington and Bjorndal 1991, Witherington 1992, Cowan et al. 2002, Deem et al. 2007, Bourgeois et al. 2009).

Beach nourishment also affects the incubation environment and nest success. Although the placement of sand on beaches may provide a greater quantity of nesting habitat, the quality of that habitat may be less suitable than pre-existing natural beaches. Constructed beaches tend to differ from natural beaches in several important ways. They are typically wider, flatter, more compact, and the sediments are more moist than those on natural beaches (Nelson et al. 1987, Ackerman 1997, Ernest and Martin 1999). Nesting success typically declines for the first year or two following construction, even when more nesting area is available for turtles (Trindell et al. 1998, Ernest and Martin 1999, Herren 1999). Likely causes of reduced nesting success on constructed beaches include increased sand compaction, escarpment formation, and changes in beach profile (Nelson et al. 1987, Grain et al. 1995, Lutcavage et al. 1997, Steinitz et al. 1998, Ernest and Martin 1999, Rumbold et al. 2001). Compaction can inhibit nest construction or increase the amount of time it takes for turtles to construct nests, while escarpments often cause female turtles to return to the ocean without nesting or to deposit their nests seaward of the escarpment where they are more susceptible to frequent and prolonged tidal inundation. In short, sub-optimal nesting habitat may cause decreased nesting success, place an increased energy burden on nesting females, result in abnormal nest construction (Carthy 1996), and reduce the survivorship of eggs and hatchlings. In addition, sand used to nourish beaches may have a different composition than the original beach; thus introducing lighter or darker sand, consequently affecting the relative nest temperatures (Ackerman 1997, Milton et al. 1997).

In addition to effects on sea turtle nesting habitat, anthropogenic disturbances also threaten coastal foraging habitats, particularly areas rich in seagrass and marine algae. Coastal habitats are degraded by pollutants from coastal runoff, marina and dock construction, dredging, aquaculture, oil and gas exploration and extraction, increased under water noise and boat traffic, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999, Lee Long et al. 2000, Waycott et al. 2005)

Conant (2009) included a review of the impacts of marine pollutants on sea turtles: marine debris, oil spills, and bioaccumulative chemicals. Sea turtles at all life stages appear to be highly sensitive to oil spills, perhaps due to certain aspects of their biology and behavior, including a lack of avoidance behavior, indiscriminate feeding in convergence zones, and large pre-dive inhalations (Milton et al. 2003). Milton et al. (2003) state that the oil effects on turtles include increased egg mortality and developmental defects, direct mortality due to oiling in hatchlings, juveniles and adults, and impacts to the skin, blood, salt glands, and digestive and immune systems. Vargo et al. (1986) reported that sea turtles would be at substantial risk if they encountered an oil spill or large amounts of tar in the environment. In a review of available information on debris ingestion, Balazs (1985) reported that tar balls were the second most prevalent type of debris ingested by sea turtles. Physiological experiments showed that sea turtles exposed to petroleum products may suffer inflammatory dermatitis, ventilator disturbance, salt gland dysfunction or failure, red blood cell disturbances, immune response, and digestive disorders (Vargo et al. 1986, Lutz and Lutcavage 1989, Lutcavage et al. 1995).

Conant’s (2009) review describes the potentially extensive impacts of climate change on all aspects of a sea turtle's life cycle, as well as impact the abundance and distribution of prey items. Rising sea level is one of the most certain consequences of climate change (Titus and Narayanan 1995), and will result in increased erosion rates along nesting beaches. This could particularly affect areas with low-lying beaches where sand depth is a limiting factor, as the sea will inundate nesting sites and decrease available nesting habitat (Daniels et al. 1993, Fish et al. 2005, Baker et al. 2006). The loss of habitat because 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 (Baker et al. 2006). On some undeveloped beaches, shoreline migration will have limited effects on the suitability of nesting habitat. The Bruun rule specifies that during a sea level rise, a typical beach profile will maintain its configuration but will be translated landward and upward (Rosati et al. 2013). However, along developed coastlines, and especially in areas where erosion control structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation. Non-native vegetation often out competes native species, is usually less stabilizing, and can lead to increased erosion and degradation of suitable nesting habitat. Exotic vegetation may also form impenetrable root mats that can prevent proper nest cavity excavation, invade and desiccate eggs, or trap hatchlings.

Threats in the Southeast United States. In the southeastern U.S., numerous erosion control structures that create barriers to nesting have been constructed. The proportion of coastline that is armored is approximately 18 percent (239 km) in Florida (Clark 1992, Schroeder and Mosier 1998, Witherington et al. 2006), In the Northwest Atlantic, jetties have been placed at many ocean inlets to keep transported sand from closing the inlet channel. Erosion of Northwest Atlantic beaches and dunes is accelerated by sheet flow, through stormwater outfalls, or through small diameter pipes. These outfalls create localized erosion channels, prevent natural dune establishment, and wash out sea turtle nests (Humiston & Moore Engineers 2010, FDEP 2008). Contaminants contained in stormwater, such as oils, grease, antifreeze, gasoline, metals, pesticides, chlorine, and nutrients, are discharged onto the beach. Reports of hatchling disorientation events[4] in Florida alone describe several hundred nests each year and are likely to involve tens of thousands of hatchlings (Nelson et al. 2002). However, this number calculated from disorientation reports is likely a vast underestimate. Independent of these reports, Witherington et al. (1996) surveyed hatchling orientation at nests located at 23 representative beaches in six counties around Florida in 1993 and 1994 and found that, by county, approximately 10 to 30 percent of nests showed evidence of hatchlings disoriented by lighting.

Green Sea Turtle

Description. Green sea turtles have a smooth shell with shades of black, gray, green, brown, and yellow; their bottom shell is yellowish white. Adults weigh 300-350 pounds (135-150 kg) and measure 3 feet in length. Hatchlings weigh 0.05 pounds (25 g) and are 2 inches (50 mm) long. Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004), and density of turtles in foraging areas (Bjorndal et al. 2000, Seminoff et al. 2002b, Balazs and Chaloupka 2004).

Status. Federal listing of the green sea turtle was published July 28, 1978. The Florida and Pacific coast of Mexico breeding populations were listed as endangered and all other populations were listed as threatened (43 FR 32800). Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are

[4] Hatchlings orienting away from the ocean and towards artificial light.

decreasing. The most important nesting concentration for green sea turtles in the western Atlantic is in Tortuguero, Costa Rica where nesting has increased considerably since the 1970s (NMFS and USFWS 2007a). Trend data should be interpreted cautiously because data are only available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004). Over the course of a long-term study along Cape Canaveral, Florida, average turtle length and recapture rate both declined (Redfoot and Ehrhart 2013).

Use of Florida Waters. The vast majority of green sea turtle nesting within the southeastern U.S. occurs in Florida (Johnson and Ehrhart 1994, Meylan et al. 1995). Nesting has been increasing since 1989 (FFWCC, Florida Marine Research Institute Index Nesting Beach Survey Database) with biennial peaks in abundance and a generally positive trend during the ten years of regular monitoring. This includes the Atlantic coast of Florida on beaches where only loggerhead nesting was observed in the past (Pritchard 1997). Recent modeling by Chaloupka et al. (2008a) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent.

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

Habitat and Forage. Once hatched, turtles enter the sea to live a pelagic phase preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam (NMFS and USFWS 1998a). At approximately 20-25 cm carapace length, juveniles leave pelagic habitats, enter benthic foraging areas (Bjorndal 1997), and spend the majority of their lives in coastal foraging grounds (MacDonald et al. 2012). These areas include both open coastline and protected bays and lagoons. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley et al. 1998, Heithaus et al. 2002, Seminoff et al. 2002a, Hatase et al. 2006, Hart et al. 2013, Parker and Balazs 2005). A shift to a more herbivorous diet occurs when individuals move into neritic habitats (i.e., sandy, muddy bottoms, Cardona et al. 2010).

The largely plant-eating diet of green turtles is believed to be responsible for their particularly slow growth rates (Bjorndal 1982). If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark et al. 2009). There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009).

Threats. Adult survivorship is lower in areas of human impact on green sea turtles and their habitats (Bjorndal et al. 2003, Campbell and Lagueux 2005). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint et al. 2009). Major anthropogenic impacts to the nesting and marine environment affect green sea turtle survival and recovery (Patino-Martinez 2013). Hundreds of mostly immature green sea turtles were killed between 2006 and 2008 due to bycatch and direct harvest along Baja California Sur (Senko et al. 2014). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34). Ingested debris appeared to be the direct cause of mortality in three of the 34 animals (Tourinho et al. 2009). The introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996). Very few green sea turtles are bycaught in U.S. fisheries (Finkbeiner et al. 2011). Fuentes et al. (2010) predicted that rising temperatures due to climate change would be a much greater threat in the long term to the hatching success of sea turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010).

Chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB have been detected in green sea turtle tissues (Miao et al. 2001, Gardner et al. 2003). DDE has not been found to influence sex determination at levels below cytotoxicity (Podreka et al. 1998, Keller and McClellan-Green 2004). Flame retardants have been measured in tissues from healthy individuals (Hermanussen et al. 2008). Copper, lead, manganese, cadmium, and nickel have been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (Van de Merwe et al. 2009). Exposure to sewage effluent may result in green sea turtle eggs harboring antibiotic-resistant strains of bacteria (Al-Bahry et al. 2009). To date, no tie has been found between pesticide concentration and susceptibility to FP, although degraded habitat and pollution have been tied to the incidence of the disease in green turtle (Aguirre et al. 1994, Foley et al. 2005). It has also been theorized that exposure to macroalgae from eutrophic environments (Van Houtan et al. 2014), tumor-promoting compounds produced by cyanobacteria *Lyngbya majuscule* (Arthur et al. 2008) or dinoflagellates of the genus *Prorocentrum* (Landsberg et al. 1999) promote the development of FP.

Designated critical habitat. On September 2, 1998, designated critical habitat for green sea turtles was designated in coastal waters surrounding Culebra Island, Puerto Rico (63 FR 46693). Aspects of these areas that are important for green sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and seagrasses, which are the principal dietary component of juvenile and adult green turtles throughout the Wider Caribbean region (Bjorndal 1997).

Hawksbill Sea Turtle

Description. Hawksbill sea turtles have a dark to golden brown shell, with streaks of orange, red, and/or black with a serrated back and overlapping "scutes," while the bottom shell (plastron) is clear yellow. Hatchlings are mostly brown. Adults weigh up to 100-150 pounds (45-70 kg) and measure 25-35 inches (65-90 cm) long. Hatchlings weigh 0.5 ounces (15 g). Within United States territories and U.S. dependencies in the Caribbean Region, hawksbill sea turtles nest principally in Puerto Rico and the U.S. Virgin Islands, particularly on Mona Island and Buck Island.

Status. Hawksbill sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and since 1973 have been listed as endangered under the ESA. Although no historical records of abundance are known, hawksbill sea turtles are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007b). Among 42 sites for which recent trend data are available, 10 (24 percent) are increasing, three (7 percent) are stable and 29 (69 percent) are decreasing.

Use of Florida Waters. Hawksbill sea turtles appear to be rare visitors to the U.S. Gulf of Mexico, with Florida being the only Gulf state with regular sightings (Rabalais and Rabalais 1980, Hildebrand 1983, Witzell 1983, NMFS and USFWS 1993, Rester and Condrey 1996). Within the continental United States, hawksbill sea turtles nest only on beaches along the southeast coast of Florida and in the Florida Keys.

Habitat and Forage. Hawksbill sea turtles use a wide range habitats during their lifetimes (Musick and Limpus 1997, Plotkin 2003). After hatching, hawksbills are pelagic, associated with sargassum (Musick and Limpus 1997) until they are approximately 22-25 cm in straight carapace length (Meylan 1988, Meylan and Donnelly 1999). In the post pelagic phase, they inhabit coral reefs or other hard-bottom habitats, seagrass, algal beds, mangrove bays and creeks (Musick and Limpus 1997, Bjorndal and Bolten 2010), and mud flats (R. von Brandis, unpublished data in NMFS and USFWS 2007b). Dietary data from oceanic stage hawksbills are limited, but indicate a combination of plant and animal material (Bjorndal 1997). Sponges and octocorals are common prey off Honduras (Berube et al. 2012, Hart et al. 2013).

Threats. One natural threat unique to hawksbill sea turtles is hybridization (Mortimer and Donnelly in review) with other species of sea turtles. Future impacts from climate change and global warming may result in significant changes in hatchling sex ratios. The fact that hawksbill turtles exhibit temperature-dependent sex determination (Wibbels 2003) suggests that there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos).

Designated critical habitat. On September 2, 1998, NMFS designated critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey.

Kemp's Ridley Sea Turtle

Description. The Kemp's ridley sea turtle has a grayish-green, nearly circular, top shell with a pale yellowish bottom shell. Adults weight 100 pounds (45 kg) and measure 24-28 inches (60-70 cm) in length. Each of the front flippers has one claw while the back flippers may have one or two. Hatchlings weigh 0.5 ounces (14 g) and are 1.5 inches (3.8 cm) long.

Status. The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18319). Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990, USFWS 1999). Historic information indicates that tens of thousands of Kemp's ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). From 1978 through the 1980s, arribadas involved 200 turtles or less, and by 1985, the total number of nests at Rancho Nuevo had dropped to approximately 740 for the entire nesting season, or a projection of roughly 234 turtles (USFWS and NMFS 1992, TEWG 2000). Beginning in the 1990s, an increasing number of beaches in Mexico were being monitored for nesting, and the total number of nests on all beaches in Tamaulipas and Veracruz in 2002 was over 6,000; the rate of increase from 1985 ranged from 14-16 percent (TEWG 2000, USFWS 2002, Heppell et al. 2005). Preliminary estimates of 2011 and 2012 nesting support 19,368 and 20,197 nests, respectively (Gallaway et al. 2013). Gallaway et al. (2013) estimated that nearly 189,000 female Kemp's ridley sea turtles over the age of two years were alive in 2012. Extrapolating based upon sex bias, the authors estimated that nearly a quarter million age two or older Kemp's ridleys were alive at this time.

Use of Florida Waters. The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. The migratory corridors appear to extend throughout the coastal areas of the Gulf of Mexico and most turtles appear to travel in waters less than roughly 164 feet in-depth. Turtles that headed north and east traveled as far as southwest Florida, whereas those that headed south and east traveled as far as the Yucatan Peninsula, Mexico (Morreale et al. 2007). Kemp's ridleys in south Florida begin to migrate northward during spring toward Long Island Sound and even Nova Scotia in late summer (Bleakney 1955), returning south in the winter as local water temperatures cool (Lutcavage and Musick 1985, Byles 1988, Keinath 1993, Renaud 1995). They reside in winter-feeding areas for several months (Byles and Plotkin 1994, Morreale et al. 2007). During spring and summer, juvenile Kemp's ridleys occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida. In the fall, most Kemp's ridleys migrate to deeper or more southern warmer waters and remain there through the winter (Schmid 1998). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS et al. 2010).

Habitat and Forage. Developmental habitats for juveniles occur throughout the entire coastal Gulf of Mexico and U.S. Atlantic coast northward to New England (Schmid 1998, Wibbels et al.

2005, Morreale et al. 2007). Key foraging areas in the Gulf of Mexico include Sabine Pass, Texas; Caillou Bay and Calcasieu Pass, Louisiana; Big Gulley, Alabama; Cedar Keys, Florida; and Ten Thousand Islands, Florida (Carr and Caldwell 1956, Ogren 1989, Coyne et al. 1995, Schmid 1998, Schmid et al. 2002, Witzell et al. 2005). Foraging areas studied along the Atlantic coast include Pamlico Sound, Chesapeake Bay, Long Island Sound, Charleston Harbor, and Delaware Bay. Near-shore waters of 120 feet or less provide the primary marine habitat for adults, although it is not uncommon for adults to venture into deeper waters (Byles 1989, Mysing and Vanselous 1989, Renaud et al. 1996, Shaver et al. 2005, Shaver and Wibbels 2007). Benthic coastal waters of Louisiana and Texas seem to be preferred foraging areas for Kemp's ridley sea turtles (particularly passes and beachfronts), although individuals may travel along the entire coastal margin of the Gulf of Mexico (Renaud 1995, Landry et al. 1996, Landry and Costa 1999). Kemp's ridley diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks. Immature Kemp's ridleys off southwest Florida documented predation on benthic tunicates, a previously undocumented food source for this species (Witzell and Schmid 2005).

Threats. Kemp's ridley sea turtles are particularly prone to cold stunning along Cape Cod (Innis et al. 2009). Habitat destruction remains a concern in the form of bottom trawling and shoreline development. Trawling destroys habitat utilized by Kemp's ridley sea turtles for feeding and construction activities can produce hazardous runoff. The vast majority of fisheries interactions with sea turtles in the U.S. are either Kemp's ridleys or loggerhead sea turtles (Finkbeiner et al. 2011). Roughly three-quarters of annual mortality was attributed to shrimp trawling prior to Turtle Exclusion Device regulations (Gallaway et al. 2013). However, this has dropped to an estimated one-quarter of total mortality nearly 20 years after Turtle Exclusion Device Turtle Exclusion Devices were implemented in 1990 (Gallaway et al. 2013).

Designated critical habitat. NMFS has not designated critical habitat for Kemp's ridley sea turtle.

Leatherback Sea Turtle

Description. Leatherback sea turtles have a primarily black shell with pinkish-white coloring on their belly. A leatherback's top shell (carapace) is about 1.5 inches (4 cm) thick and consists of leathery, oil-saturated connective tissue overlaying loosely interlocking dermal bones. Their carapace has seven longitudinal ridges and tapers to a blunt point, which help give the carapace a more hydrodynamic structure. Adults weigh up to 2,000 pounds (900 kg) and measure 6.5 feet (2 m) long. Hatchlings weigh 1.5-2 ounces (40-50 g) and are 2-3 inches (50-75 cm) in length.

Status. Leatherback sea turtles initially received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA. Western Pacific and Eastern Pacific leatherbacks continue to decline. Western Pacific leatherbacks have declined more than 80 percent over the last three generations, and Eastern Pacific leatherbacks have declined by more than 97 percent over the last three generations. Of the Eastern Pacific leatherbacks, the Mexico nesting population -- once considered to be the world's largest with 65 percent of the worldwide population -- is now less than one percent of its estimated size in 1980. In the Caribbean, Atlantic, and Gulf of Mexico, leatherback populations are generally increasing. In the U.S., nesting in Puerto Rico, St. Croix, and the U.S. Virgin Islands continues to increase as well, with some shift in the nesting between these two islands.

Use of Florida Waters. Florida's Atlantic coast is one of the main nesting areas in the continental U.S. Data from this area reveals a fluctuating, but general upward trend. Florida index nesting beach data from 1989-2014, indicate that number of nests at core index nesting beaches ranged from 27 to 641 in 2014. Leatherback sea turtles feed in shallow waters on the continental shelf waters along the Florida Panhandle, the Mississippi River Delta, and the Texas coast (Collard 1990). Leatherbacks occur along the southeastern U.S. year-round, with peak abundance in summer (TEWG 2007). In spring, leatherback sea turtles appear to be concentrated near the coast, while other times of the year they are spread out at least to the Gulf Stream.

Habitat and Forage. Leatherbacks are primarily pelagic but occur throughout marine waters including nearshore habitats (Schroeder and Thompson 1987, Shoop and Kenney 1992, Grant and Ferrell 1993, Starbird et al. 1993). After nesting, female leatherbacks migrate from tropical waters to more temperate latitudes, which support high densities of jellyfish prey in the summer.

Threats. Plastic ingestion is very common in leatherbacks, blocking gastrointestinal tracts and potentially leading to death (Mrosovsky et al. 2009). Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide. Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale et al. 2008, Gless et al. 2008, Fossette et al. 2009, Petersen et al. 2009).

Designated critical habitat. On March 23, 1979, leatherback designated critical habitat was identified adjacent to Sandy Point, St. Croix, U.S. Virgin Islands from the 183 m isobath to mean high tide level between 17° 42'12" N and 65°50'00" W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant designated critical habitat deterioration. On January 26, 2012, NMFS designated critical habitat for leatherback sea turtles in waters along Washington State and Oregon (Cape Flattery to Cape Blanco; 64,760 km^2) and California (Point Arena to Point Arguello; 43,798 km^2).

Northwest Atlantic DPS of the Loggerhead Sea Turtle

Description. Adult loggerhead sea turtles have relatively large heads, which support powerful jaws. They have a reddish-brown, slightly heart-shaped top shell with pale yellowish bottom shell. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. They weigh 250 pounds (113 kg) and measure 3 feet (~1 m) in length. Hatchlings are brown to dark gray with a yellowish to tan bottom shell. Their flippers are dark gray to brown above with white-to-white-gray margins. They weigh 0.05 pounds (20 g) and are 2 inches (4 cm) long.

Status. Loggerhead sea turtles were originally listed as threatened under the ESA on July 28, 1978 (43 FR 32800). On September 22, 2011, NMFS designated 9 DPSs of loggerhead sea turtles as threatened (76 FR 58868). The global abundance of nesting female loggerhead turtles was estimated at 43,320–44,560 (Spotila 2004).

Use of Florida Waters. The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located on the Yucatán Peninsula of Mexico, Columbia, Cuba, South Africa (Márquez 1990, LGL Ltd. 2007).

Because of its size, the south Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS and USFWS 1991, NMFS 2006c). The South Florida population increased at ~5.3 percent per year from 1978-1990, and was initially increasing at 3.9-4.2 percent after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3 percent (FFWCC 2007a, 2007b, Witherington et al. 2009). This is likely due to a decline in the number of nesting females within the population (Witherington et al. 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size. While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern. Loggerhead nesting is thought to consist of just 60 nesting females in the U.S. Caribbean and U.S.Gulf of Mexico (NMFS 2006b). Data from several studies showed decreased growth rates of loggerheads in U.S. Atlantic waters from 1997-2007, corresponding to a period of 43 percent decline in Florida nest counts (Bjorndal et al. 2013).

Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10 percent of the loggerhead captures) and the Mediterranean Sea (where they represent ~45 percent of loggerhead sea turtles captured). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. Satellite tracking of loggerheads from southeastern U.S. nesting beaches supports three dispersal modes to foraging areas: one northward along the continental shelf to the northeastern U.S., broad movement through the southeastern and mid-Atlantic U.S., and residency in areas near breeding areas (Reina et al. 2012).

An estimated 12 percent of all western North Atlantic Ocean loggerhead sea turtles reside in the eastern Gulf of Mexico, with the vast majority in western Florida waters (TEWG 1998, Davis et al. 2000a). Loggerheads may occur in both offshore habitats (particularly around oil platforms and reefs, where prey and shelter are available; (Fritts et al. 1983, Rosman et al. 1987, Lohoefener et al. 1990, Gitschlag and Herczeg 1994, Davis et al. 2000b), as well as shallow bays and sounds (which may be important developmental habitat for late juveniles in the eastern Gulf of Mexico; (Lohoefener et al. 1990, USAF 1996, Davis et al. 2000b).

Habitat and Forage. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker et al. 2005). Hatchling loggerheads migrate to the ocean, where they are generally believed to lead a pelagic existence for as long as 7-12 years (Avens et al. 2013) feeding on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988, Wallace et al. 2009). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998b). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich et al. 2010, Vander Zanden et al. 2010).

Threats. High temperatures before hatchlings emerge from their nests can reduce hatchling success, as can bacterial contamination and woody debris in nests (Trocini 2013). Brevetoxin-producing algal blooms can result in loggerhead sea turtle death and pathology, with nearly all stranded loggerheads in affected areas showing signs of illness or death resulting from exposure (Fauquier et al. 2013). Shrimp trawl fisheries account for the highest number of captured and killed loggerhead sea turtles. Along the Atlantic coast of the U.S., NMFS estimated that shrimp trawls capture almost 163,000 loggerhead sea turtles each year in the Gulf of Mexico, of which 3,948 die. However, more recent estimates from suggest interactions and mortality has decreased from pre-regulatory periods, with a conservative estimate of 26,500 loggerheads captured annually in U.S. Atlantic fisheries causing mortality up to 1,400 individuals per year (Finkbeiner et al. 2011). Commercial gillnet fisheries are estimated to have killed 52 loggerheads annually along the U.S. mid-Atlantic (Murray 2013). Pacific bycatch is much less, with about 400 individuals bycaught annually in U.S. fisheries resulting in at least 20 mortalities (Finkbeiner et al. 2011). Offshore longline tuna and swordfish longline fisheries are also a serious concern for the survival and recovery of loggerhead sea turtles and appear to affect the largest individuals more than younger age classes (Bolten et al. 1994, Aguilar et al. 1995, Howell et al. 2008, Tomás et al. 2008, Carruthers et al. 2009, Marshall et al. 2009, Petersen et al. 2009). Longline hooking along Hawaii and California suggests a 28 percent mortality rate for hooked and released loggerheads, with no significant difference between shallow- versus deep-hooked individuals (Swimmer et al. 2013). Deliberate hunting of loggerheads for their meat, shells, and eggs has declined from previous exploitation levels, but still exists and hampers recovery efforts (Lino et al. 2010).

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

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

Tissues taken from loggerheads sometimes contain very high levels of organochlorines (Rybitski et al. 1995, McKenzie et al. 1999, Corsolini et al. 2000, Gardner et al. 2003, Keller et al. 2004a, Keller et al. 2004b, Keller et al. 2005, Alava et al. 2006, Perugini et al. 2006, Storelli et al. 2007, Monagas et al. 2008, Oros et al. 2009, Guerranti et al. 2013). High levels of organochlorines potentially suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2004c, Keller et al. 2006, Oros et al. 2009). Organochlorine contaminants have the potential to depress immune function of loggerhead sea turtles (Keller et al. 2006) and likely have similar effects on other sea turtle species. These contaminants potentially cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Godley et al. 1999, Saeki et al. 2000, Anan et al. 2001, Fujihara et al. 2003, Gardner et al. 2006, Storelli et al. 2008, Garcia-Fernandez et al. 2009). These metals are likely accumulated from plants (Anan et al. 2001, Celik et al. 2006, Talavera-Saenz et al. 2007).

The omnivorous nature of loggerheads results in greater exposures to toxicants that biomagnify in the food web relative to other sea turtle species (Godley et al. 1999, McKenzie et al. 1999). Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley et al. 1999, Pugh and Becker 2001). Elevated mercury levels are associated with deformities in hatchlings versus healthy individuals (Trocini 2013). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds. Antimicrobial agents in the marine environment are also of concern. Antibiotic-resistant bacteria found in loggerhead sea turtles suggested high use and discharge of antimicrobial agents marine ecosystems (Foti et al. 2009).

Designated critical habitat. On July 10, 2014, NMFS and USFWS designated critical habitat for loggerhead sea turtles along the U.S. Atlantic and Gulf of Mexico coasts from North Carolina to Mississippi (79 FR 39856). While not within NMFS' jurisdiction, the USFWS designated about 685 miles of coastal beach habitat as important for the recovery of the threatened Northwest Atlantic Ocean population of loggerhead sea turtles. The terrestrial designated critical habitat areas include 88 nesting beaches in coastal counties located in North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. These beaches account for 48 percent of an estimated 1,531 miles of coastal beach shoreline and about 84 percent of the documented nesting (numbers of nests) within these six states. These areas contain one or a combination of the following:

- Suitable nesting beach habitat.
- Sand suitable for nest construction and embryo development.
- Suitable nesting habitat with sufficient darkness so as not to deter nesting turtles
- Natural coastal processes or artificially created or maintained habit mimicking natural conditions.

Figure 9 shows the extent of designated critical habitat in Florida waters.

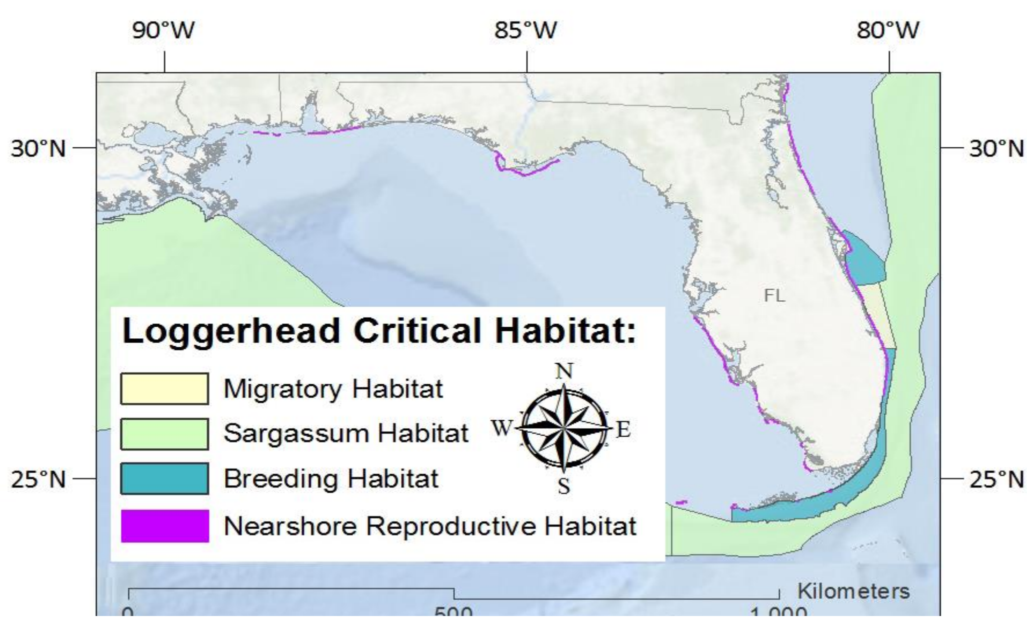

Figure 9. Loggerhead Sea Turtle Designated Critical Habitat in Florida.

FISH

Smalltooth Sawfish

Description. Although they are rays, sawfish physically more resemble sharks, with only the trunk and especially the head ventrally flattened. Smalltooth sawfish are characterized by their "saw," a long, narrow, flattened rostral blade with a series of transverse teeth along either edge. Adults weight 70 pounds (350 kg) and measure 18-25 feet (5.5-7 m) in length. Recent data from smalltooth sawfish caught off Florida indicate that young are born at 76 to 87 cm (Simpfendorfer and Wiley 2004). Males reach maturity at approximately 2.7 m and females at approximately 3.6 m (Simpfendorfer 2002). They live for 25-30 years and are "ovoviviparous," meaning the mother holds the eggs inside of her until the young are ready to be born.

Status. The U.S. smalltooth sawfish DPS was listed as endangered under the ESA on April 1, 2003 (68 FR 15674). The smalltooth sawfish was common throughout their historic range up until the middle of the 20th century. The dramatic decline is attributed to the vulnerability of the sawfish life history to the impacts of fishing (both as bycatch and direct harvest) and habitat modification. As of 2001 the estimated U.S. population size was less than 5 percent of its size at the time of European settlement (Simpfendorfer 2001). The capture of a smalltooth sawfish off Georgia in 2002 is the first record north of Florida since 1963. This information and recent encounters in new areas beyond the core abundance area suggest that the population may be increasing. The abundance of juveniles encountered, including very small individuals, suggests that the population remains reproductively active and viable (Seitz and Poulakis 2002, Simpfendorfer 2003, Simpfendorfer and Wiley 2004). From 1989-2004, smalltooth sawfish relative abundance in the Everglades National Park has increased by about 5 percent per year (Carlson et al. 2007). Recent data from the ISED suggest increasing trends in reported encounters of juvenile sawfish in Florida with a lag in increase in larger juveniles (Figure 10). However, recovery of the species is expected to be slow given the species' life history and other remaining threats to the species, and therefore the population's future remains tenuous.

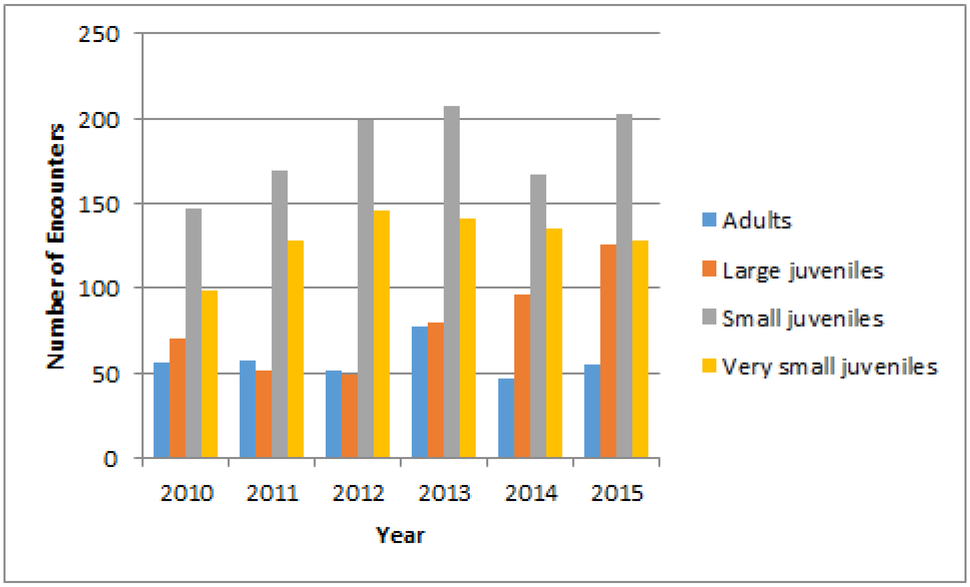

Figure 10. Smalltooth Sawfish Encounter Data Within Florida Waters from the International Sawfish Encounter Database (ISED).

Use of Florida Waters. The majority of smalltooth sawfish encounters today are from the southwest coast of Florida between the Caloosahatchee River and Florida Bay. Outside of this core area, the smalltooth sawfish appears more common on the west coast of Florida and in the Florida Keys than on the east coast, and occurrences decrease the greater the distance from the core area (Simpfendorfer and Wiley 2004). Water temperatures no lower than 61°F to 64.4°F and the availability of appropriate coastal habitat serve as the major environmental constraints limiting the northern movements of smalltooth sawfish in the western North Atlantic (Simpfendorfer 2001). As a result, most records of this species from areas north of Florida occur during spring and summer periods (May to August) when inshore waters reach appropriately high temperatures. The data also suggest that smalltooth sawfish may use warm water outflows of power stations as thermal refuges during colder months, either to enhance their survival or because they have become trapped by surrounding cold water from which they would normally migrate. Almost all occurrences of smalltooth sawfish in warm-water outflows were during the coldest part of the year.

Habitat and Forage. Smalltooth sawfish occur in waters with a broad range of salinities from freshwater to full seawater (Simpfendorfer 2001). Poulakis and Seitz (2004) reported that almost all of the sawfish <3 m in length were found in water less than 10 m deep and 46 percent of encounters individuals >3 m in Florida Bay and the Florida Keys were reported at depths between 70 to 122 m. Recent data from sawfish encounter reports and from satellite tagging indicate mature animals occur regularly in waters in excess of 164 feet (Poulakis and Seitz 2004, Simpfendorfer and Wiley 2004). Since large animals are also observed in very shallow waters, it is believed that smaller (younger) animals are restricted to shallow waters, while large animals roam over a much larger depth range (Simpfendorfer 2001).

Smalltooth sawfish are most common in shallow coastal waters less than 25 m (Bigelow and Schroeder 1953). Nursery areas occur throughout Florida in areas of shallow water, close to shore and typically associated with mangroves (Simpfendorfer and Wiley 2004). Younger, smaller individuals tend to inhabit very shallow mud banks that are less than 1 foot (30 cm) deep and tides are a major factor in their movement (Simpfendorfer et al. 2010). As they grow, juveniles tend to occupy deeper habitat, but shallow areas (<1 m depth) remain preferred habitat (Simpfendorfer et al. 2010). Simpendorfer (2003) investigated the home range size of very small, young-of-year (i.e., fish born within the last year <100 cm, n=2) and larger juvenile smalltooth sawfish (approximately 150 cm, n=2). The daily home ranges of the larger sawfish ranged from < 0.001 to 0.35 km^2. The data indicated a total home range of 0.12 and 1.22 km^2 with a high level of site fidelity. For these larger individuals, there was less overlap in home range use between days, relative to smaller sawfish. Smaller young-of-year fish daily home ranges ranged from <0.001 to 0.007 km^2 with overall home ranges of 0.01 and 0.08 km^2 (see table 3 in Simpfendorfer 2003). In later work, Simpendorfer et al. (2011) reported smalltooth sawfish in the nursery areas to have mean daily activity space of about 100-1000 m^2.

Smalltooth sawfish feed primarily on fish, with mullet, jacks, and ladyfish believed to be their primary food resources (Simpfendorfer 2001). In addition to fish, smalltooth sawfish also prey on shrimp and crabs, which are located by disturbing bottom sediment with their saw (Norman and Fraser 1937, Bigelow and Schroeder 1953).

Threats. The primary natural threat to smalltooth sawfish survival is the species low reproductive rate. In the face of reduced population sizes, this biological parameter means that recovery, at best, will be slow, and that catastrophic perturbations can have severer consequences to recovery. Historical decline has been largely due to fisheries interactions (see NMFS 2009 for a review). However, additional anthropogenic impacts result from habitat loss. Destruction of mangrove habitat, dredging, trawling and filling, and loss of reef habitat have negative impacts on all life stages of smalltooth sawfish. Habitat degradation due to runoff containing pesticides, eutrophying agents, and other contaminants can also have a negative impact on smalltooth sawfish habitat.

Designated critical habitat. On September 2, 2009, designated critical habitat was designated for smalltooth sawfish along the central and southwest coast of Florida (74 FR 45353, Figure 11). Mangrove and adjacent shallow euryhaline habitat are important nursery habitat for smalltooth sawfish. Nursery habitat consisting of areas adjacent to red mangroves and euryhaline habitats less than 0.9 m deep in southwestern Florida were later determined to be particularly significant (Norton et al. 2012).

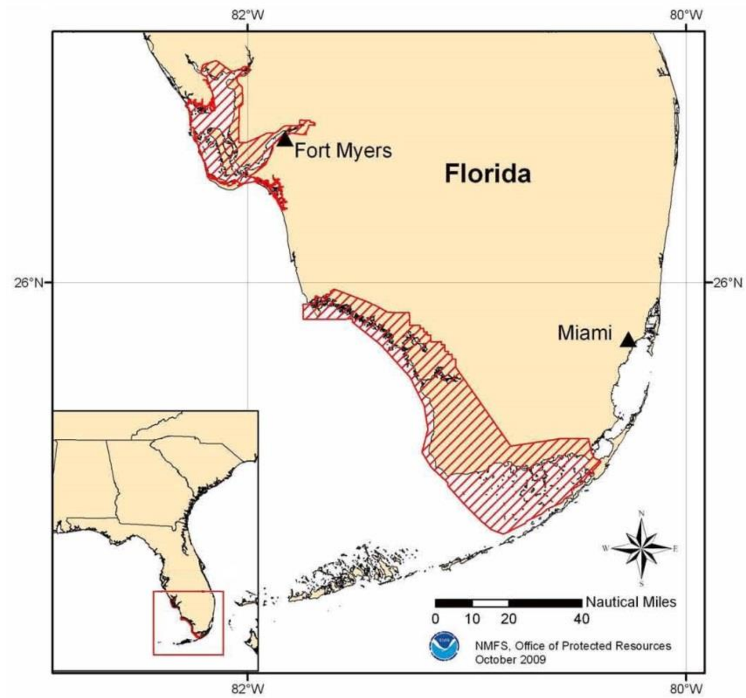

Figure 11: Smalltooth Sawfish Designated Critical Habitat.

Shortnose Sturgeon

Description. Adult shortnose sturgeon grow to up to 50 pounds (23 kg) and 4.5 feet (1.4 m) long. They have bony plates called "scutes" along their back. Lifespans average 30 years, but the species has been reported to live up to 67 years.

Status. Shortnose sturgeon were listed as endangered on March 11, 1967 under the Endangered Species Preservation Act (32 FR 4001) and remained on the endangered species list with enactment of the ESA of 1973, as amended. NMFS' recovery plan recognized 19 wild populations based on their strong fidelity to their natal streams, and captive populations maintained for educational and research purposes (NMFS 1998b). Despite their longevity, the viability of sturgeon populations is sensitive to variability in juvenile recruitment and survival (Anders et al. 2002, Gross et al. 2002, Secor et al. 2002).

The largest shortnose sturgeon population inhabits Hudson River and appears to have increased to approximately 60,000 individuals (NMFS 1998b). The Kennebec River population also appears to be increasing. The most recent estimate of 9,500 fish (Squiers 2003), suggests a 30 percent increase over approximately twenty years. The Delaware River population appears to be stable (Brundage 2006, O'Herron et al. 1993, Hastings et al. 1987). Populations are relatively small south of Chesapeake Bay, with the largest Altamaha River population about an order of magnitude smaller than the Hudson River population and the Ogeechee River population, which appears to be declining, is orders of magnitude smaller than the Hudson River population (NMFS 1998a, DeVries 2006). By some accounts, shortnose sturgeon, populations may be extinct in several basins (e.g., St. Johns in Florida, St. Marys, Potomac, Housatonic, and Neuse rivers). Those few fish that have been observed in these basins are generally presumed to be immigrants from neighboring basins.

Use of Florida Waters. Rogers and Weber (1995), Kahnle et al. (1998a), and Collins et al. (2000) concluded that shortnose sturgeon are extinct from the St. Johns River in Florida and the St. Marys River along the Florida and Georgia border. However, a 2010 report from the shortnose sturgeon status review team indicated both Atlantic and shortnose sturgeon are found in the St. Marys River. A 2001-2004 Florida FFWCC shortnose sturgeon survey in the St. Johns yielded a single individual (63.5 cm TL; 1,589, FFWCC 2007c). This survey applied the NMFS survey protocol and at that time it was realized that this protocol may need modification for use within the St. John system given the broad river coupled with fast moving water. Applying a revised protocol may either confirm the original observations or reveal a larger population (Shortnose Sturgeon Status Review Team 2010). No reproduction of sturgeon in the St. Johns River has ever been documented, and no large adults have been positively identified. Given the marginal spawning habitat, it is possible that shortnose sturgeon never actively spawned in the St. Johns. The species is retained in this analysis because the St. Marys and St. Johns Rivers may yet contain populations and these rivers may eventually serve the species in future recovery.

Habitat and Forage. Habitat use in fresh water during summer and winter months overlaps between adult and age-1 shortnose sturgeon (O'Herron II et al. 1993, Rogers and Weber 1995, Kynard et al. 2000). Kynard et al. (2000) found that both age classes preferred deep-water curves with sand and cobble to higher velocity runs during winter months and shifted to channel habitat as water temperatures rose in summer months. Many fish also exhibited diel movement patterns between deeper waters during the day and shallower waters at night (Kynard et al. 2000). During the summer, at the southern end of their range the species tends to congregate in cool, deep, areas of rivers (Flournoy et al. 1992a, Rogers and Weber 1995, Weber 1996).

Shortnose sturgeon have ventrally located, sucker-like mouths, structured for feeding on benthos. Foraging generally occurs in areas with abundant macrophytes, where juvenile and adult shortnose sturgeon feed on amphipods, polychaetes, and gastropods (Dadswell et al. 1984, Moser and Ross 1995, NMFS 1998a). Starting as larvae, sturgeon use electroreception to identify prey. Olfaction and taste are also likely important to foraging, while vision is thought to play a minor role (Miller 2004). As adults, a significant portion of the shortnose sturgeon diet may consist of freshwater mollusks (Dadswell et al. 1984). Based on observations by Kynard et al. (2000), shortnose sturgeon will consume the entire mollusk, excreting the shell after ingestion.

Threats. Yellow perch, sharks, and seals are predators of shortnose sturgeon juveniles (NMFS 1998a). Shortnose sturgeon have declined from the combined effects from the construction of hydropower and water diversion projects, dredging and blasting, water pollution, fisheries, and hatcheries. The construction of dams has resulted in substantial loss of shortnose sturgeon habitat and access to spawning areas along the Atlantic seaboard. The effects of fishing in the late nineteenth and early twentieth centuries may have latent and long-lasting impacts on some populations (NMFS 1998a).

Studies demonstrate that shortnose sturgeon carry a wide number of potentially hazardous contaminants. Individuals from the Delaware River contain heavy metals, dioxins, dibenzofurans, polychlorinated biphenyls, dichlorodiphenyltrichloroethane degradates, bis (2-ethylhexyl) phthalate, di-n-butylphthalate, and chlordane (ERC 2002). Most of these metals, dioxins, deibenzofurans, and polychlorinated biphenyls were also found in shortnose sturgeon in the Kennebec River (ERC 2003).

Climate change has the potential to affect sturgeon through disruption of spawning habitat, barriers to migration, and degraded water quality. Increased extremes in river flow can disrupt and fill in spawning habitat that sturgeon rely upon (ISAB 2007). Low flow rates during migration can impede or block sturgeon movement. Sturgeon are directly sensitive to elevated water temperatures. Increased mortality can occur if cooler water refuges are not available in freshwater habitats. If temperatures rise beyond thermal limits for extended periods, the species range can contract, as southern habitats may become uninhabitable (Lassalle et al. 2010). Apart from direct changes to sturgeon survival, altered water temperatures may also disrupt the availability of prey or result in increased water withdrawals to support agriculture (ISAB 2007).

Designated critical habitat. Designated critical habitat has not been established for shortnose sturgeon.

South Atlantic DPS Atlantic sturgeon

Description. Atlantic sturgeon are a long-lived, late maturing, iteroparous, anadromous species. They are bluish-black or olive brown with paler sides and a white belly. This species is a bottom-feeder that has a ventral suctorial mouth without teeth, four whiskers halfway between the snout and mouth, five rows of scutes (armor- like scales), and a tail longer on top than on the bottom. They grow to up to 800 pounds (370 kg) and 14 feet (4.3 m) long and the average lifespan is 60 years.

Status. NMFS listed five DPSs of Atlantic sturgeon: the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs as endangered and the Gulf of Maine DPS as threatened on February 6th 2012 (77 FR 5914). The Interim 4(d) Rule for Protective Regulations for the Gulf of Maine DPS was published November 11, 2013 (78 FR 69310).

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these. Record landings were reported in 1890, where over 3350 metric tons of Atlantic sturgeon were landed from coastal rivers along the Atlantic Coast (Smith and Clugston 1997, Matthiopoulos and Aarts 2010). Between 1890 and 1905, Atlantic sturgeon populations declined dramatically due to sale of meat and caviar. The fishery collapsed in 1901 and was closed by the Atlantic States Marine Fisheries Commission in 1998, when a coastwide fishing moratorium was imposed for 20 to 40 years, or at least until 20 year classes of mature female Atlantic sturgeon were present (ASMFC 1998). The Hudson River (New York Bight DPS) and Altamaha River (South Atlantic DPS) are the two largest spawning populations on the East Coast. Kahnle et al. (2007) reported that approximately 870 adults per year returned to the Hudson River between 1985 and 1995. Peterson et al. (2008) reported that approximately 324 and 386 adults per year returned to the Altamaha River in 2004 and 2005, respectively. Other DPSs within the U.S. are predicted to have fewer than 300 adults spawning per year. However, evaluating the status of the species depends on the status of the smaller extant populations because maintaining those populations maintains genetic heterogeneity and having a broad range prevents a single catastrophic event from causing their extinction.

Habitat, lifecycle, and forage. Modern genetic analyses suggest that, despite extensive mixing in coastal waters, Atlantic sturgeon exhibit high fidelity to their natal rivers (Harwood 2010) and most rivers appear to support independent populations (Waldman and Wirgin 1998, Wirgin et al. 2000, King et al. 2001, Wirgin et al. 2002, Grunwald et al. 2008). Sub-adult and adult Atlantic sturgeon spend most of their life in the marine environment. Migratory sub-adults and adults normally occur in shallow (10-50m) waters dominated by gravel and sand substrate (Stein et al. 2004). Spawning adults generally migrate upriver in the spring and early summer; this includes February-March in southern systems, April-May in mid-Atlantic systems, and May-July in Canadian systems (Smith 1985, Bain 1997, Smith and Clugston 1997, Kahnle et al. 1998b).

Sturgeon larvae assume a bottom-dwelling existence until the yolk sac is absorbed then move downstream to rearing grounds (Kynard and Horgan 2002) using benthic structure (e.g., stream bed gravel matrix) as day-time refugia (Kynard and Horgan 2002). Juvenile sturgeon continue to move further downstream into brackish waters, and eventually become residents in estuarine waters for months or years. Estuaries along the coast that do not support Atlantic sturgeon spawning populations may still be important rearing, feeding, and migration habitats (Harrison and Thurley 1974, Dovel and Berggren 1983, Bain 1997).

Atlantic sturgeon feed primarily on polychaetes, isopods, and amphipods in the marine environment, while in fresh water, they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Moser and Ross 1995, Johnson et al. 1997, Haley 1998, Haley 1999, Brosse et al. 2002, Guilbard et al. 2007, Savoy 2007, Collins et al. 2008). There is conflicting evidence whether fish forage in the springtime or in freshwater (Brosse et al. 2002, Collins et al. 2008).

Water quality conditions required by the species were reviewed in Schlenger et al. (2013). Minimum water quality requirements for young-of-year sturgeon include water temperatures of 0-28^{o}C, salinity of 0-22 ppt, and DO concentrations of at least 3.3 mg/L. Optimal conditions for young-of-year fish are water temperatures of 16-24 ^{o}C, 3.5 to 18.5 ppt salinity, and DO concentration of 5 mg/L. Yearlings differ from young-of-year fish only in their salinity tolerance and optima, with salinities of 0-29 ppt required and 18.5-25.5 ppt salinity optimal.

Use of Florida Waters. Atlantic sturgeon were abundant in the St. Marys and St. Johns Rivers prior to 1884 (Hamlen 1884). Atlantic sturgeon were once thought to be extirpated in the St.

Marys River. Recent captures of sub-adult sturgeon suggest the potential for regaining breeding populations in Florida. The FFWCC's 2011 Biological Status Review reported these captures:

> *In January 2010, shrimp try-nets in 15 meter depths were used for chase-trawling chilled sea turtles during Kings Bay Trident submarine channel maintenance. During this exercise, a trawler netted and released 21 sub-adult (~1 meter) Atlantic sturgeon in the St. Marys estuary (Slay, Pers. Comm. 2010). Dr. Doug Peterson's University of Georgia sampling study also captured nine subadult (~1 meter) Atlantic sturgeon in the tidally-influenced St. Marys, ranging through summer, fall, and winter captures during 2010 (Peterson, Pers. Comm. 2010). In February of 2011, two year-one/year-two juvenile (~40 centimeter) Atlantic sturgeon were caught on hook and line, from the shore, in the St. Johns River (Snyder, Pers. Comm. 2011). This could suggest that the nearby Atlantic sturgeon populations are increasing sufficiently to re-establish resident juvenile populations in the St. Marys and St. Johns Rivers. This is the first step, which necessarily precedes the St. Marys River and St. Johns River regaining their own breeding populations, as the resident juveniles mature. So the status is "extirpated or nearly extirpated, but migrants are occupying northeast Florida rivers."*

During time of criteria development (2012-2013), FDEP sought advice from NMFS Southeast Region on the use of Florida waters by ESA-listed sturgeon. NMFS Southeast Region reported that most of the sturgeon captures in the St. Marys occurred between river km 26 and 44 and that there is no evidence that spawning has occurred in the St. Marys River due to unfavorable natural conditions. Sturgeon were captured in portions of the river having limited anthropogenic inputs, but at DO levels as low as 2.7 mg/L. FDEP attributes low DO levels in the St. Marys to natural wetland inputs, contributions of organic matter from bankside vegetation, and low flows.

The St. Marys River accounts for 30 of the 34 recorded Atlantic sturgeon captures in Florida. Captures have also been reported in the Nassau (1 capture) and St. Johns Rivers (3 captures), but these are considered vagrant occurrences (FFWCC, 2013). More recently, the June 3, 2016, NMFS proposed designated critical habitat for the South Atlantic DPS of the Atlantic sturgeon to include the St. Marys River. The St. Marys was identified as a spawning river for Atlantic sturgeon based on the capture of young-of-year Atlantic sturgeon. Nine Atlantic sturgeon were captured in sampling efforts between May 19 and June 9, 2014. Captured fish ranged in size from 293 mm (young-of-year) to 932 mm (subadult). This is a possible indication of a slow and protracted recovery in the St. Marys (see 81 FR 36077). Meanwhile the proposed designated critical habitat did not include the St. Johns River because it does not appear to support spawning and juvenile recruitment or contain suitable habitat features to support spawning because spawning areas are inaccessible due to man-made structures and alterations. In the southeast U.S., Atlantic sturgeon appear to spawn in the fall (J. Kahn, NMFS OPR, pers. comm. to P. Shaw-Allen, NMFS OPR, June 28, 2015).

The map in Figure 12 identifies the distribution and sites of capture for Atlantic sturgeon in Florida up to 2013. The St. Marys River accounts for 30 of the 34 recorded Atlantic sturgeon captures in Florida. Captures have also been reported in the Nassau (1 capture) and St. Johns Rivers (3 captures), but these are considered vagrant occurrences (FFWCC, 2013). More recently, the June 3, 2016, NMFS proposed designated critical habitat for the South Atlantic DPS of the Atlantic sturgeon to include the St. Marys River. The St. Marys was identified as a spawning river for Atlantic sturgeon based on the capture of young-of-year Atlantic sturgeon. Nine Atlantic sturgeon were captured in sampling efforts between May 19 and June 9, 2014. Captured fish ranged in size from 293 mm (young-of-year) to 932 mm (subadult). This is a possible indication of a slow and protracted recovery in the St. Marys (see 81 FR 36077). Meanwhile the proposed designated critical habitat did not include the St. Johns River because it does not appear to support spawning and juvenile recruitment or contain suitable habitat features to support spawning because spawning areas are inaccessible due to man-made structures and alterations.

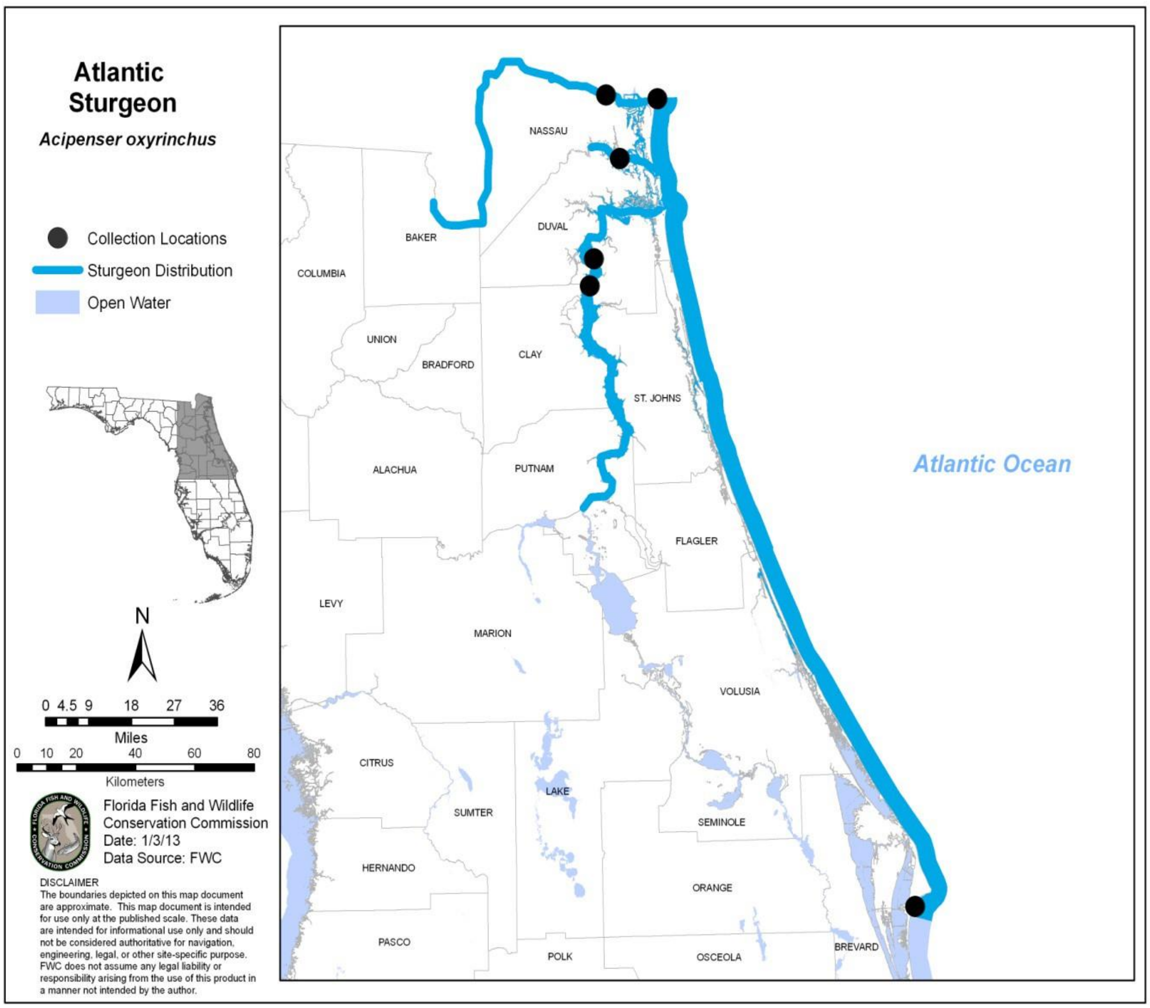

Figure 12: Florida Priority Watershed Areas Known or Having Potential to Harbor Atlantic Sturgeon.

Threats. Alee effects, the phenomenon of declining individual fitness in sparse populations, may be influencing small populations in some rivers. Water quality, ship strikes, bycatch, dams, and poaching all contribute to currently depressed populations of Atlantic sturgeon.

The 2011 biological status review report (FFWCC, 2011) placed a priority on habitat management actions that restore minimum DO concentrations exceeding 3.0 ppm throughout river systems.

In large river systems like the Delaware, James and Hudson rivers, large ships move upstream from the mouths of the river to ports upstream through narrow shipping channels. The channels are dredged to the approximate depth of the ships, usually leaving less than 6 feet of clearance between the bottom of ships and the benthos of the river. Because of the size of the propellers used on large ships, everything along the bottom is sucked through the propellers. The act of dredging channels can also kill sturgeon. Dredging projects in the Kennebec, Delaware, James, Cape Fear, and Savannah Rivers put Atlantic sturgeon at moderate risk (Atlantic Sturgeon Status Review Team 2007). Dredging primarily affects sturgeon by removing food resources and homogenizing habitat, eliminating holding areas and other high quality habitat.

Atlantic sturgeon are caught as bycatch in several fisheries both within river systems and along the coast. In the James River, bycatch in the striped bass fishery poses a moderately high risk to the species, while it poses a moderate risk in nearly every other river system on the East Coast (Atlantic Sturgeon Status Review Team 2007). While these determinations were made for Atlantic sturgeon in each river system, the majority of the commercial fisheries interactions occur in estuaries and along the coast, where sturgeon from all rivers could be captured as bycatch.

On the East Coast, there is no good means of fish passage for Atlantic sturgeon in the systems with dams. Sturgeon in the Santee-Cooper River system and the Cape Fear River are at a moderately high risk because of dams. Additionally, sturgeon in the Neuse River are at a moderate risk from dams.

Industrialization, poor water quality, and loss of habitat adversely affect Atlantic sturgeon populations (Van Eenennaam et al. 1996, Jager et al. 2001, Collins et al. 2002, Stein et al. 2004). Most Atlantic sturgeon managers and researchers consider water quality as a moderate risk to every DPS in the United States (Atlantic Sturgeon Status Review Team 2007). Atlantic sturgeon are sensitive to pesticides, heavy metals, and other toxins in the aquatic environment.

Designated critical habitat. Designated critical habitat has not been proposed for Atlantic sturgeon.

Gulf Sturgeon

Effects of the FDEP criteria on the Gulf sturgeon were previously evaluated by the USFWS. The jurisdictional disposition for ESA section 7 consultations for the Gulf sturgeon was clarified in the designated critical habitat designation. The USFWS is responsible for all consultations regarding Gulf sturgeon and designated critical habitat in all riverine actions and in those estuarine actions for which the EPA is the action agency. NMFS is responsible for all consultations regarding Gulf sturgeon and designated critical habitat in marine waters. Federal projects that extend into the jurisdiction of both the Services are to be consulted on by the USFWS with internal coordination with NMFS. While EPA's approval of the FDEP water quality criteria is within the jurisdiction of both USFWS and NMFS, internal consultation by USFWS with NMFS was not necessary because NMFS provided technical assistance to FDEP in the development of the criteria. For this reason, Gulf sturgeon are not considered further in this opinion.

Nassau grouper

Description. The Nassau grouper is a long-lived, moderate sized marine fish with large eyes and a robust body. The range of color is wide, but ground color is generally buff, with 5 dark brown vertical bars and a large black saddle blotch on top of caudal peduncle and a row of black spots below and behind eye. Color pattern can change within minutes from almost white to bicolored to uniformly dark brown, according to the behavioral state of the fish (Longley 1917, Colin 1992, Heemstra and Randall 1993, Carter et al. 1994).

Status. The Nassau grouper has been designated a candidate species since 1991. NMFS began a status review on the species in 1993 and identified research that needed to be conducted to fill some of the gaps in the information concerning the species biology, genetics and habitat requirements. Under the authority of the Magnuson-Stevens Fishery Conservation and Management Act, NMFS classified the Nassau grouper as "overfished" in its October 1998 "Report to Congress on the status of Fisheries and Identification of overfished Stocks." The species was proposed for listing as a threatened species under the ESA September 2, 2014 (79 FR 51929). The final listing for this species was published on June 29, 2016 to become effective July 29, 2016 (81 FR 42268).

Habitat, lifecycle, and forage. The Nassau grouper is primarily a shallow-water, insular fish species found from inshore to about 330 feet (100m) depth. The species is considered a reef fish, but it transitions through a series of developmental shifts in habitat. As larvae, they are planktonic. After an average of 35-40 days and at an average size of 32 mm (total length or TL), larvae recruit from an oceanic environment into demersal habitats (Colin 1992, Eggleston 1995). Following settlement, Nassau grouper juveniles are reported to inhabit macroalgae (primarily Laurencia spp.), coral clumps (*Porites* spp.), and seagrass beds (Eggleston 1995, Dahlgren 1998). Juvenile Nassau grouper (120-150 mm TL) are relatively solitary and remain in specific areas for months (Bardach 1958). Juveniles of this size class are associated with macroalgae, and both natural and artificial reef structure. As juveniles grow, they move progressively to deeper areas and offshore reefs (Brill et al. 2008, Colin et al. 1997). Schools of 30-40 juveniles (250-350 mm TL) were observed at 8-10 m depths in the Cayman Islands (Brill et al. 2008). No clear distinction can be made between types of adult and juvenile habitats, although a general size segregation with depth occurs—with smaller Nassau grouper in shallow inshore waters (3 to 16

m) and larger individuals more common on deeper (17 to 55 m) offshore banks (NMFS 2013). Adult Nassau grouper tend to be relatively sedentary and are generally associated with high relief coral reefs or rocky substrate in clear waters to depths of 130 m.

Maximum age has been estimated up to 29 years, based on an ageing study using sagittal otoliths (Belcher and Jennings 2010). Most studies also indicate rapid growth, which has been estimated to be about 10 mm/month TL for small juveniles, and 8.4 to 11.7 mm/month for larger juveniles (30-270 mm TL; Beets and Hixon 1994, (Eggleston 1995). Maximum size is about 122 cm TL and maximum weight is about 25 kg (Heemstra and Randall 1993, Humann and DeLoach 2002). Generation time (the average age of parents in the population) is estimated as 9-10 years (Sadovy and Colin 1995). Nassau grouper reproduce in site specific spawning aggregations. Spawning aggregations, of a few dozen up to perhaps thousands of individuals have been reported from the Bahamas, Jamaica, Cayman Islands, Belize, and the Virgin Islands. These aggregations occur in-depths of 20-40 mat specific locations of the outer reef shelf edge. Spawning takes place in December and January, around the time of the full moon, in waters 25-26 degrees C.

Use of Florida Waters. The species is distributed throughout the islands of the western Atlantic including Bermuda, the Bahamas, southern Florida and along the coasts of central and northern South America. It is not known from the U. S. Gulf of Mexico except at Campeche Bank off the coast of the Yucatan Peninsula, at Tortugas, and off Key West. Adults are generally found near coral reefs and rocky bottoms while juveniles are found in shallower waters in and around coral clumps covered with macroalgae (*Laurencia* spp.) and over seagrass beds. Their diet is mostly fishes and crabs, with diet varying by age/size. Juveniles feed mostly on crustaceans, while adults (>30 cm; 11.8 in) forage mainly on fish. The Nassau grouper usually forages alone and is not a specialized forager.

Threats. Because Nassau grouper spawn in aggregations at historic areas and at very specific times, they are easily targeted during reproduction. Because Nassau grouper mature relatively late (4-8 years), many juveniles may be taken by the fishery before they have a chance to reproduce.

Designated critical habitat. Designated critical habitat is not designated for species proposed for listing as endangered or threatened under the ESA.

CORALS

Seven species of hard corals that occur within Florida waters are listed as threatened under the ESA: elkhorn coral, staghorn coral, lobed star coral, boulder star coral, mountainous star coral[5], pillar coral, and rough cactus coral. Elkhorn and staghorn corals were listed together as threatened under the ESA on May 9, 2006 (71 FR 26852). The remaining species were listed as threatened on September 10, 2014 (79 FR 53852).

[5] This species presence is based on a strong prediction of occurrence and not confirmed record (Veron 2014).

Hard corals are colonies of small animals with calcium carbonate skeletons that collaboratively form reefs by creating structures that are firmly attached to the sea floor. Rapid calcification by hard corals is made possible by the symbiotic algae which reside within coral polyps, called zooxanthellae. Reef-building corals do not thrive outside of an area characterized by a fairly narrow mean temperature range (typically 25 °C-30 °C). Soft corals differ from hard corals in that they are flexible, have calcareous particles in their body walls for structural support, can be found in both tropical and cold ocean waters, do not grow in colonies or build reefs, and do not always contain zooxanthellae.

Zooxanthellae photosynthesize during the daytime producing energy for the host coral. At night, polyps extend their tentacles to filter-feed on microscopic particles in the water column such as zooplankton, providing additional nutrients for the host coral. In this way, reef-building corals obtain nutrients autotrophically (i.e., via photosynthesis) during the day, and heterotrophically (i.e., via predation) at night.

Most coral species use both sexual and asexual propagation. Asexual reproduction most commonly involves fragmentation, where colony pieces or fragments are dislodged from larger colonies to establish new colonies, although the budding of new polyps within a colony can also be considered asexual reproduction. In many species of branching corals, fragmentation is a common and sometimes dominant means of propagation.

Biological and physical factors affect spatial and temporal patterns of recruitment. These include substrate availability and community structure, grazing pressure, fecundity, mode and timing of reproduction, behavior of larvae, hurricane disturbance, physical oceanography, the structure of established coral assemblages, and chemical cues (Lewis 1974, Birkeland 1977, Goreau et al. 1981, Rogers et al. 1984a, Baggett and Bright 1985, Harriott 1985, Hughes and Jackson 1985, Sammarco 1985, Morse et al. 1988, Fisk and Harriott 1990, Richmond and Hunter 1990).

Threats common to corals. The coral species living off the coast of Florida are vulnerable to the same anthropogenic stressors which threaten corals worldwide: climate change, fishing impacts, and pollution. The following discussion was adapted from the NOAA Coral Reef Conservation Program threat summaries (http://coralreef.noaa.gov/threats, July 13, 2015), the NOAA South East Region fisheries recovery outline for ESA-listed corals in the region, and the listing documentation for corals listed as threatened under the ESA.

Increased water temperatures and ocean acidification resulting from climate change increases coral vulnerability to infection or disease and bleaching and impairs the construction and maintenance of calcium carbonate-based skeletal frameworks. Ocean acidification is caused by increased dissolved CO_2 in ocean water. This changes the solubility and form of sea water minerals in even slightly more acidic sea water. Most critically, acidification reduces seawater saturation with aragonite, the form of calcium carbonate used by corals and other marine species to construct protective shells and skeletal frameworks, thereby eroding the shells which form coral hard parts (Anthony et al. 2008, De’ath et al. 2009, Wei et al. 2009, Crawley et al. 2010).

Acidification also reduces thermal tolerance of corals, meaning that bleaching can occur at lower temperatures (Anthony et al. 2008).

Mass coral bleaching, which results from the expulsion of the symbiotic zooxanthellae algae, is linked to excursions in ocean temperatures outside of coral physiological tolerances. Warm water bleaching events typically co-occur with high subsurface light levels and are associated with major El Niño-Southern Oscillation events (e.g., 1982–83, Glynn and D'croz 1990; 1997–98, Wilkinson 2000; and 2002, Berkelmans et al. 2004) . Laboratory experiments have confirmed this association (Coles and Jokiel 1978), (Glynn and D'croz 1990). Increased coral mortality due to the stress from bleaching alters reef habitats, structures, and biodiversity (Eakin 2001), (Graham et al. 2006). The most severe and extensive Caribbean mass warm water bleaching event occurred in 2005. Only localized warm water bleaching was observed in the years between 2006 and 2013 (Walter 2014 after Manzello 2015) and a cold water bleaching event occurred in the Florida Keys over the winter of 2009-2010. In 2005, wide-scale bleaching occurred throughout the Caribbean with wide-scale mortality, with some areas reaching 95 percent of coral colonies affected (Wilkinson and Souter 2008). Puerto Rico and Florida also experienced disease rates of 50 percent of coral colonies or greater. Following the 2005 bleaching event, monitoring data indicate that total coral cover is now less than 12 percent on many reefs (Rogers et al. 2008). Coral mortality due to the 2005 bleaching event was more severe than at any time in the last 40 years of monitoring in U.S. Virgin Islands (Woody et al. 2008). Bleaching events can lead to increased thermal tolerance in affected reefs, meaning that subsequent bleaching events are not as severe (Maynard et al. 2008).

Taken together, disease and ocean warming are major threats affecting the potential for coral recovery in the southeast U.S. because they are severe, ongoing, synergistic, and have increased in the recent past. Mortality rates after disease and bleaching events have not been compensated for through recruitment or growth. Sea-surface temperature is expected to continue to rise over time and exacerbate disease impacts. Climate change effects will impact corals, such as sea level rise, altered ocean circulation, and changes in the frequency, intensity, and distribution of tropical storms. These changes may increase physical damage to coral reefs (Madin et al. 2012, Teixido et al. 2013) or harm corals by severely reducing salinity with large influxes of stormwater runoff (Berkelmans et al. 2012, Lough et al. 2015). Hurricanes fueled by warmer waters can cause wide-scale inhibition of recruitment in years following storm passage as well as physical damage to coral colonies themselves (Mallela and Crabbe 2009). A record number of hurricanes in 2005 caused extensive damage to coral reefs; the prevalence of hurricanes and subsequent coral reef damage has been linked to climate change (Wilkinson and Souter 2008).

Fishing impacts on coral reefs include direct harvests of coral, cascading effects due to the removal or reduction of important functional species from coral reef communities, and physical damage by certain fishing gears and fishing methods that can directly contact coral reefs and the anchoring of fishing vessels on coral reefs. Cascading effects resulting from altered trophic structure of the reef community degrades coral condition and habitat and increases synergistic stress effects (e.g., bleaching, disease).

Coastal development contributes localized threats through run-off of land-based pollutants, including excess nutrients and sediment, and through physical damage from activities such as dredging, cable and pipeline deployment, construction, and beach nourishment. Suspended sediment and sediment deposition act to limit coral growth, feeding patterns, photosynthesis, recruitment, and survivorship. Reductions in long-term water clarity can also reduce the coral photosynthesis to respiration ratio. Telesnicki and Goldberg (1995) and Yentsch et al. (2002) found that elevated turbidity levels did not affect gross photosynthetic oxygen production, but did lead to increased respiration that consumed the products of photosynthesis with little remaining for coral growth. Excessive sedimentation can smother corals and increased nutrient availability promotes algal growth on corals, leading to light blockage to zooxanthellae and death of corals (*Acropora* Biological Review Team 2005). Although reefs in the Florida Keys currently experience about 10 percent macroalgal cover or less, much of the wider Caribbean Sea may exceed 20 percent cover (Bruno 2008), inhibiting and reducing coral survival.

The Acropora: Elkhorn and Staghorn Coral

Description. Elkhorn coral forms frond-like branches radiating from a central trunk. Colonies can reach 6.6 feet high and 13 feet in diameter (Veron 2000). Corallites (branches) are tube-like and porous, 0.08 inch to 0.16 inch long, about 0.08 inch in diameter, white near the growing tip, and brown to tan away proximally. Staghorn coral branches are irregular, with secondary branches forming at 60 to 90 degree angles relative to a primary branch branches. Individual colonies are up to 5 feet across and typically form monospecific thickets. Branches are 0.1 inch to 0.6 inch in diameter and rarely may grow back together. Prominent axial corallites form at branch tips; bract-like corallites radiate symmetrically around branches. Tissue color ranges from golden yellow to medium brown, with little or no color near the growing branch tips.

Status. Precipitous declines for these species began in the early 1980s throughout their range. Although quantitative data on historical distribution and abundance are scarce, best available data indicate declines in abundance (coverage and colony numbers) by greater than 97 percent. Monitoring data do not indicate significant recovery after the widespread mortality associated with the 2005 bleaching event (Rothenberger et al. 2008, Woody et al. 2008). Overall, colonies of Atlantic *Acropora* have declined by up to 98 percent and live colonies were no longer present at many study sites in the U.S. Virgin Islands following the 2005-2006 bleaching event.

Both species occur in the Florida Keys, Abaco Island (The Bahamas), Alacran Reef, Mexico, Belize, Colombia, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, Venezuela, Bonaire, Cayman Islands, Jamaica, Puerto Rico, U.S. Virgin Islands, Navassa, and throughout the West Indies (Goreau 1959, Kornicker and Boyd 1962, Storr 1964, Scatterday 1974, Jaap 1984, Dustan and Halas 1987, NMFS 2006a). However, abundance within the distribution is reduced, largely due to water temperature and quality issues.

Growth and reproduction. Branching species, such as acroporid corals, grow differentially in response to light such that coral polyp growth maximizes exposure to available light (Kaniewska et al. 2009). The dominant mode of reproduction for elkhorn and staghorn corals is asexual fragmentation and dispersal (Tunnicliffe 1981, Bak and Criens 1982). Sexual reproduction is accomplished by releasing sperm and egg during spawning events. Colonies are referred to as simultaneous hermaphrodites, meaning that a given colony contains both female and male reproductive sex organs (Szmant 1986). Spawning events are relatively short, with gametes released only a few nights during July, August, and/or September. Once fertilization occurs, planktonic larvae form before settling and metamorphosizing on appropriate substrates, preferably coralline algae (Bak 1977, Sammarco 1980, Rylaarsdam 1983). Initial calcification ensues and develop into daughter corallites. Studies indicate that larger colonies (as measured by surface area of the live colony) have higher fertility and fecundity rates (Soong and Lang 1992).

Biological and physical factors affect spatial and temporal patterns of recruitment. These include substrate availability and community structure, grazing pressure, fecundity, mode and timing of reproduction, behavior of larvae, hurricane disturbance, physical oceanography, the structure of established coral assemblages, and chemical cues (Lewis 1974, Birkeland 1977, Goreau et al. 1981, Rogers et al. 1984a, Baggett and Bright 1985, Harriott 1985, Hughes and Jackson 1985, Sammarco 1985, Morse et al. 1988, Fisk and Harriott 1990, Richmond and Hunter 1990). Larval recruitment is influenced by the type and availability of benthic substrate, with certain types of coral or rock substrates resulting in greater or lesser recruitment success (Ritson-Williams et al. 2009).

Habitat. Although staghorn coral colonies are sometimes found interspersed among colonies of elkhorn coral, they are generally in deeper water or seaward of the elkhorn zone and more protected from wave action. Staghorn coral occur in back reef (landward slope) and fore reef (seaward slope) environments from 0-100 feet (0 to 30 m) deep. The upper limit is defined by wave forces, and the lower limit is controlled by suspended sediments and light availability. Fore reef zones at intermediate depths of 15-80 feet (5-25 m) were formerly dominated by extensive single species stands of staghorn coral until the mid-1980s. In southeastern Florida, this species historically occurred on the outer reef (52 to 66 feet), on spur, groove bank, and transitional reefs, and on octocoral-dominated hard-bottom (Goldberg 1973, Davis 1982, Jaap 1984, Wheaton and Jaap 1988). Colonies were common in back- and patch-reef habitats (Gilmore and Hall 1976, Cairns 1982).

Colonies of elkhorn coral often grow in dense stands and form interlocking framework known as thickets in fringing and barrier reefs, ranging in-depth from 3.3 to 49 feet (Jaap 1984, Dustan 1985, Dustan and Halas 1987, Tomascik and Sander 1987, Wheaton and Jaap 1988). However, optimal depth range is considered to be 3.3 to 16.4 feet in-depth, with possible exposure at low tide (Goreau and Wells 1967). Elkhorn coral thrive in shallow reef zones where wave energy is a significant factor. In areas with strong wave energy conditions only isolated colonies occur, while denser thickets may develop in intermediate wave energy conditions (Geister 1977). The preferred habitat of elkhorn coral is the seaward face of a reef (Shinn 1963, Cairns 1982, Rogers et al. 1982)

Threats. White band disease is thought to be the major factor responsible for the rapid loss of Atlantic *Acropora* due to mass mortalities. White band disease is the only coral disease to date that has been documented to cause major changes in the composition and structure of reefs (Humann and Deloach 2003). In 2011, Sutherland et al. (2011) were able to definitively identify human waste as a cause for white pox disease in elkhorn corals.

While the dominant mode of reproduction for elkhorn and staghorn corals is asexual fragmentation allows rapid recovery from physical disturbances such as storms, this mode of reproduction makes recovery from disease or bleaching episodes (in which entire colonies or even entire stands are killed) very difficult. The large role of asexual reproduction in both species increases the likelihood that genetic diversity in remnant populations may be very low. As broadcast spawners once colonies become rare, the distance between colonies may limit fertilization success and there is substantial evidence to suggest that sexual recruitment of staghorn corals is currently compromised. Reduced colony density in some areas is compounded by low genotypic diversity, indicating that fertilization success and consequently, larval availability, is likely reduced. This can have long-term implications for genetic variability of remaining colonies due to the reduced potential for exchange of genetic material between populations that are spatially further apart (Bruckner 2002).

Both elkhorn and staghorn coral require relatively clear water. The many small polyps and branching morphology of these corals optimizes light capture. This morphology is inefficient for zooplankton capture because zooplankton does not uniformly saturate the water column as light does, so densely arrayed polyps cannot be equally nourished through heterotrophy (Porter 1976). Elkhorn and staghorn corals therefore depend almost entirely upon symbiotic photosynthesizers for nourishment, making them more susceptible to increases in water turbidity and temperature. Different strains of symbiotic zooxanthellae (*Symbiodinium* spp.) can confer different thermal and light tolerances to acroporid (Abrego et al. 2009, Ainsworth and Hoegh-Guldberg 2009, Abrego et al. 2010).

Elkhorn and staghorn corals are also particularly susceptible to damage from sedimentation. Synergistic analyses have found that high temperature increases the risk of colony mortality under a variety of sediment loading conditions, but excessive sediment appears to reduce mortality risk under high light and temperature regimes, possibly by reducing exposure to these stressors (Anthony et al. 2007, Boyett et al. 2007). High sediment with otherwise good light and temperature conditions appears to increase colony mortality (Anthony et al. 2007). High temperature or rapid heating can result in heat shock and alter cellular metabolism within the coral as well as possibly hinder immune response or the ability of zooxanthellae to thrive (Rodriguez-Lanetty et al. 2009, Middlebrook et al. 2010). High sediment with otherwise good light and temperature conditions appears to increase colony mortality.

Designated critical habitat. NMFS published a final rule to designate designated critical habitat for elkhorn and staghorn corals on November 26, 2008 (73 FR 72210). This habitat serves as substrate of suitable quality and availability, in water depths from the mean high water line to 98 feet (except along some areas of Florida, where 6 foot contour is the shoreward limit), to support successful larval settlement, recruitment, and reattachment of fragments. Four specific areas are proposed for designation: the Florida unit, which comprises approximately 1,329 square miles of marine habitat (Section 4.1.2; Figure 13); the Puerto Rico unit, which comprises approximately 1,383 square miles of marine habitat; the St. John/St. Thomas unit, which comprises approximately 121 square miles of marine habitat; and the St. Croix unit, which comprises approximately 126 square miles of marine habitat. There is a single physical feature that is essential to the conservation of the species: natural consolidated hard substrate or dead coral skeleton that are free from fleshy or turf macroalgae cover and sediment cover. This feature is essential to the conservation of these two species because of the extremely limited recruitment observed and the need for this species to have suitable recruitment habitat.

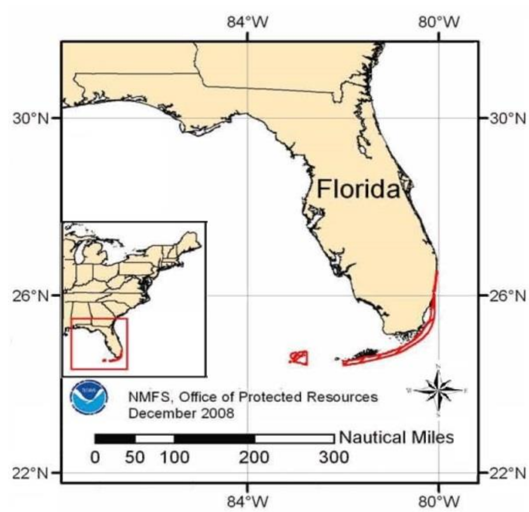

Figure 13. *Acropora* Designated Critical Habitat in Florida.

The Orbicella: Lobed Star Coral, Boulder Star Coral, and Mountainous Star Coral

Description. Lobed star coral is distinguished by large, unevenly arrayed polyps that give the colony its characteristic irregular surface. Colony form is variable, and the skeleton is dense with poorly developed annual bands (Weil and Knowlton 1994). Colony diameter can reach up to 5 m with a height of up to 2 m. Common colors are green, grey, and brown (Szmant et al. 1997).

Boulder star coral colonies grow in columns that exhibit rapid and regular upward growth. In contrast to the other species, margins on the sides of columns are typically senescent (Weil and Knowlton 1994). Live colony surfaces usually lack ridges or bumps. Corallites on tops of columns are closely packed, uniformly distributed, and evenly exsert, with maximum diameters of mature corallites typically 2.1–2.6 mm.

Mountainous star coral grows in heads or sheets, the surface of which may be smooth or have keels or bumps. Septa are highly exsert and the skeleton is much less dense than in the other two ESA-listed *Orbicella* species (Weil and Knowlton 1994). Colony diameter can reach up to 10 m with a height of 4–5 m (Szmant et al. 1997). Common colors are grey, green, and brownish (Szmant et al. 1997).

Status. The ESA-listed star corals are found throughout the Caribbean Sea, including the Bahamas and Flower Garden Banks. The range is restricted to the west Atlantic and there is no range fragmentation. There is also a reliable record for boulder star coral in Bermuda and some evidence that lobed star coral may be found in Bermuda as well (Veron 2014).

Star coral species have historically been a dominant species on Caribbean coral reefs, characterizing the so-called “buttress zone” and “annularis zone” in the classical descriptions of Caribbean reefs (Goreau 1959). While declines in the two ESA-listed *Acropora* species began in the early-to-mid-1980s, declines in star coral species were first noticed in the Florida Keys during the mid-1970s and became obvious in the 1990s and 2000s, most often associated with combined disease and bleaching events. It should be noted that, given the dramatically low productivity of the star coral species (low growth and extremely low recruitment), any substantial declines in adult populations would suggest increased extinction risk since their capacity for population recovery is extremely limited.

In Florida, the percent cover data from four fixed sites have shown the star coral species have declined in absolute cover from 5 percent to 2 percent in the Lower Keys between 1998 and 2003 as well as 5– 40 percent colony shrinkage and virtually no recruitment (Smith et al. 2008). Earlier studies from the Florida Keys indicated a 31 percent decline of star coral species absolute cover between 1975 and 1982 (Dustan and Halas 1987) at Carysfort Reef and greater than 75 percent decline (from over 6 percent cover to less than 1 percent) across several sites in Biscayne National Park between the late 1970s and 1998–2000 (Dupont et al. 2008). Taken together, these data imply extreme declines in the Florida Keys (80-95 percent) between the late 1970s and 2003, and it is clear that further dramatic losses occurred in this region during the cold weather event in January 2010. Similar declines have also been documented for relatively remote Caribbean reefs. At Navassa Island National Wildlife Refuge, percent cover of star coral species on randomly sampled patch reefs declined from 26 percent in 2002 to 3 percent in 2009, following disease and bleaching events in this uninhabited oceanic island (Miller and Williams 2007). Additionally, two offshore islands west of Puerto Rico showed reductions in live colony counts of 24 percent and 32 percent between 1998/2000 and 2008 (Bruckner and Hill 2009). Cumulatively, decadal-scale declines across these remote islands in the central Caribbean constitute over 85 percent of the populations. In the U.S. Virgin Islands, data show a decline of star coral species from just over 10 percent cover in 2003 to just over 3 percent cover in 2009 following mass bleaching and disease impacts in 2005 (Miller et al. 2009). This degree of recent decline was preceded by a decline from over 30 percent star coral species cover to about 10 percent between 1988 and 2003 (Edmunds and Elahi 2007). Similarly, percent cover of star corals in a marine protected area in Puerto Rico declined from 49 percent to 8 percent between 1997 and 2009 (Hernandez-Pacheco et al. 2011). Data suggest an 80-90 percent decline in star corals species over the past two decades in the main U.S. Caribbean territories. While Bak and Luckhurst (1980) indicated stability in star coral species cover across depths in Curaçao in the mid-1970s, this region has also manifested star coral declines in recent years. Bruckner and Bruckner (2006b) documented an 85 percent increase in the partial star coral colony mortality across three reefs in western Curaçao between 1998 and 2005, approximately twice the level for all other scleractinian species combined.

Star coral species' declines in additional locations can be noted. At Glovers Reef, Belize McClanahan and Muthiga (1998) documented a 38-75 percent decline in relative cover of star coral species across different reef zones between 1975 and 1998, and a further 40 percent decline in relative cover has occurred since then (Huntington et al. 2011). In contrast, star coral populations have shown stable status at sites in Columbia between 1998 and 2003 (Rodríguez-Ramírez et al. 2010), although demographic changes in star coral species at both degraded and less-degraded reefs imply some degree of population decline in this region (Alvarado-Chacón and Acosta 2009).

The boulder star coral, in particular, has a very high estimated extinction risk based on very low productivity (growth and recruitment), documented dramatic declines in abundance, its restriction to the degraded reefs of the wider Caribbean region, and its preferential occurrence in shallow habitats (yielding potentially greater exposure to surface-based threats).

Lobed star coral had a marginally lower estimated extinction risk than the other two *Orbicella* species because of its greater distribution in deep and mesophotic depth habitats, which are not expected to be as vulnerable to some surface-based threats. The overall likelihood that boulder star coral will fall below the critical risk threshold by 2100 was estimated to be in the "likely" risk category with a mean likelihood of 78 percent and a standard error (SE) of 7 percent. The overall likelihood that lobed star coral will fall below the critical risk threshold by 2100 was also estimated to be "likely" (mean likelihood 74 percent, SE of 9 percent), as was the extinction risk for mountainous star coral (mean likelihood of 78 percent and a SE of 7 percent).

Growth and reproduction. (Hubbard and Scaturo 1985) reported that star coral growth rates were consistently higher in the clear waters than those at a more turbid and sediment rich site, confirming that light and sediment load are controlling factors of growth rates. All three of the ESA-listed star coral species are hermaphroditic broadcast spawners, with spawning concentrated on nights 6–8 following the new moon in late summer (Levitan et al. 2004). Fertilization success is highly linked to the number of colonies observed spawning at the same time (Levitan et al. 2004). Eggs and larvae are small and post-settlement growth rates are very slow, both of which may contribute to extremely low post-settlement survivorship *(*Szmant and Miller 2005). There may be a depth-related fecundity cost arising from morphological differences in polyp spacing (Villinski 2003), suggesting the spatial distribution of colonies may influence population fecundity on a reef. Studies from throughout the Caribbean report recruitment to be negligible to absent (Bak and Engel 1979, Rogers et al. 1984b). Despite their generally massive form, at least the lobate star coral form is capable of some degree of fragmentation/fission and clonal reproduction.

Habitat. Star coral occur in most reef environments (Veron 2000, Carpenter et al. 2008). *Orbicella* spp. are a common, often dominant component of Caribbean mesophotic reefs (Smith et al. 2010), suggesting the potential for deep refugia. Lobed star coral tend to have a deeper distribution than the other two listed species of *Orbicella (*Szmant et al. 1997), occurring in water depths ranging from 5 m to 50 m (Weil and Knowlton 1994, Carpenter et al. 2008, Bongaerts et al. 2010), while boulder star coral occurs in waters 0.5-20 m deep (Szmant et al. 1997) and mountainous star coral typically occurs between 10-20 m in fore-reef environments, although it may be found in 0.5-40 m (Weil and Knowlton 1994, Carpenter et al. 2008).

Threats. Both Bruckner and Bruckner (2006b) and Miller et al. (2009) demonstrated profound population declines for star coral species from disease impacts, both with and without prior bleaching. Both white plague and yellow-band diseases can invoke this type of population level decline. Disease outbreaks can persist for years in a population—star coral colonies suffering from yellow-band in Puerto Rico still manifested similar disease signs four years later, with a mean tissue loss of 60 percent (Bruckner and Bruckner 2006a).

Star corals species do not suffer from catastrophic outbreaks of predators. While star corals can host large populations of corallivorous snails, they rarely display large feeding scars that are apparent on other coral prey, possibly related to differences in tissue characteristics or nutritional value (Baums et al. 2003). However, low-level predation can have interactive effects with other stressors. For example, predation by butterflyfish can serve as a vector to facilitate infection of mountainous star coral with black-band disease (Aeby and Santavy 2006). Parrotfishes are also known to preferentially target star corals species in so-called “spot-biting” which can leave dramatic signs in some local areas (Bruckner et al. 2000, Rotjan and Lewis 2006), and chronic parrotfish biting can impede colony recovery from bleaching (Rotjan et al. 2006). Although it is not predation per se, star coral colonies have often been infested by other pest organisms. Bioeroding sponges (Ward and Risk 1977) and territorial damselfishes can cause tissue loss and skeletal damage. Damselfish infestation of star coral species appears to have increased in areas where their preferred, branching coral habitat has declined because of loss of other species (Precht et al. 2010).

The only study conducted regarding the impact of acidification on this genus is a field study (Helmle et al. 2011) that did not find any change in field-sampled colonies of mountainous star coral calcification in the Florida Keys through 1996. Recent work in the Mesoamerican reef system indicated that mountainous star corals had reduced thermal tolerances in locations and over time (Carilli et al. 2010) with increasing human populations, implying increasing local threats (Carilli et al. 2009).

Published reports of individual bleaching surveys have consistently indicated that star coral species are highly-to-moderately susceptible to bleaching (Oxenford et al. 2008, Brandt 2009, Bruckner and Hill 2009, Wagner et al. 2010). Star corals can contain multiple varieties of zooxanthellae, depending on depth and other environmental conditions (Rodriguez-Roman et al. 2006, Thornhill et al. 2006). Bleaching has been shown to prevent gametogenesis in star coral colonies in the following reproductive season after recovering normal pigmentation (Szmant and Gassman 1990, Mendes and Woodley 2002) and leave permanent records in coral growth records (Leder et al. 1991, Mendes and Woodley 2002).

Particularly well documented mortalities in star coral species following severe mass bleaching in 2005 highlight the immense impact that thermal stress events and their aftermath can have (Miller et al. 2009). Hernandez-Pacheco et al. (2011) showed that demographic transitions (vital rates) for star coral species were substantially altered by the 2005 mass thermal bleaching event. Size-based transition matrix models based on these measured vital rates showed that population growth rates were stable (λ not significantly different from 1) in the pre-bleaching period (2001–2005) but declined to $\lambda = 0.806$ one year after and to 0.747 two years after the bleaching event. Although population growth rate returned to $\lambda = 1$ the following year, simulation modeling of different bleaching probabilities predicted extinction of a population with these dynamics within 100 years at a bleaching event once every 5-10 years (Hernandez-Pacheco et al. 2011). Cervino et al. (2004) also showed that higher temperatures (20–31° C) resulted in faster rates of tissue loss and higher mortality in yellow-band affected star coral species.

Tomascik and Logan (1990) found a general pattern of decreasing growth rates over the past 30 years at seven fringing reefs along the west coast of Barbados and contributed this decrease to the deterioration of water quality. Average growth rate of star coral species increased with improving water quality conditions on fringing reefs in Barbados. (Torres and Morelock 2002) noted a similar decline in star coral species growth at sediment-impacted reefs in Puerto Rico. Density and calcification rate increased from high to low turbidity and sediment load, while extension rate followed an inverse trend (Carricart-Ganivet and Merino 2001). Eakin et al. (2010) demonstrated declines in star coral species linear extension during periods of construction in Aruba. Downs et al. (2005) suggested that localized toxicant exposure may account for a localized mortality event of star coral species in Biscayne National Park. Mountainous star coral induces the toxicant-metabolizing enzyme cytochrome p450 and antioxidant enzymes under acute exposure to benzo(a)pyrene (Ramos and Garcia 2007), but effects of chronic long-term exposure are not known. Star coral species' skeletons are among those that incorporate toxic heavy metals, making them useful in documenting long-term contamination of reef sites (Medina-Elizalde et al. 2002, Runnalls and Coleman 2003). Nutrient-related runoff has also been deleterious to star coral species. Elevated nitrogen reduced respiration and calcification in star coral *and* stimulated zooxanthellae populations (Marubini and Davies 1996). Fecal coliform microorganisms were among the bacterial communities associated with *Orbicella* in the Florida Keys (Lipp et al. 2002), suggesting potential sewage impacts to the corals. Elevated nutrients increased the rate of tissue loss in star coral species affected by yellow-band disease (Bruno et al. 2003). Chronic nutrient elevation can produce bleaching and partial mortality in star coral species, whereas anthropogenic dissolved organic carbon kills corals directly (Kuntz et al. 2005).

Designated critical habitat. Designated critical habitat has not been proposed for any of the *Orbicella* spp.

Pillar coral

Description. Pillar coral colonies have encrusting bases on which cylindrical columns are developed that may reach 2 m in height. Valleys are meandroid. Tentacles remain extended during the day giving columns a furry appearance. Colonies are generally grey-brown in color (Veron 2000).

Status. Pillar coral is reported to be uncommon (Veron 2000) with isolated colonies scattered across a range of habitat types. Overall colony density throughout south Florida was estimated to be about 0.6 colonies per 10 m^2 (Wagner et al. 2010), while it was estimated to be 172 ± 177 ind/m2, mean density 172 per km^2 in the Columbian Caribbean (Acosta and Acevedo 2006). Pillar coral is restricted to the west Atlantic where it is present throughout the greater Caribbean but is one of the Caribbean genera absent from the southwest Gulf of Mexico (Tunnell 1988). Pillar coral occurs in south Florida and the U.S. Caribbean but appears to be absent from the Flower Garden Banks.

Growth and reproduction. Pillar corals have separate male and female colonies that release gametes that float and create a sheen on the water (Szmant 1986). This “gonochoric” spawning coupled with persistently low population densities results in low probability for successful fertilization and, therefore, larval supply. No juvenile pillar coral were observed in surveys of 566 sites in the Florida Keys during 1999–2009 (Miller et al. 2011), in larval settlement studies in the U.S. Virgin Islands in the early 1980s (Rogers et al. 1984b), or in juvenile surveys in the mid-1970s in the Netherlands Antilles (Bak and Engel 1979). Propagation of pillar coral by fragmentation following storms or other physical disturbances is the likely source of unexpected aggregations of colonies (Hudson and Goodwin 1997). Annual growth rates of 12–20 mm per year in linear extension have been reported (Hudson and Goodwin 1997), but up to 80 mm annually have been reported (Hughes 1987, Acosta and Acevedo 2006). Partial mortality rates have been size-specific but generally low (Acosta and Acevedo 2006). Feeding clearance rates are low (Lewis 1976), but pillar coral has a relatively high photosynthetic rate and stable isotope values suggest it receives substantial amounts of photosynthetic products translocated from its zooxanthellae (Muscatine et al. 1989).

Habitat. Pillar coral inhabits most reef environments (Veron 2000), but in the Florida Keys it appears to be absent in nearshore hard bottoms, nearshore patch reefs, and backreef environments and more common on forereef spur-and-groove habitats (Miller et al. 2011). Pillar coral has been reported in water depths ranging from 2-25 m (Carpenter et al. 2008).

Threats. There are conflicting characterizations of bleaching susceptibility of pillar coral in the literature. The species was bleaching-resistant during the 1983 mass bleaching event in Florida (Jaap 1985). Characterizations of the 2005 mass bleaching event in southern Florida and in the

U.S. Virgin Islands noted that no bleached pillar coral colonies were observed (Clark et al. 2009, Wagner et al. 2010). In contrast, Oxenford et al. (2008) report that 100 percent of the 15 colonies they observed in Barbados during the 2005 mass bleaching event were bleached. Pillar coral is sensitive to cold shock in the Caribbean (Muscatine et al. 1991).

Black-band disease can affect pillar coral colonies (Ward et al. 2006), but white plague causes more extensive impacts, which can cause rapid tissue loss (Miller et al. 2006). The large colony size suggests that individual colonies are less likely to suffer complete mortality from a given disease exposure, but low colony density in this species suggests that even small degrees of mortality increase extinction risk.

The corallivorous fireworm has been observed on diseased colonies of pillar coral (Miller et al. 2006), but, generally, predation is not observed to cause noticeable mortality.

Bak and Elgershuizen (1976) found that the rate of sand removal from pillar coral tissues in laboratory conditions was intermediate among 19 Caribbean coral species tested. Along a eutrophication gradient in Barbados, pillar coral was found at only a single site—one of those farthest removed from pollution (Tomascik and Sander 1987).

Given the apparent naturally rare status of this species, some undescribed adaptations to low population density may exist in this species (particularly with regard to overcoming fertilization limitation between spawned gametes from gonochoric parent colonies that are at great distance from one another (Brainard et al. 2011).

The overall likelihood that pillar coral will fall below the critical risk threshold by 2100 was estimated to be in the “likely” risk category with a mean likelihood of 74 percent and a SE of 6.6 percent (Brainard et al. 2011).

Designated critical habitat. Designated critical habitat has not been proposed for pillar coral.

Rough Cactus Coral

Description of the species. Rough cactus coral consists of encrusting laminar plates. Colonies are thin, weakly attached plates with interconnecting, slightly sinuous narrow valleys. Corallite centers are usually in single rows. Columellae are rudimentary or absent. Colonies are most commonly greys and browns, with valleys and walls of contrasting colors. Maximum colony size is 50 cm (Veron 2000).

Status. Rough cactus coral occurs along the southern tip of Florida and the Florida Keys. Disease has resulted in population declines over the past several decades in the Florida Keys. Rough cactus coral is uncommon (Veron 2000), constituting < 0.1 percent of coral colonies and occurs at densities < 0.8 colonies per 10 m^2 in Florida (Wagner et al. 2010) and at 0.8 colonies per 100 m transect in Puerto Rico sites (http://www.agrra.org). Monitoring data since 2000 from Florida, Puerto Rico, and St. Croix show rough cactus coral cover to be consistently less than 1 percent, with occasional observations up to 2 percent (available online at http://www8.nos.noaa.gov/biogeo_public/query_habitat.aspx). Dustan (1977) suggests that rough cactus coral was much more abundant in the upper Florida Keys in the early to mid-1970s than currently. The overall likelihood that rough cactus coral will fall below the critical risk threshold by 2100 was estimated to be in the "likely" risk category with a mean likelihood of 70 percent and a SE of 8 percent (Brainard et al. 2011).

Growth and reproduction. Rough cactus coral is hermaphroditic and a brooder. Polyps produce 96 eggs per cycle on average (Szmant 1986). Their larvae contain zooxanthellae that can supplement maternal provisioning with energy sources provided by their photosynthesis (Baird et al. 2009). Colony size at first reproduction is > 100 cm^2 (Szmant 1986). Recruitment appears to be very low (Dustan 1977).

Habitat. Rough cactus coral has been reported to occur in shallow reef environments (Veron 2000) ranging from 5-30 m (Carpenter et al. 2008).

Threats. No bleached rough cactus coral colonies were observed during the 2005 mass coral bleaching event in Florida (Wagner et al. 2010) or Barbados (Oxenford et al. 2008), although the number of colonies was small in Barbados.

Rough cactus coral are susceptible to acute and subacute white plague. (Dustan 1977) reported dramatic impacts from this disease to the population in the upper Florida Keys in the mid-1970s. He also reported that the rate of disease progression was positively correlated with water temperature and measured rates of disease progression up to 3 mm daily. Rough cactus coral were absent at fringing reef sites impaired by sewage pollution (Tomascik and Sander 1987).

Designated critical habitat. Designated critical habitat has not been proposed for rough cactus coral.

JOHNSON'S SEAGRASS

Description. Johnson's seagrass has paired linearly shaped spatulate leaves with smooth margins. The leaves are 0.2-1.0 inches (0.5-2.5 cm) long and growing from a creeping rhizome with petioles, sessile (that is, attached to their bases) female flowers, and long-necked fruits. The male flowers are unknown.

Status and trends. On September 14, 1998, Johnson's seagrass was listed as threatened under the ESA (69 FR 49035). Historical abundance estimates of Johnson's seagrass are not available due to the species having only recently been differentiated. Limited data indicate no large distributional gaps or changes in abundance over much of Johnson's seagrass distribution from 1994 to 1999. However, recent increases in reported occurrence could be an artifact of recent increases in search efforts.

The species has only relatively recently been identified as a distinct species and therefore no historical distribution information is available (Eiseman and McMillan 1980). Current distribution includes lagoons along approximately 125 miles of southeastern Florida between Sebastian Inlet and north Biscayne Bay, which means that Johnson's seagrass has the most limited geographic distribution of any seagrass in the world (Kenworthy 1997). However, northern range extensions (likely temporary) have recently been observed (Virnstein and Hall 2009). The largest known groups of patches are located near Sebastian Inlet and Lake Worth, Florida.

Habitat. Patches of Johnson's seagrass have been observed to grow from the intertidal zone down to 3.3 feet water depth and in waters with variable temperatures and salinities (15 to 43 parts per thousand) and temperatures (Dawes et al. 1989, Kenworthy 1993, Virnstein et al. 1997, Kahn and Durako 2009). Patches near freshwater discharges have been observed (Gallegos and Kenworthy 1996), although Torquemada et al. (2005) noted that highly hypo- or hypersaline conditions can negatively impact growth. Intertidal patches may be completely exposed at low tides, suggesting tolerance to desiccation and wide temperature ranges (Kahn and Durako 2009).

Growth and reproduction. Only female flowers have been observed; no fruit or seeds have been found to date (Eiseman and McMillan 1980, Heidelbaugh et al. 2000). However, there is no evidence of male flowers, meaning Johnson's seagrass probably reproduces by cloning or asexual branching and fragmentation (Jewitt-Smith et al. 1997, Hammerstom and Kenworthy 2003). Consequently, genetic diversity is low (Freshwater and York 1999), putting Johnson's seagrass at a potential genetic disadvantage compared to other seagrasses.

Clonal reproduction occurs when plants form new leaf-pair, root and rhizome segments that arise from terminal buds (Posluszny and Tomlinson 1990). As clones expand, high density "patches" are formed ranging from three to 66 feet^2 in size (Kenworthy 1997, Virnstein et al. 1997, Kenworthy 2000, 2003, Virnstein and Morris 2007). Patches can expand rapidly (nine feet^2 per month, Kenworthy 2003) leading to coalescence with adjacent patches and large meadows of up to 30 acres (Kenworthy 1997).

Johnson's seagrass appears to be physiologically adapted to exploit unstable environments and unvegetated patches, with minimal resources allocated to the holding of space (Dean and Durako 2007). Fragments or entire plants can be uprooted and drift extensively, providing a mechanism for dispersal and colonization of new areas (Hall et al. 2006). Johnson's seagrass frequently undergo whole patch mortality followed by recolonization (Virnstein et al. 1997, Heidelbaugh et al. 2000, Greening and Holland 2003, Kenworthy 2003, Virnstein and Morris 2007). Although successful in unstable areas, Johnson's seagrass may be out-competed by more stable-selected plants in areas not subject to regular disturbance (Durako 2003). Due to this species' physiology, low capacity for storage, and shallow root system, growth over large unsuitable patches may be unlikely, and its ability to recover from widespread habitat loss may be limited.

Threats. Storms pose the greatest natural threat to Johnson's seagrass. Storms can easily uproot or rip apart individuals and scatter them widely. Although this can serve to disperse individuals into new habitats, it can also catastrophically eliminate established meadows. Subsequent siltation following high turbidity events can also bury individuals or parts of plants. Due to its delicate morphology, small range, lack of genetic diversity and a physiology ill equipped to hold space and compete with other seagrasses, Johnson's seagrass is vulnerable to prolonged widespread human-induced disturbance and habitat loss and its potential for recovery may be limited. The growth of boating in Florida and development of coastal areas has resulted in trampling, propeller scarring, dredging, filling, shading, and altered water quality that has degraded these areas compared to historical conditions. The species is under threat from high development pressure and subsequent habitat degradation throughout its range. Johnson's seagrass and its habitat are threatened by several specific natural and anthropogenic factors, including (1) dredging and filling, (2) construction and shading from in- and overwater structures, (3) prop scarring and anchor mooring, (4) trampling, (5) altered water quality (such as stormwater runoff and turbidity), (6) siltation, and (7) climate change (Waycott et al. 2009).

Designated critical habitat. Designated critical habitat for Johnson's seagrass was designated on April 5, 2000 (65 FR 17786). The designated critical habitat occurs entirely within Florida and includes (1) locations with populations that have persisted for 10 years; (2) locations with persistent flowering populations; (3) locations at the northern and southern range limits of the species; (4) locations with unique genetic diversity; and (5) locations with a documented high abundance of Johnson's seagrass compared to other areas in the species' range. These are critical to the conservation of the species because they protect persistently reproductive and genetically diverse populations, allow for protective buffers along the distribution limits (i.e., edges of survival), and protect regions of high density that without further knowledge of species biology, appear to serve the needs of Johnson's seagrass. Ten regions of sheltered bay and inlet waters are designated, including north and south of Sebastian Inlet, near Fort Pierce Inlet, north of St. Lucie Inlet, a portion of Hobe Sound, the southern side of Jupiter Inlet, Lake Worth Lagoon (north of Bingham Island and Boynton Inlet), waters of Lake Wyman, and wide areas of northern Biscayne Bay. These regions occupy approximately 22,574 acres or 9,139 hectares (Figure 14). Simply the nature of Johnson's seagrass designated critical habitat makes it variable and prone to change.

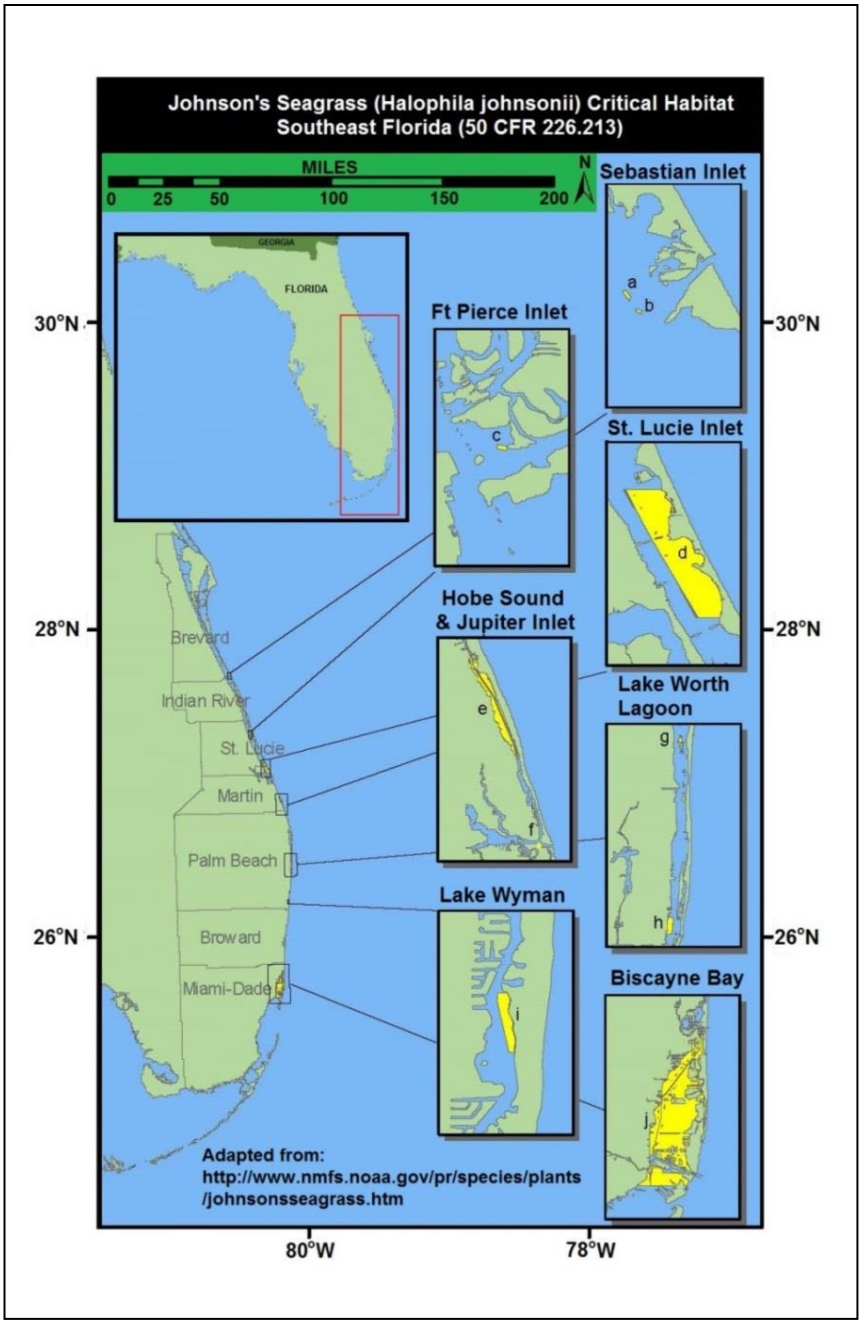

Figure 14. Johnson's Seagrass Designated Critical Habitat. a) North of Sebastian Inlet Channel, b) South of Sebastian Inlet channel, c) Ft. Pierce Inlet, d) north of St. Lucie Inlet, e) Hobe Sound, f) South Side of Jupiter Inlet, g) a Portion of Lake Worth Lagoon North of Bingham Island, h) a Portion of Lake Worth Lagoon, Located Just North of Boynton Inlet, i) a Portion of Northeast Lake Wyman, Boca Raton, j) a Portion of Northern Biscayne Bay.

4.1.3 Environmental Baseline

The *Environmental Baseline* includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The key purpose of the *Environmental Baseline* is to describe the condition of the ESA-listed species and designated critical habitat within the action area and the consequences of that condition without the action.

Baseline conditions nationwide are reflected within the state of Florida. Flather et al. (1998) identified habitat loss and alien species as the two most widespread threats to endangered species, affecting more than 95 percent and 35 percent of listed species, respectively. For example, the net effect of human-altered hydrology creates conditions which increase stormwater runoff, transporting land based pollutants into surface waters and reduces the filtration of stormwater runoff through wetlands prior to reaching surface waters. As a result, altered hydrology has reduced the spatial extent and quality of available habitat and the connectivity among rivers and streams which is necessary for anadromous species to complete their migratory lifecycles.

Increases in polluted runoff have been linked to a loss of aquatic species diversity and abundance, including many important commercial and recreational fish species. Non-point source pollution has also contributed to coral reef degradation, fish kills, seagrass bed declines and algal blooms, including blooms of toxic algae. In addition, many shellfish bed and swimming beach closures can be attributed to polluted runoff. As discussed in EPA's latest National Coastal Condition Report, non-point sources have been identified as one of the stressors contributing to coastal water pollution (USEPA 2012a).

With its mean elevation above sea level of 30 meters and porous limestone aquifers, Florida is uniquely vulnerable to sea level rise associated with climate change. Expansion of inland tidal marshes replacing lowland coastal forests over the last 120 years was demonstrated along the Big Bend of Florida (Raabe and Stumpf 2016). Temperature records between 1878 and 2012 for Florida Keys coral reef habitats indicate an increase of 0.8^{o}C in the last century (Kuffner et al. 2015).

The Intergovernmental Panel on Climate Change (IPCC) estimated that average global land and sea surface temperature has increased by 0.85°C (± 0.2) since the late 1800s, with most of the change occurring since the mid-1900s (IPCC 2013). This temperature increase is greater than what would be expected given the range of natural climatic variability recorded over the past 1,000 years (Crowley and Berner 2001). All species discussed in this opinion are presently, or are likely to be, threatened by the direct and indirect effects of global climatic change. Global climate change stressors, including consequent changes in land use, are major drivers of ecosystem alterations (USEPA 2008). Climate change is projected to have substantial direct effects on individuals, populations, species, and the community structure and function of marine, coastal, and terrestrial ecosystems in the foreseeable future (McCarty 2001, IPCC 2002, Parry et al. 2007, IPCC 2013). A northward shift in loggerhead nest placement was reported for Melborne Beach, Florida, the largest U.S. rookery for this species (Reece et al. 2013). Climate change is most likely to have its most pronounced effects on species whose populations are already in tenuous positions (Williams et al. 2008). Increasing atmospheric temperatures have already contributed to changes in the quality of freshwater, coastal, and marine ecosystems and have contributed to the decline of populations of endangered and threatened species (Mantua et al. 1997, Karl et al. 2009, Littell et al. 2009).

Increasing surface water temperatures can cause the latitudinal distribution of freshwater and marine fish species to change: as water temperatures rise, cold and warm water species will spread northward (Hiddink and ter Hofstede 2008, Britton et al. 2010). Climate-mediated changes in the global distribution and abundance of marine species are expected to reduce the productivity of the oceans by affecting keystone prey species in marine ecosystems such as phytoplankton, krill, and cephalopods. For example, climate change may reduce recruitment in krill by degrading the quality of areas used for reproduction (Walther et al. 2002). Aquatic nuisance species invasions are also likely to change over time, as oceans warm and ecosystems become less resilient to disturbances (USEPA 2008). Invasive species that are better adapted to warmer water temperatures could outcompete native species that are physiologically geared towards lower water temperatures; such a situation currently occurs along central and northern California (Lockwood and Somero 2011). Warmer water stimulates biological processes which can lead to environmental hypoxia. Oxygen depletion in aquatic ecosystems can result in anaerobic metabolism increasing, thus leading to an increase in metals and other pollutants being released into the water column (Staudinger et al. 2012).

Ocean acidification, as a result of increased atmospheric carbon dioxide, can interfere with numerous biological processes in corals including: fertilization, larval development, settlement success, and secretion of skeletons (Albright et al. 2010). In addition to global warming, acidification poses another significant threat to oceans because many major biological functions respond negatively to increased acidity of seawater. Photosynthesis, respiration rates, growth rates, calcification rates, reproduction, and recruitment may be negatively impacted with increased ocean acidity (RoyalSocietyofLondon 2005). Kroeker et al. (2010) review of 139 studies quantifying ocean acidification effects determined that the effects were variable depending on species, but effects were generally negative, with calcification being one of the most sensitive processes.

Aquatic species, especially marine species, already experience stress related to the impacts of rising temperature. Corals, in particular, demonstrate extreme sensitivity to even small temperature increases. When sea temperatures increase beyond a coral’s limit, the coral “bleaches” by expelling the symbiotic organisms that not only give coral its color, but provide food for the coral through their photosynthetic capabilities. According to (Hoegh-Guldberg 2010), bleaching events have steadily increased in frequency since the 1980s.

Baseline Condition of Florida's Aquatic Resources

The baseline condition of Florida's aquatic resources is described in detail in the 2014 Integrated Water Quality Assessment for Florida (FDEP 2014). The following paragraphs are derived from that document. There are 54,836 miles of streams and rivers, 49,128 miles of ditches and canals, and 17,698 square miles of freshwater and tidal wetlands in Florida (Figure 15). Florida's coastline ranks second in length only to Alaska. Florida's low relief, coupled with its geologic history, has created unique hydrogeologic features making groundwater quality particularly critical to surface water quality.

Human Alterations of Surface Waters

Major dams have been built on the Apalachicola, Ocklawaha, Ochlockonee, Hillsborough, and Withlacoochee (Citrus County) Rivers. The most extreme alterations were damming the Ocklawaha to create the Cross-Florida Barge Canal and channelizing the Kissimmee River. The hydrology of the southern third of Florida's peninsula has been significantly altered, and few naturally flowing streams and rivers remain. Most fresh waterbodies in south Florida are canals. Several efforts are under way to reverse some of the alterations, thus restoring natural flows and function to waterbodies. Significant work on the Kissimmee River since the 1990s has successfully restored flow in portions of the historical river channel, leading to improved habitat, fisheries, and water quality.

In the past, many wetlands were drained for agriculture, logging, and urban development, and numerous rivers were channelized for navigation. The modifications were most intense in south Florida, where, beginning in the 1920s, canals and levees were built to control flooding and to drain wetlands. These modifications resulted in the loss of much of the original Everglades wetlands from Lake Okeechobee south. The Everglades restoration under way is intended to improve water quality. There are preliminary successes; however, restoration is a long-term effort involving many agencies working to revitalize the heavily altered system. The logging and agricultural activities that were once occurred along the St. Marys River are no longer pursued and the area and the St. Marys River has rejuvenated, The river is currently a popular area for recreation and sightseeing. Intense development along the St. Johns River contributed pollutants through stormwater, wastewater discharges, and agricultural runoff.

Currently the Port of Miami is being dredged to accommodate the newest generation of freighters. Among sediment impacts assessed, the most severe is for a sedimentation assessment site located 200 m north of the dredged channel. This assessment characterized 81 percent of the points surveyed as 'sediment over hardbottom' compared to 1 percent at the corresponding reference site.

Figure 15: Map of Major Surface Waters in Florida[6].

Pollutants

Arsenic has recently arisen as the pollutant of concern. The Tampa Bay Tributaries, Withlacoochee, Sarasota–Peace–Myakka, and Ocklawaha Basins have had the highest number of water systems reporting samples with elevated arsenic. The basins with the highest number of wells with exceedances for the two-year period associated with the Tampa Bay Tributaries,

[6] Adapted from http://www.thepalmbeachtimes.com/TravelNavigator/FloridaMileage.php. Added north arrow, labeled Ten Thousand Islands and Indian River, recolored and relocated scale bar for legibility.

Suwannee, Withlacoochee, and Springs Coast Basins. Arsenic in ground water may be naturally occurring, of anthropogenic origin due to human-induced geochemical changes, or a true contaminant released as a result of human activities. The prevalence of elevated arsenic detections in the southwest Florida basins and the Suwannee Basin may be due to the chemical makeup of the aquifer in these areas.

In addition to this natural source, potential anthropogenic sources include arsenic-based pesticides applied to cotton fields; citrus groves; road, railroad, and power line rights-of way; golf courses; and cattle-dipping vats, which were in use in Florida until 1961 (McKinnon et al. 2011). In recent years, the use of arsenical pesticides has significantly decreased, and as of 2013 its use is restricted only to monosodium methanearsonate on cotton fields, golf courses, sod farms, and highway rights-of-way (78 CFR 59). However, residues from past use, when bound to soil particles, do not readily dissipate. Higher numbers of reported exceedances may be considered an artifact of the change in the EPA arsenic standard for ground water, which was reduced from 50 to 10 μg/L in 2001, and was fully implemented in 2006.

Activities such as mining, well drilling, stormwater discharge into drainage wells, aquifer storage and recovery projects (Arthur et al. 2002, Price and Pichler 2006), and over pumping can potentially release previously stable arsenic into ground water. In addition, drought can lower the water table, allowing oxygen to permeate the aquifer matrix and cause the release of arsenic compounds from limestone.

Ground water contamination by nitrate remains an ongoing problem and a challenge to water resource managers in Florida. One effort to reduce fertilizer leaching into wells is the implementation of agricultural best management practices by farmers. Another aspect that may be reducing contamination is the transition from agricultural to residential land uses, resulting in less fertilizer use in some agricultural areas. Also, in some of these transitioning areas, public water supplies have become available to homeowners who were previously on individual wells. The combination of reduced sources and reduced number of wells requiring monitoring may be partially responsible for the decrease in the number of wells found to be contaminated in recent years.

In aquatic environments, sediments provide essential habitat but, at the same time, may be a source of contamination and recycled nutrients. Sediment contaminants, such as trace metals, organic pesticides, and excess nutrients, accumulate over time from upland discharges, the decomposition of organic material, and atmospheric deposition. Periodic water quality monitoring cannot fully evaluate aquatic ecosystems, as it is not usually designed to assess the cumulative impact of sediment contaminants. Knowledge of a site's sediment quality is important for environmental managers in evaluating future restoration and dredging projects. Unlike many water column constituents, the FDEP has no criteria for sediment and no statutory authority to establish criteria. Therefore, it is important to use scientifically defensible thresholds to estimate the condition of sediments and determine the ecological significance of these thresholds.

Fisheries Bycatch

Bycatch occurs when fishing operations discard fish or interact with marine mammals, sea turtles, protected fish species, corals, sponges, or seabirds. Bycatch is the primary reason for the decline and, ultimately, the listing of smalltooth sawfish as endangered in 2003 (NMFS 2009) The long, toothed rostrum of the smalltooth sawfish causes this species to be particularly vulnerable to entanglement in fishing nets. Historical reports of smalltooth sawfish caught in otter trawls, trammel nets, and seine nets were relatively common in Florida and other areas in the Gulf of Mexico (NMFS 2009). Bigelow and Schroeder (1953), who described smalltooth sawfish as "plentiful in Florida waters," noted they were of "considerable concern to fishermen as nuisances because of the damage they do to drift- and turtle nets, to seines, and to shrimp trawls in which they often become entangled and because of the difficulty of disentangling them without being injured by their saws." Smalltooth sawfish bycatch in shrimp trawl operations declined rapidly in the second half of the 20th century due to population decline. In Louisiana shrimp trawl landings, which were reported as high as 34,900 pounds in 1949, dropped to zero landings recorded after 1978 (Simpfendorfer 2002). In Florida, smalltooth sawfish have only occasionally been recorded in shrimp trawl landing since the 1990's (NMFS 2009). Smalltooth sawfish are also caught incidentally in shark drift gillnet and shark bottom longline fisheries, although interactions with these fisheries are considered relatively rare. A 2003 Highly Migratory Species Opinion estimated one incidental capture of a sawfish every five years in the shark gillnet fishery (NMFS 2003). An estimated 61 smalltooth sawfish were captured in the Atlantic and Gulf of Mexico shark bottom longline fishery from 2005-2006 (NMFS 2011). Smalltooth sawfish are also caught incidentally by recreational anglers, particularly within the Everglades National Park. However, such interactions are considered very rare and the impacts to the species associated with post-release mortality are probably small (NMFS 2009).

Sturgeon bycatch estimates based on NMFS' ocean observer data are considered to be underestimated since bycatch is underreported in state waters and no observer coverage exists in South Atlantic (North Carolina-Florida) U.S. Federal waters (ASMFC Technical Committee 2006). Commercial fishery bycatch data for other waters indicate that bycatch is a significant threat to the viability of listed sturgeon species and populations (Atlantic Sturgeon Status Review Team 2007, Shortnose Sturgeon Status Review Team 2010). Although directed harvest of Atlantic, shortnose, and Gulf sturgeon is prohibited, these species are still incidentally caught in several commercial fisheries operating throughout their ranges. Shortnose sturgeon are primarily captured in gillnets but have also been caught in pound nets, fyke/hoop nets, catfish traps, shrimp trawls and hook and line fisheries (recreational angling). Bycatch of shortnose sturgeon from shad gillnet fisheries can result in a significant source of mortality (Shortnose Sturgeon Status Review Team 2010). In one study from South Carolina, out of 51 shortnose sturgeon captured, 16 percent resulted in bycatch mortality and another 20 percent were visibly injured (Collins et al. 1996). Bycatch could also have a substantial impact on the status of Atlantic sturgeon, especially in rivers or estuaries that do not currently support a large subpopulation (< 300 spawning adults per year). Estimated bycatch mortality rates for Atlantic sturgeon range from 0 percent-51 percent depending on gear and other conditions, with greatest mortality occurring in sink gill nets (Atlantic Sturgeon Status Review Team 2007). Inland American shad gill net fisheries in two southern locations (Winyah Bay and Altamaha River) were estimated to capture 530 Atlantic sturgeon, of which 58 likely resulted in mortality. Atlantic sturgeon mortality associated with bycatch has been estimated as high as 1,400 deaths per year from 1989–2000 in the ocean fisheries ranging from North Carolina to Maine (Stein et al. 2004).

Commercial fishing operations have been identified as the most significant source of injury and mortality of juvenile, subadult, and adult sea turtles and a major threat that has contributed to ESA listings of several sea turtle species. Bycatch of sea turtles in shrimp trawl fisheries conducted off the southeast United States (from North Carolina to the Atlantic coast of Florida) and U.S. Gulf of Mexico (from the Gulf coast of Florida to Texas) can result in significant demographic effects on sea turtle populations. Participants in these fisheries have been required to use turtle exclusion devices since 1987. Turtle exclusion devices are estimated to reduce shrimp trawl related mortality by as much as 94 percent for loggerheads and 97 percent for leatherbacks. Total sea turtle bycatch estimates for 2010 were 6,850 individuals, 6,199 of which were estimated to be mortalities in the two southeast shrimp trawl fisheries (NMFS 2013). The U.S. Gulf of Mexico fishery had an estimated bycatch mortality of 5,166 individuals (18 leatherback, 778 loggerhead, and 486 green and 3,884 Kemp's ridley sea turtles). The Southeastern Atlantic fishery had an estimated bycatch mortality of 1,033 individuals (8 leatherback, 673 loggerhead, and 28 green and 324 Kemp's ridley turtles). The fishery with the next highest estimated sea turtle bycatch, particularly of leatherbacks and loggerheads, is the Atlantic highly migratory species pelagic longline fishery. From 1999 to 2003, the fleet interacted with an average of 772 loggerhead and 1,013 leatherback sea turtles per year, based on observed takes and total reported effort (NMFS 2015). Sea turtle bycatch in the Atlantic pelagic longline fishery has decreased significantly in the last decade. In 2005, the fleet was estimated to have interacted with 275 loggerhead and 351 leatherback sea turtles outside of experimental fishing operations. These numbers have been further reduced to 259 loggerhead and 268 leatherback sea turtles interactions in 2014 (NMFS 2015).

Five other fisheries had a combined estimated sea turtle bycatch of 133.4 individuals in 2010 (live and dead): the U.S. Gulf of Mexico reef fish bottom longline fishery (26.5 loggerhead turtles), U.S. Gulf of Mexico reef fish vertical line fishery (32.9 loggerhead turtles), large coastal and small coastal shark aggregates (drift, strike, and bottom gillnet; 2.9 Kemp's ridley turtles and 8.9 loggerhead turtles), Southeastern Atlantic snapper-grouper vertical line fishery (56.3 green turtles), and the Southeastern Atlantic and Gulf of Mexico shark bottom longline fishery (5.8 loggerhead turtles) (NMFS 2013). The Atlantic sea scallop fishery also results in sea turtle bycatch, primarily loggerhead (estimated 49 captured in 2013).

Aquatic Invasive Species

Aquatic invasive species are aquatic organisms that are introduced into new habitats and subsequently produce harmful impacts on the natural resources in and human uses of these ecosystems (http://www.anstaskforce.gov). Not all non-native (also called alien or nonindigenous) species are considered invasive. Overall, there have been 374 documented invasive species in U.S. waters, 150 of which have arrived since 1970 (Pew 2003). The Nonindigenous Aquatic Species database[7] lists 53 non-native species reported in Florida's brackish and marine waters. Among these are 16 species with established populations in one or more of the estuaries and coastal areas of Florida. The presence of established populations for 32 of the species is unknown and 5 species failed to establish populations. Many of the fish species are aquarium releases and some of the established populations were actually stocked as forage fish (e.g., shad and blueback herring). The lionfish, originally from the indo-pacific is a particularly harmful invasive fish species in Florida's waters. Lionfish are a major predator on commercial and sport fish species and the herbivorous fish species that are important to controling algal growth on coral reefs (Albins and Hixon. 2013, Côte et al. 2013, Lesser and Slattery 2011). Their presence in reef systems has been associated with severe declines in fish abundance Albins and Hixon, 2008). Initial observations in the mid-1980's are attributed to aquarium releases. They are established in coastal waters from North Carolina to South America. Lionfish have invaded the Loxahatchee estuary (i.e., Jupiter Inlet on the Atlantic coast of Florida). Over 200 young-of-year individuals ranging from 23 to 185 mm were collected over a one-year survey period. They were primarily associated with man-made structures and associated debris along the shoreline as far as 5.5 km inland (Jud et al. 2011).

Introduced aquatic invasive species are one of the main sources of risk to ESA-listed species, second only to habitat loss (Wilcove and Chen 1998). They have been implicated in the endangerment of 48 percent of the species listed under ESA (Czech and Krausman 1997). The USFWS considers invasive species to be a significant contributing factor in determining the “threatened” or “endangered” status of many native species (OTA 1993, Ruiz et al. 1997). Invasive species impact aquatic environments in many different ways. They can reduce native species abundance and distribution, and reduce local biodiversity by out-competing native species for food and habitat. They may displace food items preferred by native predators, disrupting the natural food web. They may alter ecosystem functions. Exotic plants can clog channels and interfere with recreational fishing and swimming. Introduced non-native algal species combined with nutrient overloading may increase the intensity and frequency of algal blooms. An overabundance of algae can lead to depleted DO. Oxygen depletion can result in

[7] These data are preliminary or provisional and are subject to revision. They are being provided to meet the need for timely best science. The data have not received final approval by the U.S. Geological Survey (USGS) and are provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the data.

"dead zones," murky water, seagrass and coral habitat degradation, and large-scale fish kills (Deegan and Buchsbaum 2005).

Harmful Algal Blooms

Florida monitors for HABs in fresh, estuarine, and marine waters. Blooms can occur any time of year in Florida, due to its subtropical climate. The HABs are caused by a suite of unique taxa that can bloom under particular physical, chemical, and biological conditions. The drivers of some HABs are well understood, while the drivers of other HABs, such as the red tide organism *Karenia brevis*, are still unclear. While HABs can occur naturally, they are frequently associated with elevated nutrient concentrations. HABs may produce toxins that contaminate shellfish or finfish, making them unsuitable for human consumption. They can also affect plant and animal communities. The Gulf of Mexico Alliance, a partnership between Alabama, Florida, Louisiana, Mississippi, and Texas, is working to increase regional collaboration to enhance the Gulf's ecological and economic health. Reducing the effects of HABs is one of its water quality priorities.

Freshwater cyanobacteria (or blue-green algae) blooms have received increased attention in recent years because of their potential to produce toxins that can harm humans, livestock, domestic animals, fish, and wildlife. While blooms of cyanobacteria can occur naturally, they are frequently associated with elevated nutrient concentrations, slow-moving water, and warm temperatures. Cyanotoxins are bioactive compounds naturally produced by some species of cyanobacteria that can damage the liver (hepatotoxins), nervous system (neurotoxins), and skin (dermatotoxins) of humans and other animals. Potentially toxigenic cyanobacteria have been found statewide in Florida's rivers, streams, lakes, and estuaries. There are also concerns that freshwater cyanotoxins can be transported into coastal systems. The results of the Cyanobacteria Survey Project (1999–2001), managed by the Harmful Algal Bloom Task Force at the FFWCC (FWCC) Fish and Wildlife Research Institute, indicated that the taxa *Microcystis aeruginosa, Anabaena* spp., and *Cylindrospermopsis raciborskii* were dominant, while species with the genera *Aphanizomenon, Planktothrix, Oscillatoria*, and *Lyngbya* were also observed statewide but not as frequently. Cyanotoxins (microcystins, saxitoxin [STX], cylindrospermopsins, and anatoxin) were also found statewide (Williams et al. 2007). Other cyanobacteria of concern in Florida are reported in (Abbott et al. 2009).

More than 50 marine and estuarine HAB species occur in Florida and have the potential to affect public health, water quality, living resources, ecosystems, and the economy. Any bloom can degrade water quality because decomposing and respiring cells reduce or deplete oxygen, produce nitrogenous byproducts, and form toxic sulfides. Declining water quality can lead to animal mortality or chronic diseases, species avoidance of an area, and reduced feeding. Such sublethal, chronic effects on habitats can have far-reaching impacts on animal and plant communities. *Karenia brevis*, sometimes mixed with related *Karenia* species, causes red tides that are an ongoing threat to human and environmental health in the U.S. Gulf of Mexico. Blooms occur annually on the west coast of Florida and less frequently in the Panhandle and east coast. *Karenia brevis* produces brevetoxins that can kill fish and other marine vertebrates, including manatees, sea turtles, and seabirds. Blooms of the STX-producing dinoflagellate *Pyrodinium bahamense* have been linked to the bioaccumulation of the neurotoxin STX in puffer fish and more than 20 cases of saxitoxin puffer fish poisoning in Florida (Landsberg et al. 2006). While these blooms raise serious concerns about the ecology of affected ecosystems, there have not been any wide-scale animal mortality events attributed to STXs in Florida. As a tropical species, *P. bahamense* has seldom bloomed north of Tampa Bay on the west coast or north of the Indian River Lagoon on the east coast. Blooms are generally limited to May through October (Phlips et al. 2006). In Florida, *Pyrodinium* is most prevalent in flow-restricted lagoons and bays with long water residence times and salinities between 10 and 30 practical salinity units. The latter conditions competitively favor *Pyrodinium* because of its slow growth rates and euryhaline character (Phlips et al. 2006). Blooms also appear to be accentuated during periods of elevated rainfall and nutrient loads to lagoons (Phlips et al. 2010), suggesting a link between coastal eutrophication and the intensity and frequency of blooms. However, discharges of naturally tannic waters from wetlands during high-rainfall events can also produce favorable conditions for this organism. These observations also point to the potential role of future climate trends in defining the dynamics of HAB species in Florida (Phlips et al., 2010).

Other bloom-forming marine species can be divided into two categories: toxin-producing species and taxa that form blooms associated with other problems, such as low oxygen concentrations, physical damage to organisms, and general loss of habitat. Potential toxin-producing planktonic marine HAB species include the diatom group *Pseudo-nitzschia* spp.; the dinoflagellates *Alexandrium monilatum, Takayama pulchella, K. mikimotoi, K. selliformis, Karlodinium veneficum, Prorocentrum minimum, P. rhathymum,* and *Cochlodinium polykrikoides*; and the prymnesiophytes *Prymnesium* spp. and *Chrysochromulina* spp., and the raphidophyte *Chattonella* sp. (Abbott et al. 2009). Many of these species are associated with fish or shellfish kills in various ecosystems around the world (Landsberg 2002). Additionally, benthic cyanobacteria and macroalgae blooms have been observed on Florida’s coral reefs and have been associated with mortality and disease events involving various organisms (Lapointe et al. 2004, Paul et al. 2005, Richardson et al. 2007).

Although many HAB species have been observed at bloom levels in Florida (Phlips et al. 2011), uncertainty remains over the relative toxicity of the specific strains. In addition to ichthyotoxic HAB species that directly cause fish kills, the list of HAB species linked to hypoxia or other density-related issues (e.g., allelopathy, physical damage to gills of fish) is extensive and includes almost any species that reaches exceptionally high biomass. Examples include the widespread bloom-forming planktonic dinoflagellate *Akashiwo sanguinea*, in the Indian River Lagoon and the St. Lucie Estuary, and the cyanobacterium *Synechococcus* in Florida Bay (Phlips et al. 1999, Phlips et al. 2011). Many fish kills, particularly those occurring in the early morning hours, are due to low DO levels in the water associated with the algal blooms and are not necessarily the result of toxins.

Another important issue associated with HABs is the loss or alteration of overall habitat quality. Prolonged and intense coastal eutrophication can result in domination by a select few species, resulting in a loss of diversity and alteration of food web structure and function. For example, during major *Pyrodinium* blooms, 80 percent to 90 percent of total phytoplankton biomass is attributable solely to this species (Phlips et al. 2006). Similar domination by a single species occurs in benthic ecosystems, where massive blooms of green and red macroalgae have periodically over-run some shallow habitats of the Florida coast (Lapointe and Bedford 2007).

Aquatic Impairments

The year 2010 is the most recent EPA-approved 303(d) list of impaired waters for Florida found in the Assessment and TMDL Tracking and Implementation System database (Table 4[8]), The 2010 data indicate 613 waterbody segments on the CWA 303(d) impaired list due to excess nutrients, algae, or the nutrient indicator Chl-a. There are 1049 waterbody segments listed as impaired due to DO, 35 of which are listed due to excess oxygen demand. Only 25 waterbody segments listed as impaired due to turbidity. An additional 608 waterbody segments listed as impaired with coliform bacteria and 19 waters listed due to un-ionized ammonia, suggesting excess nutrient loading in these areas.

Table 4. Waters Listed as Impaired for Nutrients, DO, Turbidity, or Nutrient-Related Measures.

Impairment cause		**Number of Impaired Waters**			
		EPA 2010	**Added by FDEP 2012 and 2013**	**Removed by FDEP 2012 and 2013**	**Net count of impaired waters**
Nutrients	Chl-a	321	46	134	233
	Excess Algal Growth	29	21	9	41
	Phosphorus, Total	6	-	-	6
	Trophic State Index	257	26	24	259
DO	Biochemical Oxygen Demand	35	25		60
	DO	1014	11	99	926
Turbidity		25	-	18	7
Pathogens (Coliform)		608	120	96	632
Unionized Ammonia		19	2	7	14

[8] accessed 12/14/2015 at http://iaspub.epa.gov/apex/waters/f?p=ASKWATERS:V_WO_CURRENT_IMPAIRMENTS_LIST::::P4_OWNER:ATTAINS

A more recent list of impaired and delisted waters is found on the FDEP website. This list includes data up to 2013 that is not yet integrated into EPA's 303(d) list of impairments. The "Added by FDEP 2012-2013" column in Table 4 indicates how many additional waters were identified as impaired and the "Removed by FDEP 2012-2013" column identifies how many waters were delisted. Among assessed waters, about 8 percent were delisted because they were found to be unimpaired or incorrectly assessed, 3.7 percent were delisted because a TMDL was adopted to address the impairment, and 4.4 percent were delisted due to the re-assignment, retirement or realignment of the water body identification number, thereby changing the specific standard by which it was assessed.

The April 2014 Integrated Water Quality Assessment for Florida acknowledged that new WQS for DO and NNC had been adopted and indicated that final adoption occurred after the period covered by the assessment period, and therefore were not to assess attainment in this report. Trends analysis for 38 river stations showed increases in one or more indicators of nutrients (total Kjeldahl nitrogen, nitrate-nitrite, TP, total organic carbon, and/or Chl-a) at 27 stations. Decreasing DO trends were found at three of these stations and increasing fecal coliform occurred at six of these stations. However, increasing trends for fecal coliform also occurred in four stations that did not show a trajectory towards adverse nutrient or DO conditions. Among the 38 stations, only five had trends indicating stable or improving water quality for the parameters evaluated.

The NMFS-listed species in Florida occur in coastal and estuarine habitats. Nutrient impaired waters with NNC evaluated in this opinion include 11 estuaries and 19 segments (Table 5).

The St. Marys River flows along the border of Georgia and Florida, with its headwaters in the Okefenokee Swamp. Georgia's 303(d) list identifies 46.7 river and coastal stream kilometers as impaired due to DO conditions caused by organic enrichment and oxygen depletion attributed to discharges from three point source wastewater treatment facilities and nonpoint discharges from urban, agriculture and forestry land uses.

Table 5. Nutrient-Impaired Waters with NNC Considered in this Opinion.

Estuary	Segment	Impairment
Apalachicola – Chipola		
	Apalachicola Bay	Chl-a
Charlotte Harbor		
	Charlotte Harbor (Upper Segment)	Chl-a
	North Lemon Bay	Chl-a
Everglades West Coast		
	Estero River Marine	Biochemical Oxygen Demand and Nutrients
Nassau - St. Marys		
	Nassau River	Historic Chl-a
Pensacola		
	Escambia Bay (N)	Historic Chl-a*
	Escambia Bay (North Segment)	Historic Chl-a
	Judges Bayou (Tidal Segment)	Chl-a
Sarasota Bay - Peace – Myakka		
	Myakka River (Tidal Segment)	DO, Total Phosphorus, historic Chl-a
	Peace River Estuary (Lower Segment)	Chl-a*
Springs Coast		
	Anclote River Bayou Complex (Spring Bayou)	Chl-a, DO, and Nutrients*
	Crystal River	Algal Mats
St. Lucie – Loxahatchee		
	Loxahatchee River	Historic Chl-a
	Loxahatchee River (Southwest Fork)	Chl-a*
Suwannee		
	Cedar Key	Chl-a*
Tampa Bay		
	Hillsborough Bay Upper	DO and Nutrients
Upper East Coast		
	Halifax River	Chl-a
	St. Johns County; Flagler County Intercoastal Waterway	Historic Chl-a
	Tomoka Basin	Chl-a*

*high priority for TMDL development, all others are of medium priority

The DO criteria evaluated in this opinion apply to all estuary and coastal waters. Among these waters DO impairments are more frequent than nutrient impairments (Table 6).

Table 6. Number of Estuary Segments with DO Impairments and Priority for Developing Total Maximum Daily Loads (TMDLs) to Restore Designated Use.

Estuary	TMDL Priority		
	High	Medium	Low
Caloosahatchee	1	2	
Charlotte Harbor	1	6	
Everglades West Coast		3	
Indian River Lagoon	3	2	
Lake Worth Lagoon - Palm Beach Coast			
Lower St. Johns		1	
Nassau - St. Marys		1	
Pensacola			
Sarasota Bay - Peace - Myakka	3	16	
Southeast Coast - Biscayne Bay		1	
Springs Coast	7	3	
St. Lucie - Loxahatchee		1	
Suwannee	1	1	
Tampa Bay	3	18	12
Tampa Bay Tributaries		2	1
Upper East Coast		1	1

4.1.4 Risk Hypotheses for Evaluating Approved Criteria and Limits

Risk hypotheses are statements that organize an analysis by describing the relationships among stressor, exposure, and the environmental values to be protected (also referred to as the assessment endpoints). The objective of this opinion's assessment, per the ESA, is to determine whether the WQS approved by EPA would directly or indirectly adversely affect individual survival or fitness such that the extinction risk of ESA-listed populations or species would be increased or that designated critical habitat necessary for the persistence of ESA-listed species would be adversely modified or destroyed. Generally speaking, the values to be protected are therefore the survival and fitness of individuals and the value of designated critical habitat for conservation of an ESA- listed species. Risk hypotheses are constructed by placing information on the water quality parameters for which EPA has approved standards in context of species and designated critical habitat attributes potentially affected by those parameters.

Nutrients directly affect photosynthesizing organisms through stimulating photosynthesis. Both photosynthetic and non-photosynthetic organisms are indirectly affected when excess nutrients alter the resources and physical properties of habitats through accelerated accumulation and turnover of plants and algae and the consequent cascading changes in aquatic chemistry and organic matter (i.e., eutrophication). The FDEP NNC are intended to remediate or prevent eutrophication, so these criteria are not presumed to result in eutrophication. The analysis needs to determine whether the criteria are adequately protective and prevent eutrophication. If the criteria are not protective and support eutrophication, the adverse effects of stressors resulting from eutrophic conditions must be evaluated for ESA-listed species and designated critical habitat. For this reason, a tiered approach first determines whether the NNC will promote eutrophic conditions before applying risk hypothesis to evaluate the potential for adverse effects associated with eutrophic conditions (Section 4.1.1, *Nutrients*, Figure 5). The exposure analysis will evaluate the potential for eutrophication prior to establishing the distribution and overlap of those areas where the NNC support eutrophication with ESA-listed resources under NMFS' jurisdiction. In cases where the NNC support eutrophication, the opinion will address the following risk hypotheses, as appropriate:

- NNC will support eutrophic conditions that affect the survival and fitness of individuals through:
    - lethal and sublethal exposures to ammonia
    - lethal and sublethal exposures to algal toxins
    - lethal and sublethal effects of DO extremes
    - lethal and sublethal infections
    - lethal and sublethal smothering
    - altered light penetration/turbidity
    - altered colonization substrate

- NNC will support eutrophic conditions that have indirect effects to survival and fitness through:
    - reduction in extent of inhabitable area
    - reduction in extent of useful habitat
    - reduction in prey species

Extremes in DO content of water, typically insufficient DO, may directly affect those species that obtain oxygen from water (fish, coral, and seagrass). Indirect effects to species that breathe air, like sea turtles, may include adverse changes in prey species and the coral reef and seagrass habitats they rely upon. Florida's DO criteria are intended to provide for DO levels that reflect natural conditions and are presumed to be protective of aquatic organisms. The analysis will assess whether Florida's DO criteria adversely affect ESA-listed species or essential features of their designated critical habitat using the risk hypotheses below:

- DO concentrations at FDEP saturation-based criteria will result in DO concentrations that affect the survival and fitness of individuals

- DO concentrations at FDEP saturation-based criteria will result in DO concentrations that affect the fitness of individuals through:
    - reduced survival of eggs, neonates, or breeding adults,
    - reduced nursery area

- DO concentrations at FDEP saturation-based criteria will result in DO concentrations that cause indirect effects to survival and fitness through:
    - reduction in extent of inhabitable area
    - reduction in extent of useful habitat
    - reduction in prey species

Excess turbidity is a direct stressor to those species that rely on light penetration through the water column or are susceptible to irritation by suspended particles contributing to turbidity. High turbidity can introduce additional indirect stress as suspended materials settle out of the water column and alter the substrate (e.g., fill interstitial refugia, embed hard bottom or cobble substrate), potentially smothering benthic or benthic-stage organisms.

Unlike the NNC and Florida's DO criteria, the action related to turbidity that is the subject of this opinion does not specify acceptable ambient concentrations. EPA approved a mixing zone limit for beach nourishment under Florida's JCP, along with additional protective measures to mitigate the effects of such activities. Because the activities involve discharges of sediment to waters of the U.S., the permits are bundled by FDEP and submitted as a group to the USACE for authorization. The USACE authorization is a federal action and is subject to ESA section 7 consultation if the USACE determines that an activity may affect ESA-listed species. Because the turbidity limits are relative to site specific background levels, the approval is not specifically relatable to a stressor intensity that can be evaluated through a risk hypothesis. The JCP itself is a permitting program implemented by the State, and EPA's action approved only a portion of the requirements the program implements. As such, EPA does not make the final call on what mixing zone is applied to a given activity.

This opinion will assess whether EPAs approval of a maximum mixing zone of 1000 meters for the beach nourishment, in combination with standards for determining the appropriate size of a turbidity mixing zone, ensure that ESA-listed species under NMFS' jurisdiction will not be jeopardized or the quality of designated critical habitat for those species would not be reduced. We also evaluate the aggregate implications of the standards, as beach nourishment activities recur.

The turbidity mixing zone limits approved by EPA specify the permissible maximum extent of temporary harmful levels of turbidity. Mobile species are expected to avoid temporary disturbances and thus would not be expected to be significantly directly affected by these activities. As such, the risk hypotheses focus on non-mobile coral species and Johnson's seagrass and indirect effects to sea turtles, smalltooth sawfish, sturgeon, and Nassau grouper.

- The FDEP turbidity limits will reduce the survival of individuals through smothering

- The FDEP turbidity limits will affect the fitness of individuals through:
    - Alteration of colonization substrate
    - Reduced light penetration

- The FDEP turbidity limits will indirectly affect survival and fitness through:
  - Restriction in usable habitat due to mixing zone avoidance

The individual risk hypotheses scenarios identified above do not necessarily apply to each species addressed in this opinion. For example:

- North Atlantic right whale and sea turtles breathe air, therefore these species will not be directly affected by DO concentrations in water;
- mobile organisms would not be smothered by sedimentation of particles generated through eutrophication or turbidity due to the beach nourishment; and
- coral species that are supported largely through photosynthesis would be affected by changes in light penetration, but not necessarily by reductions in planktonic prey species.

These considerations are summarized for the species groups in Table 7, which provides the organizing framework for the effects analysis of this opinion and will be repeated as the assessment proceeds. Where the table contains a check mark, the risk hypothesis applies to the species in question. Where there is not a check mark, text in the table explains why the hypothesis is not applicable to that species and the stressor scenarios are therefore determined to have "No Effect" for these ESA-listed species. Applicability of a risk hypothesis does not in itself indicate a conclusion that such adverse effects are expected to occur, but instead merely indicates that it is a hypothesis that should be evaluated.

Table 7. No Effect and May Effect (✓) Determinations for EPA-approved NNC, DO Criteria and Turbidity Limit Risk Assessment Hypotheses for ESA-listed Species Under NMFS Jurisdiction.

	North Atlantic right whale	Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles	Atlantic and shortnose sturgeon[a], smalltooth sawfish, and Nassau grouper	Elkhorn and staghorn corals, boulder lobed and mountainous star corals, pillar coral, and rough cactus coral	Johnson's seagrass
Hypothesis: NNC will support eutrophic conditions that affect the survival and fitness[b] of individuals through:					
lethal and sublethal exposures to ammonia	**No Effect:** breathes air, drinks little to no seawater	✓drink sea water	✓	✓	✓
lethal and sublethal exposures to algal toxins	**No Effect:** do not forage in Florida waters, drinks little to no seawater	✓	✓	✓	✓
lethal and sublethal DO extremes	**No Effect:** breathes air	**No Effect:** breathes air	✓	✓	✓[c]
lethal and sublethal infections	✓	✓	✓	✓	✓
lethal and sublethal smothering by algae	**No Effect:** mobile	**No Effect:** mobile	**No Effect:** mobile	✓	✓
Altered turbidity/light penetration[d]	**No Effect:** not light dependent	**No Effect:** not light dependent	**No Effect:** not light dependent	✓	✓
altered substrate	**No Effect:** not substrate dependent	**No Effect:** not substrate dependent	**No Effect:** not substrate dependent	✓	✓
Hypothesis: NNC will support eutrophic conditions that have indirect effects to survival and fitness through:					
reduction in extent of inhabitable area	✓	✓	✓	✓	✓
reduction in extent of useful habitat	✓	✓	✓	✓	✓
reduction in prey species	**No Effect:** do not forage in FL waters	✓	✓	✓	**No Effect:** autotrophic
Hypothesis: DO concentrations under Florida's saturation-based criteria will result in DO concentrations that affect the survival of individuals					
	No Effect: breathes air	**No Effect:** breathes air	✓	✓	**No Effect:** generates oxygen
Hypothesis: DO concentrations under Florida's saturation-based criteria will result in DO concentrations that affect the fitness of individuals through:					
reduced survival of eggs, neonates, or breeding adults	**No Effect:** breathes air	**No Effect:** breathes air	✓	✓	**No Effect:** generates oxygen
reduced nursery area	**No Effect:** breathes air	**No Effect:** breathes air	✓	**No Effect:** do not use nursery areas	**No Effect:** do not use nursery areas
Hypothesis: DO concentrations under Florida's saturation-based criteria will result in DO concentrations that cause					

	North Atlantic right whale	Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles	Atlantic and shortnose sturgeon[a], smalltooth sawfish, and Nassau grouper	Elkhorn and staghorn corals, boulder lobed and mountainous star corals, pillar coral, and rough cactus coral	Johnson's seagrass
indirect effects to survival and fitness through:					
reduction in the extent of usable of habitat	**No Effect:** breathes air	**No Effect:** breathes air	✓	✓	**No Effect:** generates DO
Reduction in prey species	**No Effect:** do not forage in FL waters	✓	✓	✓	**No Effect:** autotrophic
Hypothesis: Turbidity limits will affect survival of individuals through:					
Smothering	**No Effect:** mobile	**No Effect:** mobile	**No Effect:** mobile	✓	✓
reduced light penetration	**No Effect:** not light dependent	**No Effect:** not light dependent	**No Effect:** not light dependent	✓	✓
Hypothesis: Turbidity limits will affect fitness of individuals through:					
reduced light penetration	**No Effect:** not light dependent	**No Effect:** not light dependent	**No Effect:** not light dependent	✓	✓
altered substrate	**No Effect:** mobile	**No Effect:** mobile	**No Effect:** mobile	✓	**No Effect:** sand is substrate
Hypothesis: Turbidity limits will cause indirect effects to survival and fitness through:					
restriction in usable habitat due to mixing zone avoidance	✓	✓	✓	**No Effect:** not mobile	**No Effect:** not mobile

[a] St. Marys River identified as a spawning river in proposed critical habitat for Atlantic sturgeon because young-of-year fish were captured in this river in 2014.
[b] Reproductive output, colonization, or offspring viability.
[c] While seagrass generates oxygen, the species is vulnerable to anoxic extremes when coupled with reduced light penetration resulting from algal blooms under eutrophic conditions
[d] Interpreting light penetration/turbidity data with respect to nutrient enrichment is complicated by the need to differentiate the contribution of algae from that of suspended sediment.

In addition to assessing effects on species, this opinion also evaluates effects to designated critical habitat. Designated critical habitat in Florida's waters is designated for the North Atlantic right whale, the loggerhead sea turtle, elkhorn and staghorn corals, smalltooth sawfish, gulf sturgeon, and Johnson's seagrass.

The designated critical habitat assessment evaluates the effects of the NNC, DO, and turbidity levels that were approved as WQS on the value of the designated critical habitat to the conservation of the species, with a focus on the physical and biological features of designated critical habitat essential to the conservation of the species. The overarching risk hypotheses is:

> *"Florida's NNC, DO criteria, and turbidity limits approved by EPA support conditions that adversely affect the critical habitat, including the features that are essential to the conservation of the species."*

The designated critical habitat analysis also revisits the indirect effects described in Table 7 on values that are not specified in the designated critical habitat designation, but may occur within the spatial extent of designated critical habitat, to the extent effects on such values would affect the value of the habitat to the conservation of the species. Table 8 lists the physical and biological features specified in designated critical habitat designations for each species and relates these to the designated critical habitat risk hypotheses.

Table 8. No Effect and May Effect Determinations for the Risk Hypothesis: "Florida's NNC, DO Criteria, and Turbidity Limits Approved by EPA Support Conditions that Adversely Affect the Critical Habitat, Including the Features that are Essential to the Conservation of the Species."

Species	Essential Physical and Biological Features	Implications of Standards
North Atlantic right whale	Water of particular depth and temperature, Abundant prey resources, oceanographic features that aggregate prey; Waters free of obstruction and disturbance to allow whales to rest, travel, feed, breed, birth, and raise calves safely	**No Effect:** Not relatable to nutrients, DO or turbidity, right whales do not feed in action area
Loggerhead turtle *Caretta caretta:* Northwest Atlantic Ocean	Nearshore Reproductive Habitat; Nearshore waters directly off the highest density nesting beaches and their adjacent beaches as identified in 50 CFR 17.95 (c) to 1.6 km (1 mile) offshore; Waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water; Waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents	**No Effect:** Not relatable to nutrients, DO, or turbidity
	Breeding Habitat; High densities of reproductive adults; Proximity to primary Florida migratory corridor; and Proximity to Florida nesting grounds.	**No Effect:** Not relatable to nutrients, DO, or turbidity: No effect
	Migratory Habitat; Constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways; and; Passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas.	**No Effect:** Not relatable to nutrients, DO. **May Affect:** Excess turbidity a possible barrier
	Sargassum Habitat; Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the Sargassum community in water	**May Affect:** NNC, DO, and turbidity potential effects to predation and

Species	Essential Physical and Biological Features	Implications of Standards
	temperatures suitable for the optimal growth of Sargassum and inhabitance of loggerheads; Sargassum in concentrations that support adequate prey abundance and cover; Available prey and other material associated with Sargassum habitat including, but not limited to, plants and cyanobacteria and animals native to the Sargassum community such as hydroids and copepods; and; Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by Sargassum for post-hatchling loggerheads, i.e., >10 m depth.	prey species
Smalltooth sawfish *Pristis pectinata*	Juvenile Nursery Habitat; Red mangroves and adjacent shallow euryhaline habitats due to their function of providing refugia and diverse and abundant forage that facilitate recruitment of juveniles into the adult population	**May Affect:** NNC, turbidity potential to effects and refugia. nutrients, DO, turbidity potential effects to forage
Elkhorn coral *Acropora palmata* Staghorn coral *Acropora cervicornis*	Substrate of suitable quality and availability to support successful larval settlement and recruitment, and reattachment and recruitment of fragments	**May Affect:** NNC, turbidity potential effects to substrate
Johnson's seagrass *Halophila johnsonii*	Adequate water quality, salinity levels, water transparency and Stable, unconsolidated sediments free from disturbance	**May Affect:** NNC turbidity potential effects to light penetration and substrate, **No Effect:** DO criteria

4.2 Exposure and Response Analysis

The exposure analysis characterizes the spatial extent and intensity of stressors associated with an action and the overlap of that exposure with ESA-listed species and habitat. Exposure assessment for the NNC is not straightforward because nutrients are not direct stressors. When in excess, nutrients lead to eutrophication and the associated stressors and adverse effects. Exposure assessment for Florida's DO criteria is more straightforward. These criteria can be overlaid with species geospatial information to indicate which standards apply for an area of interest and the effects assessment then determines whether exposures at the criteria would cause adverse effects. The following sections first evaluate whether the NNC promote eutrophic conditions before evaluating Florida's DO criteria and turbidity limits addressed in this opinion.

The response analysis follows the exposure analysis and is organized along the risk hypotheses described in Section 5.4. To review, risk hypotheses are statements that describe the relationships among stressor, exposure, and the environmental values to be protected. The objective of our assessment is to determine whether the WQS approved by EPA would directly or indirectly adversely affect individual survival or fitness such that the extinction risk of ESA-listed populations or species would be increased or that designated critical habitat necessary for the persistence of ESA-listed species would be adversely affected. The values to be protected are therefore the survival and fitness of individuals and the value of designated critical habitat for conservation of an ESA-listed species. Risk hypotheses constructed in Section 5.4 placed information on the water quality parameters for which EPA has approved standards in context of species and designated critical habitat attributes that may be affected by those parameters.

4.2.1 **Exposure: NNC**

Florida's NNC are intended to prevent eutrophication and promote healthy conditions. The *indicators* representing healthy conditions include seagrass metrics, Chl-a concentrations, and DO regime. Seagrass metrics are used as indicators of estuary health worldwide, with declines in spatial extent, density and biomass integrating the influences of multiple stressors (Roca et al. 2016). Chl-a is a useful indicator of plankton growth which integrates nutrient loading in an aquatic system. Overstimulation of photosynthesis and increased algal growth by excess nutrients elevates Chl-a levels above natural conditions (Harding et al. 2014). The DO regime of a system is also an indicator of eutrophic conditions, with photosynthesizing algal biomass elevating DO to supersaturated levels in daylight and the oxygen consumption processes of respiration and algal decomposition and decay depleting DO at night time (Wenner et al. 2004, Prasad et al. 2011). The NNC for TP and TN are nutrient levels at which Florida expects these indicators will meet *thresholds* reflecting the reference conditions expected to protect aquatic life (i.e., sufficient seagrass coverage and water clarity, natural Chl-a levels, and natural DO regime). Seagrass metrics are used as indicators of estuary health worldwide, with measures of spatial extent, density and biomass integrating the influences of multiple stressors (Roca et al. 2016). The exposure assessment must determine whether any of the NNC promote eutrophication before determining whether ESA-listed species or designated critical habitat are exposed to the adverse effects of eutrophication. The response analysis will evaluate the potential responses of ESA-listed species at occur in areas where the NNC are expected to promote eutrophication.

Florida's NNC for estuaries are Hierarchy 1, site-specific standards. The NNC include concentration and load-based criteria that were derived through different strategies determined by the quantity and comprehensiveness of available data, and, in some cases, the complexity of the system to be protected. For example, the coastal NNC were derived from remotely-sensed Chl-a data because sufficient direct monitoring data for coastal waters were not available. In developing the coastal NNC, FDEP reviewed CWA section 303(d) listings for nutrients, Chl-a and DO; identified coastal segments adjacent to nutrient-impaired estuarine segments; consulted available scientific literature; and evaluated satellite data trends in order to exclude areas not representing reference conditions. The methods and strategies used align with EPA recommendations for developing nutrient criteria (Science Advisory Board 2011, USEPA 2012b). The concentration-based NNC are expressed in arithmetic means or, in cases where the underlying data were positively skewed, geometric means. Geometric means are used to attenuate the short-term variability reflected by skewed data to provide a more reliable long term estimate of the nutrient status. The arithmetic and geometric mean calculations produce equivalent results when applied to data that are not skewed.

NNC DEVELOPMENT

Sections below describe the specific strategies applied in the development of the NNC. These are followed by NMFS analyses of available recent data to determine whether these NNC support healthy conditions.

Reference Period-Based Approach in Collaboration with the National Estuary Programs

NNC developed in collaboration with EPA's National Estuary Programs provide values for estuary segments within Tampa Bay, Clearwater Harbor, Sarasota Bay and Charlotte Harbor. The Hierarchical BE reports that the management targets and thresholds for these NNC were based on a reference period approach defined by a period of time within each estuary (i.e., not segment-specific) when seagrass coverage was stable or increasing. The standards are not to be exceeded more than once in three years period and do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.

NNC for Charlotte Harbor/Estero Bay, Clearwater Harbor, and most of Sarasota Bay are open water, area-wide concentration-based averages. Establishing seagrass targets for tidal rivers is complicated by water color and visibility, so the Chl-a NNC for the Tidal Myakka, Tidal Peace, and Tidal Caloosahatchee rivers are based on Chl-a targets for the downstream areas: Charlotte Harbor Proper for the Tidal Peace and Tidal Myakka and San Carlos Bay for Tidal Caloosahatchee segments (Janicki Environmental 2011). The TN NNC for the Sarasota Bay proper segment of the Sarasota Bay estuary is a calculation reflecting variation in color[9], according to season and north/south delineation. This was necessary because of the complex relationship between Chl-a and TN in this segment. The TN concentration that corresponds to the threshold Chl-a concentrations for Sarasota Bay will vary from year-to-year depending upon the ambient color observed in a given season, location, and year. Finally, the Tampa Bay standards are expressed as TP and TN delivery ratios to adjust for the influence of residence time of pollutant loads in that system. Residence time shortens when freshwater inputs are greater and loadings move through the system more quickly.

[9] Color is an index of suspended particulates, humic substances, and algae expressed in Platinum-Cobalt Scale (Pt/Co) units.

"Maintain Healthy Conditions" approach for South Florida Marine Systems

Florida's NNC standards for segments within Biscayne Bay, Florida Bay, Florida Keys, and Tidal Cocohatchee River/Ten Thousand Islands were arrived at using a "Maintain Healthy Conditions" methodology. The objective of this methodology is to maintain current nutrient regimes considered to be biologically healthy from the standpoint of nutrient enrichment. Monitoring data representing "healthy conditions" were used to calculate standards as annual geometric means not to be exceeded more than once in three years. The process specifically shields against identifying a healthy system as impaired by selecting thresholds at the 90th percentile. For example, setting the threshold at the 75th percentile would result in incorrectly classifying a quarter of the benchmark sites and a large number of healthy sites as impaired, so a more inclusive approach was necessary for these waters.

This approach may appear counter-intuitive because the goal of an environmental indicator is often to detect and mitigate environmental problems, and the failure to detect a problem may result in a failure to recover an impaired system. However, the FDEP strategy for developing protective standards was to avoid identification of a problem, for example unhealthy conditions, when none actually exists, to avoid the loss of information about healthy conditions for that particular system. This is particularly important for areas associated with the Everglades and mangrove forests, which are large sources of natural inputs of organic matter. This could lead to standards that trigger unnecessary and potentially harmful corrective measures such as the removal of biomass to reduce nutrient sinks/sources (Lavery et al. 1999, Lenzi et al. 2015, Quilliam et al. 2015) or misdirected use of human capitol and resources. The potential for this inclusive approach to result in failures to detect impaired systems is mitigated through the FDEP trends analyses requirement (Chapter 62-303, F.A.C.) to detect adverse trends in water quality in order to trigger protection of downstream conditions, when necessary.

Estuary Reference Condition Approach using Distributional Statistics

FDEP applied reference condition approach using distributional statistics to most estuaries. These NNC are evaluated in EPA's Estuary BE, which reported two different TP NNC values for the Alafia River Estuary. The text reported the TP NNC to be 0.86 mg/L and the table reported it as 0.086 mg/L. The correct TP NNC is 0.86 mg/L according to F.A.C. 62-302.532. Distributional statistics are used to set NNC at a level that will maintain the current distribution of reference condition monitoring data, while accounting for natural temporal variability. Reference conditions were based on either reference period or reference site data. Reference period data are selected from a time period when the water itself was determined to be biologically unimpaired and supporting its most sensitive designated uses. When reference period data were not available, data from an unimpaired, adjacent, and functionally similar reference site were used to represent reference conditions. Eight years of data were available for the derivation of standards for most estuary segments. For each of these segments, the annual geometric mean standard not to be exceeded more than once in a three-year period is based on the 80th percent prediction limit of averaged annual geometric means (i.e., 80 percent confidence that a new observation greater than the NNC does not reflect reference conditions). For those segments with less than eight years of data, but having at least 30 total samples, a "single-sample standard" not to be exceeded in more than 10 percent of samples was determined to be the upper 90th percent prediction limit of the samples. These concentration-based estuary NNC are open water, area-wide averages. The nutrient (TP and TN) and nutrient response (Chl-a) standards do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.

Empirical Approach for the Fluctuating Influence of Freshwater Inflows

FDEP used an empirical approach to derive TP and TN NNC for the Suwannee Sound and Withlacoochee River Estuaries because both are characterized by highly variable, natural flushing rates resulting in significant freshwater inflows and wide variations in residence time. FDEP screened data using the same methodology described for the reference conditions approach above. Annual mean salinity and annual geometric mean nutrient concentrations were determined for each station for years in which all Chl-a and seagrass coverage reflected reference conditions. Salinity served as a surrogate for river flow and freshwater inputs to account for the natural spatial and temporal variability in nutrient levels and the fluctuating influence of freshwater. Linear regression describing the relationship between salinity and TP and TN concentrations ($r2 \geq 0.5$ and $p < 0.05$) provided the salinity-dependent equations used to establish these criteria. The standards are expressed as annual geometric means, for each monitoring station within the segment. These standards are not to be exceeded in more than 10 percent of stations more than once in a 3-year period. Using the annual arithmetic average salinity in practical salinity units for each station made in conjunction with the collection of the nutrient samples, the salinity-based equations are:

Mechanistic Modeling Approach

Mechanistic modeling was applied when available data and/or the existing conditions were not suitable for distributional statistics or empirical analysis. The effort applied peer reviewed models to estimate the quantity of water and pollutants associated with runoff from rain events associated with the contributing watershed of the estuary. Where data were available, a hydrodynamic model was linked to the Water Quality Analysis Simulation Program to simulate eutrophication-rates and effects. However, in Florida's Big Bend region, it was necessary to base watershed loadings on the most recent land cover information, simulated for the 1997-2009 period and the hydrodynamic and water quality modeling for the 2002-2009 period. This method was adapted for those waterbodies with low land use intensity and naturally low DO.

The Charlotte Harbor/Estero Bay TN NNC and the TP and TN NNC for Upper Escambia Bay and Judges Bayou are expressed as annual loads. This is based on the response times for Chl-a levels to return to baseline after the annual summer peaks, suggesting a relationship with pollutant load residence time effects, as observed in Tampa Bay (Janicki Environmental 2011). For concentration-based standards, Chl-a, TN, and TP results were aggregated into daily, volume weighted averages, then used to calculate annual geometric means. The annual geometric means were compared with biological data to determine the threshold at which nutrient pollution adversely impacts indicators of healthy conditions. FDEP then established NNC at levels that protect against these adverse effects to support a healthy biological community. The concentration-based estuary interpretations are open water, area-wide averages. The nutrient and nutrient response standards do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.

PROTECTIVENESS OF NNC

The following sections use the best available information to evaluate whether the criteria promote or prevent eutrophic conditions.

Do the Concentration-Based Estuary NNC promote or prevent eutrophic conditions?

As described previously, many of the FDEP estuary NNC for nutrients TN, TP and for the nutrient response variable Chl-a, are concentration-based values derived from monitoring data representing reference or "healthy" (non-eutrophic) conditions, from empirical models accommodating site-specific confounding factors, or from mechanistic models predicting the fate and effects of anticipated pollutant loads. The estuary segment specific NNC arrived at using these approaches range widely (Figure 16).

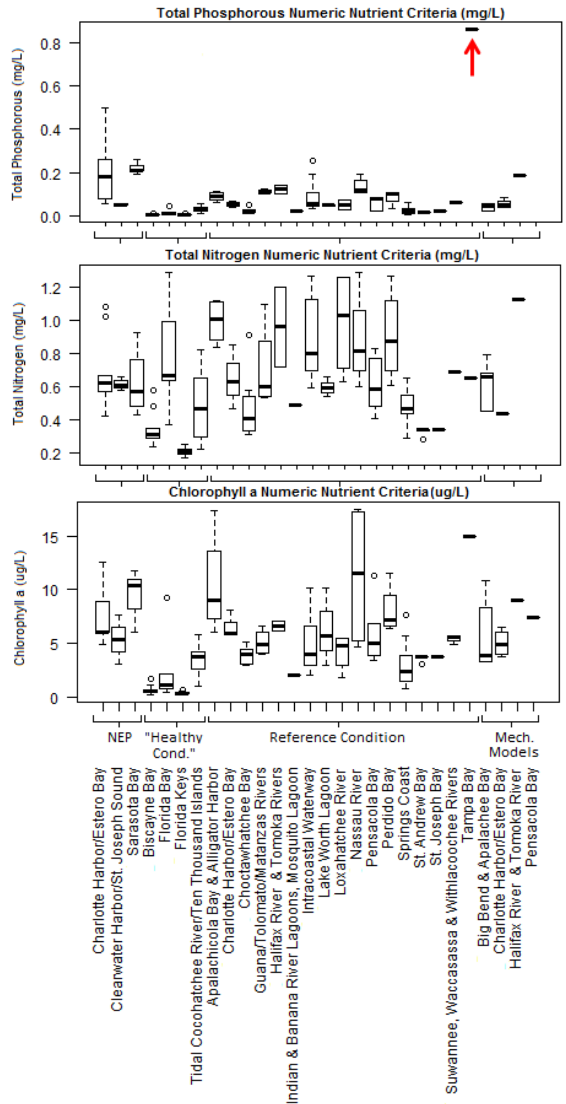

Figure 16. Concentration-based NNC for TP, TN, and Chl-a Among Estuaries. Reference Periods[10], "Healthy Cond." = inclusive "Maintain Healthy Conditions Approach," Reference Condition = excluding non-reference data for reference sites or periods, Mech. Models = Mechanistic hydrodynamic and nutrient loading modeling.

The extreme TP NNC indicated by the red arrow in Figure 16 represents the tidal segment of the Alafia River. Since TN is the limiting nutrient in this system, FDEP determined that the existing

[10] Boxplots like the one depicted in Figure 15 graphically describe the distribution of observations in a dataset. The band inside the box denotes the midpoint of the distribution, the box encloses 50 percent of the data with 25 percent of observations ocurring above the median band and 25 percent occurring below the median band. The lines extending from the box extend to the minimum and maximum observation falling within one standard deviation from the mean of the data, and the circles ocurring beyond these lines denote individual outlier observations falling outside of one standard deviation from the mean.

TP levels were protective of designated uses. Several Florida watersheds are naturally enriched in phosphorus, and the consequences of phosphorus mining dating back to the 1800's has resulted in man-caused acceleration of phosphorus loading in the associated estuaries. As a result, the limiting nutrient determining the maximum primary production potential for these systems is nitrogen.

NMFS conducted a "perfect compliance" analysis of data from individual sampling events[11] to determine whether concentration-based estuary NNC for TP and TN are consistently associated with Chl-a levels (i.e., nutrient response idicator) at or below the Chl-a NNC. The analysis used recent nutrient monitoring data from the FDEP STOrage and RETrieval (STORET) public access database. The Chl-a monitoring data were classified as either belonging to sampling events where TP and TN concentrations were at or below their respective NNC (i.e., consistent with NNC) or belonging to events where TN and/or TP concentrations were elevated over their NNC (i.e., elevated nutrients). Sampling events where the TP and TN levels were consistent with NNC would be expected to have Chl-a levels at or below the Chl-a NNC (i.e., "perfect compliance"). Similarly, sampling events where the TP and TN levels were above the NNC would be expected to have elevated Chl-a levels at a higher frequency (i.e., more observations) or greater severity (i.e., observations exceeding the Chl-a NNC to a large degree). This requires the assumption that the Chl-a NNC are sufficiently representative of reference conditions.

> ***NMFS concludes, after review of the technical documents supporting the determination of estuary Chl-a NNC that it is reasonable to expect the Chl-a NNC to represent reference (i.e., non-eutrophic) conditions and may therefore be used as an indicator to evaluate whether the TN and TP NNC support eutrophic conditions.***

Most monitoring data, are taken at a discrete location at a specific time. These snapshots in time, taken alone, do not integrate the tidal, diurnal, and seasonal variation inherent in ecological systems. These factors are integrated when sampling events from multiple stations within an estuary segment are aggregated into the open water, area wide averages not to be exceeded over a defined time period or sampling frequency (i.e., "as implemented" in implementing the criteria). In short, it is the frequency and sufficiency of data indicating a pattern of NNC exceedances that denote conditions favoring eutrophy.

The purpose of the "perfect compliance" analysis was to use the available data to evaluate how well sampling events meeting the TP and TN NNC correspond with Chl-a levels meeting the Chl-a NNC, not to infer the health status of any particular water body. Data used in the derivation of NNC were not used in this analysis because this would produce a self-confirmatory

[11] FDEP STOrage and RETrieval database, http://www.dep.state.fl.us/water/storet/

result. Limiting the analysis to recently collected, validated[12] data that were not used in NNC derivation from the FDEP STORET data portal provides data for 443 sampling events collected between 2010 and 2015. These data are distributed among 16 estuaries, with most observations (n=327) collected within the Charlotte Harbor/Estero Bay estuary, particularly from the Tidal Peace River Segment.

We are interested in cases where Chl-a exceeded the Chl-a NNC when the TN and TP were compliant with their respective NNCs (NNC-compliant). Among sampling events with known nutrient NNC status, 55 percent (n=173) were NNC-compliant (Table 9)[13]. Elevated Chl-a occurred in 37 of the NNC-compliant events and 31 of these observations were from the Tidal Peace River segment of the Charlotte Harbor/Estero Bay estuary. Looking just at the data from the Tidal Peace River segment, we found that 41 percent percent of the sampling events that were NNC-compliant had elevated Chl-a. This suggests the TN and/or TP NNC for this estuary segment are too high to result in Chl-a response levels consistent with the Chl-a NNC.

For contrast, we consider cases where TN or TP were above the NNC (elevated nutrients). Thirty four out of 158 sampling events (i.e., 21 percent) reporting TN and/or TP above their respective NNC had Chl-a above the Chl-a NNC. Again, sampling events from the Tidal Peace River dominated those cases with elevated Chl-a NNC (n=28).

Table 9. Number of Sampling Events Reporting Chl-a Levels Within and Above Chl-a NNC Relative to Events Reporting TP and TN Levels Within and Above TP and TN NNC.

	TP and/or TN Above NNC			TP and TN Within NNC		
Estuary	Chl-a Above Criteria	Chl-a Within Criteria	percent Elevated Chl-a	Chl-a Above Criteria	Chl-a Within Criteria	percent Elevated Chl-a
All data with known NNC status (331 obs)	34	124	22%	37	136	21%
Tidal Peace River (129 obs)	28	26	52%	30	45	40%
Other Segments (201 obs)	6	98	6%	6	91	6%

Consistent with expectations, Chl-a NNC exceedances were more extreme in sampling events where TP and TN were elevated over their respective NNC. Figure 17, panels A and B contrast Chl-a observations from Tidal Peace River versus data from other estuary segments. Only two of the 37 observations elevated Chl-a from NNC-consistent events reported Chl-a at more than twice the Chl-a NNC. The overall Chl-a levels for these events ranged from less than 1 percent to

[12] In cases where the analyte occurred in the sample below plausible quantitation limits, a value of one half the detection limit was applied. Data were rejected if some or all of the quality control criteria were violated such that the presence or absence of the analyte could not be determined.

[13] A detailed table listing data availability for individual segments is provided in Appendix B.

five-fold higher than the NNC (i.e., 500 percent). Meanwhile among sampling events reporting elevated TP and TN with elevated Chl-a (N=34), Chl-a levels were between 12 percent to about ten-fold over the Chl-a NNC (i.e., 1000 percent) and 15 of these were more than twice the Chl-a NNC.

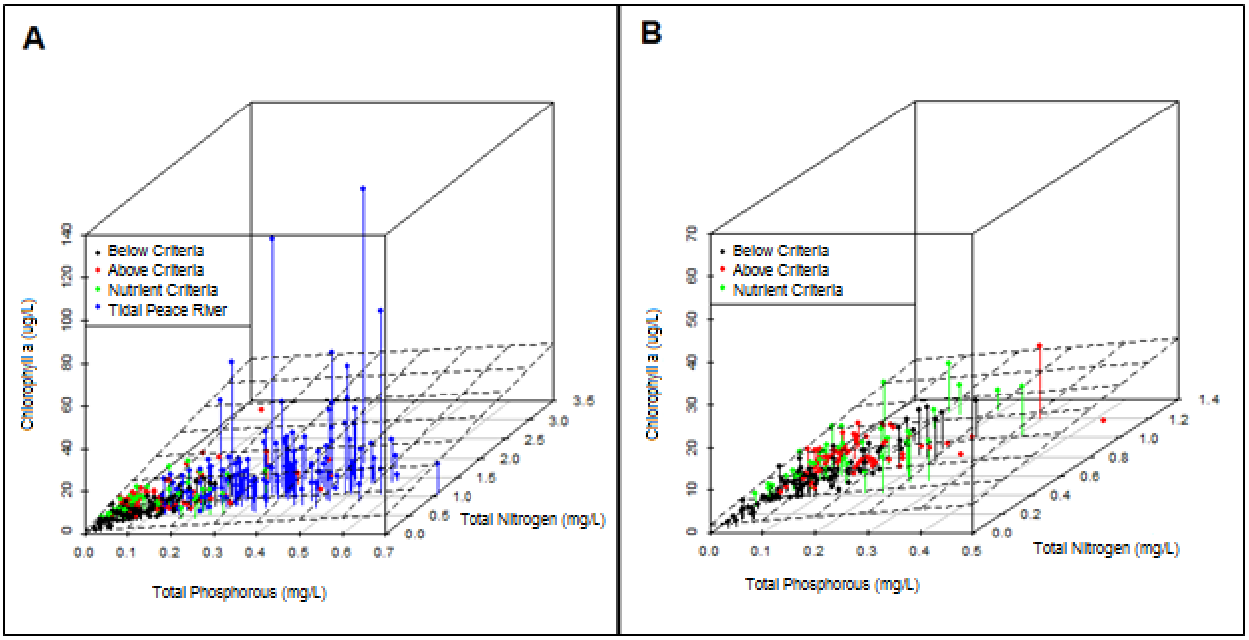

Figure 17. Relationship Between Chl-a and Nutrients Concentrations for the NNC and Data from 2010-2015. The Tidal Peace River NNC are 1.08 mg/L for TN, 0.5 mg/L for TP, and 12.6 for Chl-a. Panel A Includes Sampling Events from Tidal Peace River (Blue Symbols), Panel B Plots the Same Data Without Tidal Peace River. The regression plane was calculated from the NNC (green symbols).

Four sampling events reporting elevated Chl-a had TP levels consistent with TP NNC, but no data for TN. Two of these events did report Kjeldahl nitrogen at levels below the TN NNC, suggesting reference TN levels may be present. A third event, from the Tidal Peace River had nitrate/nitrite and ammonia concentrations reported at a concentration greater than 90 percent of other observations for these nitrogen forms. This sampling event also had a Chl-a level nearly 79 times the Chl-a NNC. While the TP level of 0.44 mg/L for this event did not exceed the TP NNC for the estuary segment, at 0.5 mg/L, the Tidal Peace River TP NNC is the second highest among all estuary TP NNC evaluated in this opinion. The Tidal Peace River TN NNC of 1.08 mg/L is also relatively higher than other TN NNC, ranked eighth out of 86 NNC. The Chl-a NNC of 12.6 μg/L for this segment is also relatively high, ranking third among Chl-a standards.

Discussion: NNC derivation for the tidal segment of the Peace River. Given the dominance of Tidal Peace River excursions and the unusually high NNC for this segment, derivation of these NNC needed to be examined more closely before a conclusion on the estuary NNCs could be arrived at. The unusually high NNCs for Tidal Peace River were established separately from the other estuary segments and submitted to EPA along with proposed Florida's DO criteria in the September 2013 *Biological Evaluation for the EPA's Approval of DO and Nutrient Related Revisions to Florida's 62-302 and 62-303 Rules*, because FDEP had originally believed a TMDL would be applied, but that TMDL has been delayed indefinitely (Giattina 2013). The quantity and quality of data used to advance recovery in segments of the Tampa Bay Estuary by limiting nutrient loading (Greening and Janicki 2006) were not available for Charlotte Harbor at the time of NNC derivation. The current NNC for the Tidal Peace River segment of Charlotte Harbor are based on the best available data Florida had at that time.

The Charlotte Harbor National Estuary Program conducted targeted efforts to develop NNC for all segments within the estuary (Janicki Environmental 2011). Derivation incorporated seagrass, water clarity, and Chl-a targets. In the absence of suitable stressor response data, TN, TP, and Chl-a NNC were derived estuary-wide as the annual mean over a reference period from 2003 to 2007, i.e., the period that was deemed to be protective of seagrass and water clarity. From the data (Janicki Environmental 2011). However, seagrass estimates in tidal rivers likely under report coverage because seagrass is difficult to delineate in highly colored waters. As a result, coverage estimates for tidal rivers are useful for evaluating general trends, but can not be used to quantify seagrass losses or gains over time (Janicki Environmental 2011). The Chl-a standard for Tidal Peace River is based on Chl-a targets in the waterbody the Tidal Peace flows into: Charlotte Harbor Proper.

Observed TP mean annual concentrations within the reference period include two years where the TP concentrations were at the highest levels since 1996. Observed annual TP and TN loadings within the reference period include three years with the highest observed loadings since 1995 (Janicki Environmental 2011). While the final two years of data indicate an approximately 2 to 6 fold decrease in loadings, Florida was experiencing a severe drought in these two years, which may have reduced the transport of land-based nutrients and freshwater inflow into the estuary. Florida also had a prolonged drought between 1998 and 2002, with this region of the state particularly hard hit (Verdi et al. 2006), so a drought-free reference period may not actually be available with current data. Taken together, the TP annual mean concentrations, the TP and TN loadings, and the influence of periodic drought suggest that, for the Tidal Peace River segment, the years 2003 to 2007 do not reflect a reference period for this segment. A reference period approach may not be appropriate for deriving standards for this estuary segment.

The Peace River watershed has a history of impacts from phosphate mining in the watershed dating back to the 1800s.[14] The area is geologically-enriched with phosphate and a history of mining practices has enhanced phosphate loading into the watershed. The Peace River basin includes waterbodies with TMDLs for nutrients and fecal coliform associated with livestock operations.[15] While it is unrealistic to identify and impose standards based on nutrient conditions

[14] http://www.chnep.wateratlas.usf.edu/upload/documents/2011-HBMP-CSR-part-2.pdf
[15] http://www.dep.state.fl.us/water/tmdl/final_tmdl.htm

pre-1800, NNCs based on a "reference period" of recent data may misrepresent the NNCs required for the recovery of this segment.

Discussion: NNC derivation for other estuary segments. The question of whether the reference period used to derive NNC for the Tidal Peace River was suitable raises concerns for other segments within this estuary. Among these, the Myakka River watershed is a smaller system with smaller relative nutrient loadings, the Tidal Myakka River segment had a similar relative seagrass profile to the Tidal Peace River segment (Figure 18) and nutrient loadings were also elevated within the reference period (Figure 19).

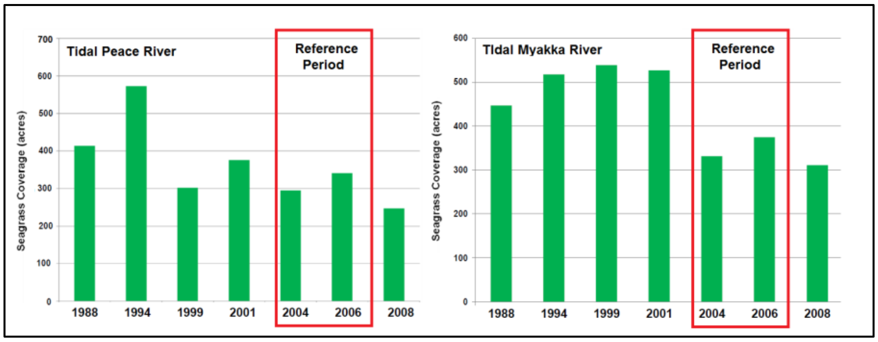

Figure 18. Comparison of Seagrass Coverage for Tidal Peace River and Myakka Rivers. Red box denotes reference period. Adapted from Janicki Environmental, 2011.

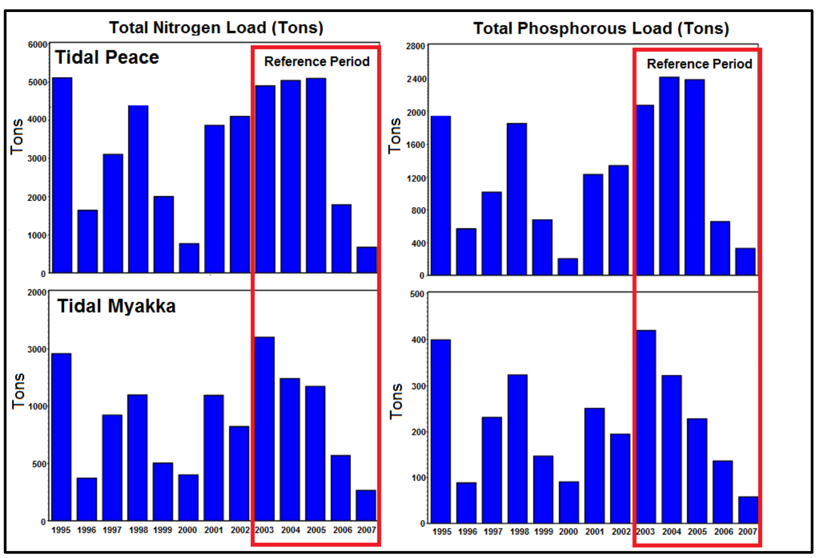

Figure 19. Tidal Peace River and Tidal Myakka River TN and TP Loads. Adapted from Janicki Environmental, 2011.

The Tidal Myakka River was not frequently sampled after 2010, but among the 28 sampling events that did occur, only one event had a Chl-a excursion over the Chl-a NNC. Even though the reference period for the Tidal Peace and Tidal Myakka rivers have generally similar seagrass and loading profiles, and similar NNC (Figure 18 and Figure 19), data for Tidal Myakka River do not suggest nutrient impairment relative to the Tidal Peace River (Figure 20). The Janicki Environmental (2011) analysis classified seagrass targets as "restoration" for the Tidal Peace River segment and "protection" for the Tidal Myakka River segment. It is useful to note that nutrient loadings into the tidal segments from their respective watersheds and the extent of seagrass were not proportional. For example, the maximum TP load within the reference period was 0.67 tons per mi^2 of the Myakka River Watershed drainage area, versus 1.02 tons TP per mi^2 for the nearly four-fold larger Peace River Watershed drainage area. Over the reference period, TN and TP loading for the Tidal Peace River segment included three years at or above the maximum prior loading rates (i.e., 2003-2005 vs 1996) while the Tidal Myakka River loadings only included one year that was at or above the highest loading observed in prior years (2003 vs 1996). The extent of seagrass in 2006 covered 5 percent of the Tidal Myakka River segment's surface area (6,828 acres) and just under 3 percent for the Tidal Peace River segment (12,283 acres).

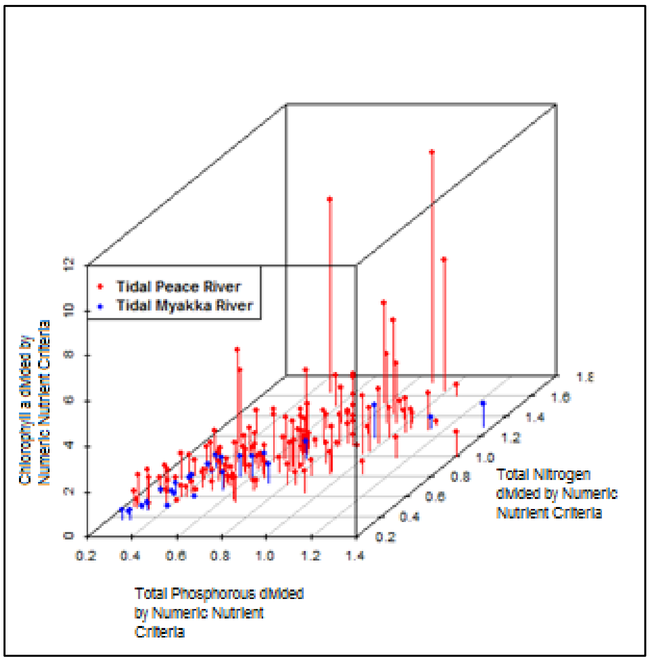

Figure 20. Ratios of TN, TP, and Chl-a Observations Relative to NNC for Tidal Peace River and Tidal Myakka River.

Several segments within the Charlotte Harbor Estuary did have greater seagrass coverage during the 2003-2007 reference period. These include Dona and Roberts Bays, San Carlos Bay, and Estero Bay (Figure 21). Meanwhile seagrass coverage for Charlotte Harbor Proper, Upper and Lower Lemon Bay, Pine Island Sound, and Matlacha Pass, within the reference period did not appear to differ substantially between 1988 and 2008.

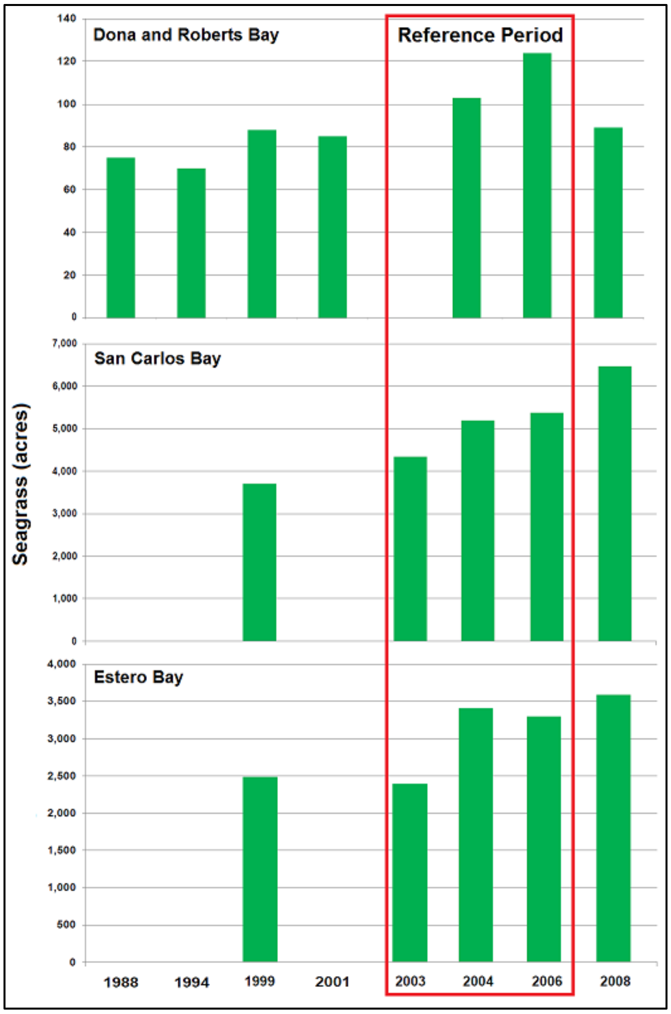

Figure 21. Available Data for Charlotte Harbor Estuary Segments Showing Positive Seagrass Trends within Reference Period Used to Derive NNC. Adapted from Janicki Environmental, 2011.

Concentration-Based Estuary NNC "As Implemented:" Area Wide Annual Means

Area wide annual averages are commonly used for water quality assessment. Annual means attenuate natural variation to provide a generalized estimate of environmental status, but do not characterize conditions during nutrient-vulnerable parts of the year, such as the late summer and early fall. In addition, averaging monitoring station data over a broad area, such as estuary segments, risks masking "hot spots." Understanding seasonal norms and hotspot detection are useful goals for diagnosing the causes of water quality impairments, but these are not among the objectives of setting water quality criteria used to identify impaired water bodies. Once an impairment is detected and confirmed, the diagnosis of that impairment can be pursued.

The intent of this "as implemented" analysis is not to determine the impairment status of Florida waters. This analysis asks: will aggregating data into area-wide means mask underlying nutrient problems? Annual means are generated from complete cases, sampling events reporting TN, TP, and Chl-a, to make sure that each sampling event is equally weighted within the annual mean for each NNC and each segment. The publically available STORET data evaluated in this opinion had 84 complete cases. There were 23 instances where TP, TN or Chl-a annual means were consistent with the NNC, but were calculated from data that included observations exceeding one or more of the NNC. These were relatively infrequent. For example, only one segment-year, 2010 data for Tidal Myakka, had annual means for TN, TP and Chl-a were consistent with the NNC, but the data used to calculate each mean included elevated TN, TP and Chl-a observations. These excursions were relatively infrequent (e.g., 2 out of 22 TN observations) and included a single Chl-a excursion that was 40 percent above the Chl-a NNC. In contrast, the TN annual means calculated for the Tidal Peace River in both 2010 and 2013 were consistent with the NNC, yet included a relatively high number of observations with elevated TN. For 2010, 20 out of 51 observations were elevated. The highest TN observation was nearly twice the NNC. The annual average Chl- a value for this year was two and a half times the Chl-a NNC. For 2013, 53 percent (9 out of 17) of the TN observations used to calculate that annual mean exceeded the NNC. The maximum TN observation was 60 percent higher than the NNC, and the annual mean Chl-a for that year was just above the NNC and included five observation that were up to four times the NNC. The outcome for both of these years would be "not in compliance with NNC" based the Chl-a observations alone, even with fairly frequent elevated TN levels factoring into an annual mean that was consistent with the TN NNC.

Conclusion: Concentration-Based Estuary NNC

With respect to the individual NNC, the key finding of the "perfect compliance analysis" is that Chl-a exceedances in estuary segments other than the Tidal Peace River were least severe in sampling events that were consistent with the nutrient NNC. These excursions may represent normal background fluctuations that would be attenuated when incorporated into the area wide annual means. If repeated, they may reflect an emerging nutrient impairment that would become evident in subsequent monitoring. The relatively equal frequency of Chl-a exceedances in sampling events that did and did not exceed TN and TP NNC for these estuaries was accompanied by a relatively low intensity of Chl-a excursions in those events consistent with TN and TP NNC. While there were data gaps among the estuaries, taken together, the data for NNC-compliant events in these estuaries contrast markedly with Tidal Peace River sampling events that were compliant with the TN and TP NNC. The magnitude of the Tidal Peace TN and TP NNC relative to the NNC for other segments, taken with the frequency and magnitude of Chl-a responses in Tidal Peace TN and TP NNC-compliant sampling events, indicate that the Tidal Peace TN and TP NNC are set at levels that promote eutrophication. Meanwhile NMFS believes that the Chl-a profiles of TN and TP NNC-compliance sampling events in other estuary segments are more suggestive of background fluctuations.

Results of the "as implemented" analysis indicate that successful application of the NNC requires Chl-a monitoring data and consideration of the frequency and degree of individual Chl-a exceedances that do occur, if the criteria are to support a stable reference condition or a declining trajectory of eutrophication. The Tidal Peace River's problematic TP and TN NNC derivation served to challenge the application of NNC to area wide annual means, and illustrated the importance of Chl-a data.

With the exception of the Tidal Myakka River, issues with the suitability of the reference period used to develop the Tidal Peace River criteria do not occur in the data used to generate reference period-based NNC for other segments (e.g., Figure 21). The most important difference between the Tidal Myakka and Tidal Peace Rivers was the number of years during the reference period when high loadings occurred. The Chl-a excursions over the NNC that did occur were dominated by sampling events from the Tidal Peace River segment of Charlotte Harbor. Considering that the 2010-2015 STORET data indicated Chl-a excursions in 40 percent of the NNC-compliant sampling events from the Tidal Peace River segments, and further evaluation of NNC derivation for this segment suggests that the reference period used poorly represented reference conditions, and resulted in NNC that promote eutrophic conditions.

The data limitations encountered when assessing the NNC are not a reflection of how FDEP will implement the NNC. FDEP requires two to three years of data to assess a waterbody. As a result of this data sufficiency requirement, under the state's Strategic Monitoring Plan, in most years multiple basins will be monitored such that each of the five basin groups situated throughout Florida are addressed on a 5-year rotation. Strategic monitoring implemented two years prior to the assessment allows the data to be available for use under the 305(b) assessments schedule required under the CWA.

Do Pollutant Load-Based Estuary NNC Promote Eutrophication?

Estuary TP and TN NNCs expressed in terms of nutrient loading originate from TMDL development. These were implemented in July of 2012 for portions of Charlotte Harbor/Estero Bay (TN loads for Lower, Middle and Upper Caloosahatchee River segments), Pensacola Bay (TP and TN loads for Upper Escambia and Judges Bayou segment), and Tampa Bay, (TP and TN loads for Boca Ciega North, Boca Ciega South, Hillsborough Bay, Middle Tampa Bay, Lower Tampa Bay, Old Tampa Bay, Manatee River Estuary, and Terra Ceia Bay segments). Site specific NNC for 10 segments of the St. Johns River are also based on TMDLs. TMDL NNC are applied to areas already known to be nutrient impaired, and recovery from nutrient impairments would be indicated by Chl-a levels that are consistent with Chl-a NNC for these segments, in addition to increased water clarity, DO, and improvements in biological condition.

Interpreting the Chl-a observations from segments with TMDL based nutrient criteria requires the assumption that the TMDL limits are implemented and effective. If this assumption is valid, then Chl-a and nutrient data from STORET collected during sampling events occurring after TMDL implementation should show lower concentrations than data from sampling events occurring before TMDL implementation. Given an expected lag time in recovery response, substantial differences between pre and post-TMDL implementation would not be expected in the three years since TMDL implementation, however lower nutrient and Chl-a levels would suggest that water quality is improving.

Sampling events conducted between 2007 and 2015 provide nutrient and Chl-a data from before and after NNC implementation for stations within the Boca Ciega South, Middle Tampa Bay, and Old Tampa Bay segments of the Tampa Bay Estuary. These segments represent 95 percent of waters with load-based NNC that are addressed in this BiOp. The remaining segments are also part of Tampa Bay system, so this analysis should apply to the Boca Ciega North, Hillsborough Bay, Lower Tampa Bay, Manatee River Estuary, and Terra Ceia Bay segments. Pre and post load-based data were not available for the remaining segments. The majority of sampling events were conducted in the Old Tampa Bay segment, with events distributed among six stations. The TN values were not commonly available for these sampling events, so Kjeldahl nitrogen, which is TN minus the nitrate/nitrite forms of nitrogen, was evaluated in its place as an index of changes in TN levels.

The boxplots in Figure 22 describe the distribution of Kjeldahl nitrogen, TP and Chl-a levels before (green) and after (yellow) TMDL implementation within each estuary segment. While the pre- and post-TMDL values overlap considerably, the median Kjeldahl nitrogen levels were lower post TMDL in six of the seven segments for which both pre and post TMDL nitrogen data were available. Median Chl-a values were only lower post TMDL for half of the segments. In those segments where Chl-a was higher post TMDL, TP was also elevated over pre TMDL levels. Chl-a levels summarized in Table 10 show that those segments with lower frequencies of Chl-a exceedances also had lower intensities of Chl-a exceedances.

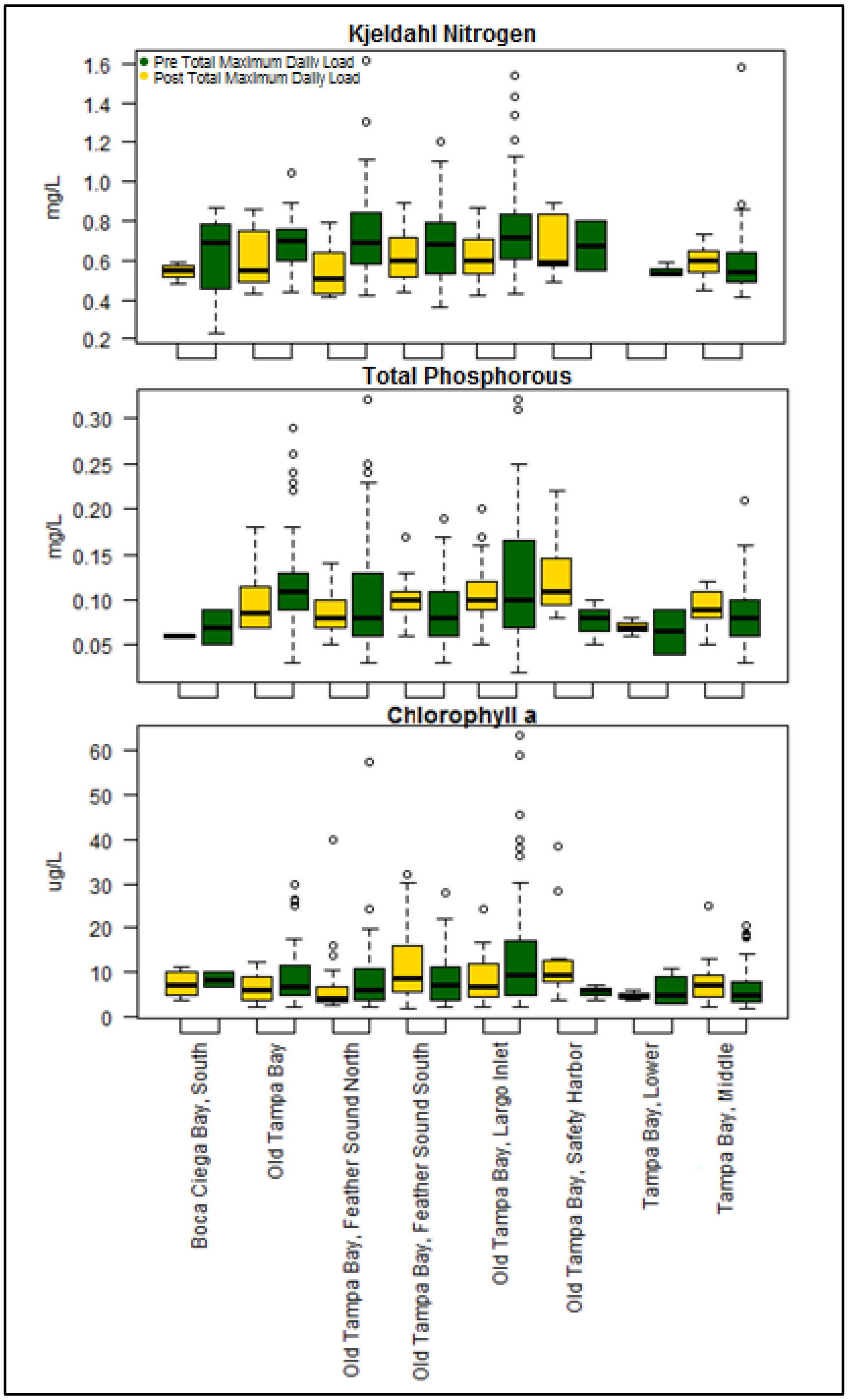

Figure 22. Distribution of TN, TP and Chl-a Data from Estuary Sampling Stations Before and After TMDL Implementation.

Table 10. Pre- and Post-TMDL, Chl-a NNC Exceedance Frequency and Ratio to Criterion[a].

Sampling Stations	Frequency of Chl-a over Criteria: average ratio to location specific criterion (range)	
	Pre TMDL	Post TMDL
Boca Ciega Bay, South	3 out of 5 (60%): 1.11 (0.7-1.6)	3 out of 6 (50%): 1.08 (0.57-1.78)
Old Tampa Bay	8 out of 28 (29%): 0.82 (0.24-3.23)	2 out of 8 (25%): 0.61 (0.25-1.33)
Old Tampa Bay, Feather Sound North	20 out of 59 (34%): 0.72 (0.23-6.19)	4 out of 18 (22%): 0.6 (0.28-4.3)
Old Tampa Bay, Feather Sound South	17 out of 44 (39%): 0.71 (0.23-3.02)	10 out of 21 (48%): 0.92 (0.22-3.44)
Old Tampa Bay, Largo Inlet	28 out of 56 (50%): 1.07(0.23-6.81)	8 out of 22 (36%): 0.77(0.25-2.59)
Old Tampa Bay, Safety Harbor	0 out of 3 (0%): 0.58 (0.41-0.75)	6 out of 11 (55%): 1.18 (0.42-4.14)
Tampa Bay, Lower	2 out of 4 (50%): 0.8 (0.46-1.73)	0 out of 3 (0%): 0.74 (0.57-0.92)
Tampa Bay, Middle	25 out of 130 (19%): 0.58 (0.22-2.4)	8 out of 21 (38%): 0.77(0.25-2.94)

[a] Ratio of the Chl-a observation to the respective NNC

Conclusion: Load-Based Estuary NNC

The lower median Chl-a observations co-occurring with lowered median TP in post TMDL sampling events is consistent with the expectation that Chl-a levels would decline with reduced nutrient levels (Figure 23). The TMDLs appear to be successful in reducing nitrogen levels. However, the limiting nutrient in Tampa Bay is nitrogen, and the occurrence of Chl-a excursions in Old Tampa Bay, Safety Harbor, Feather Sound and Middle Tampa Bay suggest that nitrogen may not be sufficiently controlled in these systems. In addition, the increased median phosphorus levels in some systems suggest that the limits set for phosphorus loading by the TMDLs are either too high, have not been achieved, or the effects of the load reductions are masked by internal cycling. Never the less, the frequency and/or intensity of Chl-a excursions above the Chl-a NNC decreased after TMDL implementation in 5 out of 8 systems examined. It is important to consider that the data in hand represent a small window in time (i.e., three years post TMDL implementation) relative to the amount of time required for nutrient regimes to shift, given internal (e.g., sediment, biota) nitrogen and phosphorus inputs cycling in the system (Bell et al. 2014, Riemann et al. 2016). Riemann et al. (2016) reviewed recovery of Danish coastal waters following substantial reductions in nitrogen and phosphorus loading in the 1990s. Trends between 1990s and 2013 include declines in Chl-a of −0.057 μmol/L/year ($p < <0.0001$), change in water depth for eel grass growth of −0.006 m/year (p=0.0080), and increased macroalgae cover of 0.69 percent/year (p= 0.0007).

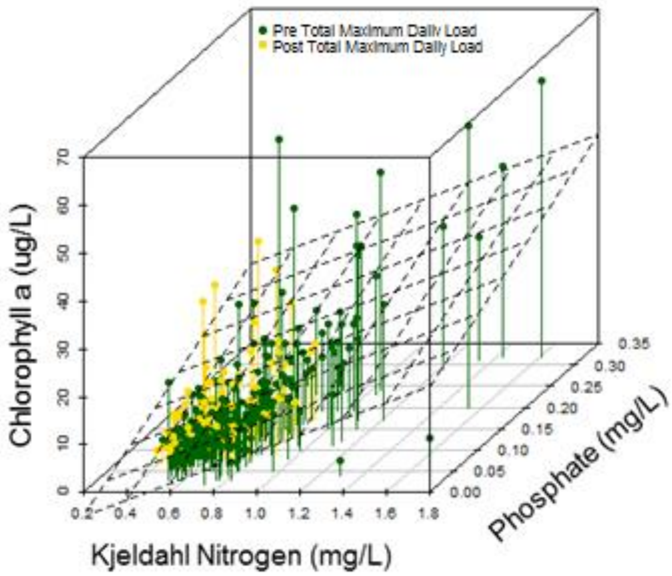

Figure 23. Pre and Post-TMDL Chl-a Levels in Relation to Kjeldahl Nitrogen and Phosphate Levels.

This analysis used the best available data for Florida waters at the time of the analysis. As with any dataset, uncertainties must be considered in the interpretation of its analysis. The small number of pre-TMDL observations in Boca Ciega Bay South (n=5), Safety Harbor (n=3), and Lower Tampa Bay (n=4) reduces our confidence in how well these data represent pre-TMDL conditions for these waters, complicating evaluation of post TMDL conditions based on the TN, TP and Chl-a levels.

Phosphate mining and export via Tampa Bay dating back to the 1800s, coupled with a growing population's discharge of untreated or barely treated sewage into Tampa Bay resulted in severely degraded ecological conditions (Lewis et al. 1998, Greening et al. 2014). Seagrass coverage estimated at 16,400 ha in 1950 was reduced to 8800 ha by 1982 (Greening and Janicki 2006). Efforts and recognition of the need to reduce nutrient loading into Tampa Bay pre-date the TMDLS evaluated here. In 1979, installation of state of the art nutrient removal technology into Tampa's water treatment system reduced nitrogen loading by an estimated 90 percent. Requirements for other municipalities discharging to Tampa bay and associated estuaries to reduce nitrogen discharges followed (Lewis et al. 1998, Greening et al. 2014). The Tampa Bay Nutrient Management Consortium established in 1996 developed the TN loading allocations that FDEP incorporated into the 2012 TMDL-based NNC evaluated here. Over this period, active community involvement, regulatory and voluntary reductions in nutrient loadings, long-term water quality and seagrass monitoring, and a commitment from public and private sectors to work together to attain restoration goals is credited with a return to pre-1950's water clarity and seagrass coverage conditions in Tampa Bay (Greening et al. 2014), indicating that the TMDL NNC, have reversed eutrophication in this estuary.

Do the Remotely Sensed Chl-a Coastal NNC Promote or sustain Eutrophic Conditions?

The coastal nutrient criteria are based on remotely sensed Chl-a data. In developing the criteria, FDEP first needed to identify and exclude areas not representing reference conditions. To accomplish this, FDEP reviewed CWA section 303(d) listings for nutrients, Chl-a and DO; identified and excluded coastal segments adjacent to nutrient-impaired estuarine segments; consulted available scientific literature; and evaluated satellite data trends. The NNC for coastal segments were then calculated as the 90th percentile of the annual geometric means of remotely sensed Chl-a concentrations under reference conditions over the 1998-2009 period for each coastal segment. The criteria range from 0.2 µg/L to nearly 6 µg/L Chl-a, with lowest values generally along the Atlantic coast and panhandle of Florida and highest values along the Gulf Coast of the Florida peninsula (Figure 24).

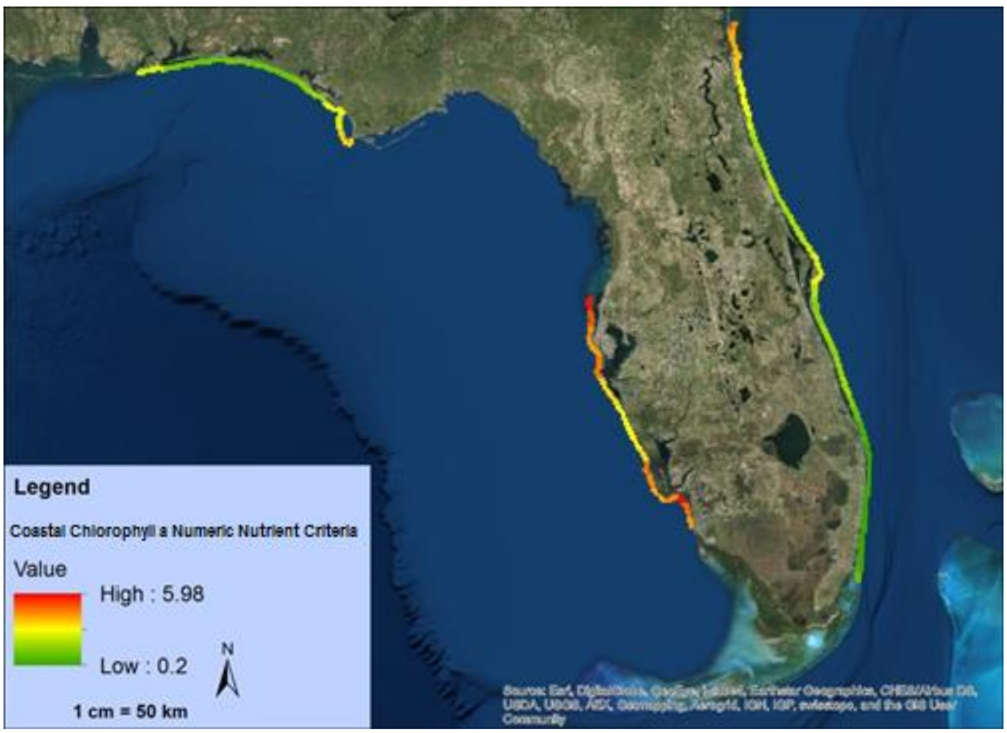

Figure 24. Distribution of Florida Coastal Chl-a NNC.

Ideally, empirical evidence for testing whether the approach used by FDEP to develop coastal standards that will reduce algal blooms would be found in recent monitoring data. To avoid a self-confirmatory result, this assessment would be limited to recent data, rather than the data used to generate the standards. Unfortunately there are only 87 recent sampling events in the STORET database that fall within the coastal segments and among those, only 38 events reported Chl-a data. This sample set is too small for evaluating these criteria "as implemented" or in context of accompanying DO data or ammonia concentrations to indicate whether eutrophy-associated stressors may be present. In the absence of sufficient data for an analysis, we must rely on evidence from elsewhere to determine whether the approach applied for Florida coastal segments will attain or support reference conditions. The evidence used included technical reviews and critiques of the NNC by third parties, information from the open literature, and state and federal reports and guidance.

The detailed methodology behind FDEP nutrient criteria was originally developed by EPA Office of Water. In 2011, EPA's Science Advisory Board (SAB) formed a review panel to conduct an external peer review of the draft technical support document, *"Methods and Approaches for Deriving Numeric Criteria for Nitrogen/Phosphorus Pollution in Florida's Estuaries, Coastal Waters, and Southern Inland Flowing Waters."* SAB panels are convened to provide scientific advice to the EPA Administrator on the quality and relevance of the scientific and technical information being used by the EPA, or proposed for use, as the basis for Agency regulations. Contributors to SAB expert panels are identified through a request published in the Federal Register for nomination of nationally and internationally recognized scientists with specialized expertise in research or management.

The SAB review of the methodology resulted in recommendations, but generally supported the approach. Their comments emphasized a role for future refinements of criteria in the spirit of adaptive management. In particular, the SAB recommended that future refinements address the impact of changing hydrology and climate to ensure the protection of designated uses. SAB recommended validating remotely-sensed data by extending its monitoring further into Gulf waters and to address potential inflation of Chl-a from *Karenia brevis* blooms originating offshore. The SAB also recommended that a preliminary assessment of nutrient inputs be undertaken to better understand chlorophyll levels in the coastal zone to relate observed chlorophyll levels in coastal waters to TN/TP concentrations or loadings from land. Finally, the SAB cautioned that seasonally influenced changes in water temperature, circulation and mixing, and influx of nutrient-rich waters from advection or upwelling would result in weak relationships between coastal nutrient concentrations and chlorophyll concentrations. Monitoring data for nutrients and Chl-a are "snap shots in time" and the infrequent sampling events in coastal waters do not integrate the complex nature of nutrient cycling and the influence of these factors over time (Science Advisory Board 2011). Work by EPA and NOAA address the SAB validation concerns with respect to monitoring beyond 3 nautical miles from the coast by demonstrating the relationship between Chl-a remote sensing estimates with field observations among sampling stations within three nautical miles from the coast and stations further offshore (Schaeffer et al 2012, Figure 25).

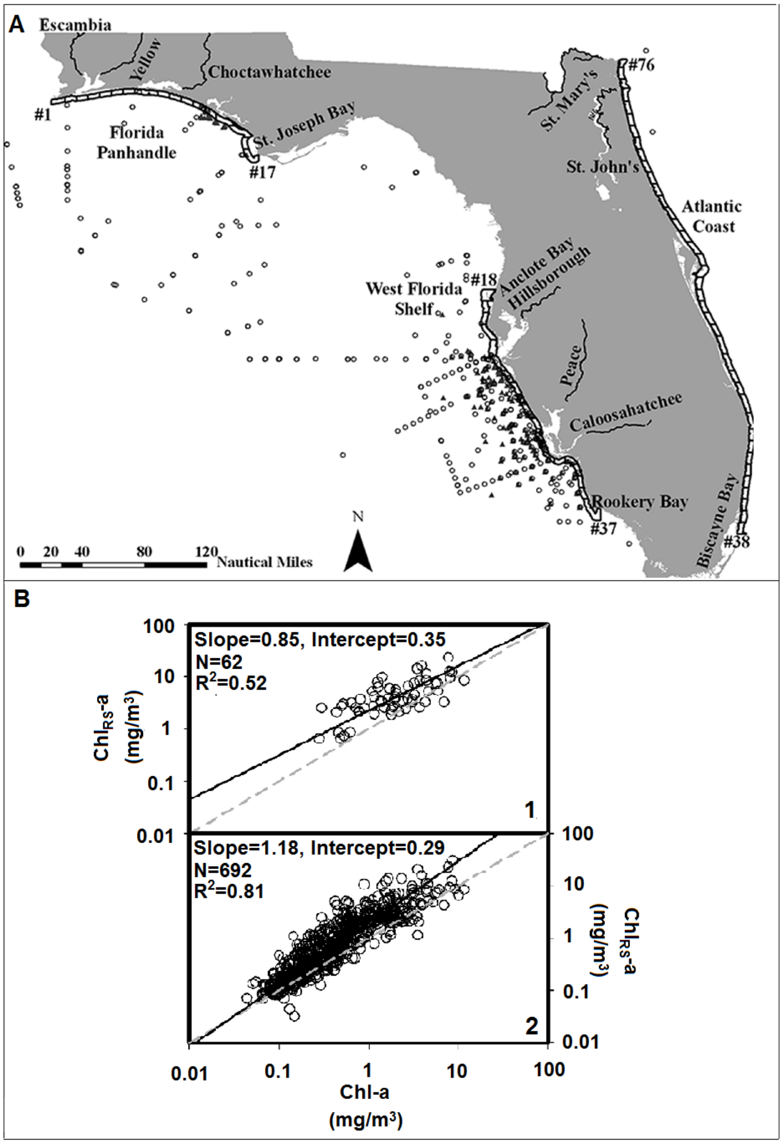

Figure 25. Station and Coastal Segments Used in Remote Sensing Chl-a Analysis and Light Attenuation for the Development of NNC[16]. A) Florida Panhandle, West Florida Shelf, and Atlantic Coast. B) Chl-a Estimates Versus Field-measured Chl-a from Stations within Three Nautical Miles from the Coast (1) and for all the Stations (2). (Gray dashed line is 1:1 fit and black line is the regression slope).

With respect to SAB recommendations to conduct preliminary work relating the Chl-a data to nutrient levels and nutrient loadings, the coastal segments ultimately delineated by FDEP in southern Florida are a minor modification of the biogeochemical classification published by Briceño et al. (2013). The Briceño segments are based on factor analysis of monitoring data

[16] Adapted from figures 1 and 2 in Schaeffer et al., 2012, Environ. Sci. Technol. 2012, 46, 916−922. (not subject to copyright). dx.doi.org/10.1021/es2014105

relating multiple water quality parameters, including TN, TP, and Chl-a. The analysis does not include empirical data for nutrient loading, but qualitative evaluation of nutrient loading sources and relative intensities supported a consistent association between loading and results (Briceño et al. 2013).

The final methodology, published in 2012, adjusted for *Karenia* blooms and excluded data from those coastal segments which were adjacent to 303(d)-listed estuaries identified as nutrient-impaired. Since the structure and composition of biological communities are a reflection of the complex biogeochemical cycles and temporal stressor profiles of the environments in which they occur (Gibson et al. 2000, Bradley et al. 2008, Abbott et al. 2009), it is NMFS' opinion that by excluding sampling events occurring during HABs and data from coastal segments adjacent to nutrient-impaired estuaries, NNC development for coastal segments are expected to reflect conditions supporting natural populations of flora and fauna, including populations of ESA-listed species that use Florida's coastal waters. However, the FDEP documentation and EPA’s decision documents are silent on whether refinements to the numeric criteria to address the future impact of changing hydrology and climate to continue to ensure that protection of designated uses will be considered. EPA's BE document states that the criteria are based on the best available science and it will encourage the State to derive numeric criteria for TP and TN as more data become available. EPA believes the current Chl-a criteria should protect these waters because Chl-a can be a sensitive biological response to nutrients and is expected to signal if nutrient pollution is creating an imbalance in the natural populations of aquatic flora and fauna.

Summary: Remotely Sensed Chl-a for Coastal NNC

Overall the SAB panel of national and international experts was supportive of the methodology used in deriving Florida’s coastal NNC. Panel recommendations to validate the relationship between remotely-sensed and field measured Chl-a was accomplished in Schaeffer et al. (2012) and compensation for uncertainty contributed by the complex nature of nutrient cycling and HABs was addressed through Florida's integration of the work of Briceño et al. (2013) and restricting data appropriately to ensure that the NNC represented reference conditions. Implementation of the criteria does not explicitly include future refinements to address the impact of changing hydrology and climate as recommended by the SAB. However, NMFS believes that this SAB recommendation is achieved through Florida's Status and Trend monitoring programs under the Integrated Water Resource Monitoring Network, which evaluates water chemistry and biological assessments to produce data used in the state’s Integrated 303(d)/305(b) Report to the EPA. These water quality monitoring activities are expected to detect and trigger action upon the emergence of any nutrient-related impairments affecting coastal water quality, regardless of specific impairment source.

> ***NMFS concludes that the remotely-sensed coastal Chl-a NNC are not expected to promote or sustain eutrophic conditions because the methodology is supported by an independent panel of national experts and***

the recommendations made by those experts to validate the methodology and integrate a mechanism to adapt the criteria to the impact of changing hydrology and climate are fulfilled.

OVERARCHING CONCLUSIONS ON EXPOSURE TO EUTROPHIC CONDITIONS UNDER FLORIDA'S NNC

Florida's NNC are intended to remediate or prevent eutrophication of Florida's water resulting from high nutrient (i.e., nitrogen and phosphorus) loads. With the exception of the NNC for the Tidal Peace River, we came to the following conclusions for the NNC evaluated in this opinion:

(1) for NNC based on monitoring data, those Chl-a exceedances that occurred in sampling events with TN and TP at or below the TN and TP NCC were suggestive of the natural fluctuations that would be attenuated when applied as area-wide annual means to identify nutrient-impaired waters,

(2) for NNC based on nutrient-impaired water bodies with established TMDLs, monitoring of TMDL data, taken with a report of seagrass recovery to pre-1950 levels, indicate the NNC will support a trajectory of recovery from eutrophication, and

(3) for remotely sensed Chl-a NNC, a panel of independent national experts review of the methodology determined the methodology used to develop the criteria would be protective and the recommendations made by this panel have been incorporated into the implementation of the criteria.

Given current monitoring data, NMFS concludes that, with the exception of the NNC for Tidal Peace River, Florida's NNC are not expected to promote or sustain eutrophic conditions, and therefore are not anticipated to adversely affect the ESA-listed species considered in this biological opinion. Adverse effects of eutrophy supported by the NNC for these waters will not be evaluated further in the response Analysis of this opinion.

NMFS concludes that the NNC for the Tidal Peace River Estuary promote eutrophication because those Chl-a exceedances that occurred in sampling events with TN and TP at or below the NCC that were not suggestive of natural fluctuations. The effects of stressors associated with eutrophic conditions under the Tidal Peace River NNC will be evaluated in the Response Analysis of this opinion.

In light of finding that one set of TN and TP NNC was found to promote or support eutrophy in one estuary segment, and the fact that existing monitoring data is not equally robust for the other estuary segments, we have also included measures to enhance the availability of monitoring data in the Incidental Take Statement in order to minimize the occurrence of any incidental take from eutrophic conditions under the NNC and enhance the ability to detect the emergence of any unanticipated eutrophic conditions.

Species Analyses Affected by these Conclusions

With respect to risk hypotheses associated with eutrophic conditions resulting from unprotective NNC, an NLAA determination is made for ESA-listed species that: (1) do not occur within the Charlotte Harbor, such that exposures are determined to have "no effect" or (2) species that occur in Charlotte Harbor, but do not frequently use the Tidal Peace River, such that their exposures to stressors associated with eutrophic conditions would be insignificant. Eutrophic conditions promoted by the Tidal Peace River NNC may affect individuals of ESA-listed species that occur in these waters and the responses of individuals of these species and the essential features of their designated critical habitat are carried through to the Response Analysis of this opinion.

Species and Critical Habitat that Do Not Occur in Charlotte Harbor

Leatherback sea turtles are primarily an open ocean species and are not expected to occur in Charlotte Harbor or Tidal Peace River (see leatherback sea turtle discussion in section 4.1.2). While larval and juvenile Nassau grouper use tidal waters, (Colin et al. 1997) the species does not occur in the eastern portion of the Gulf of Mexico (79 FR 51929). Nassau grouper is generally replaced ecologically in the eastern Gulf by red grouper (Smith 1971) in areas north of Key West or the Tortugas (Gunter and Knapp 1951). The ranges of Atlantic sturgeon, shortnose sturgeon, and the North Atlantic Right Whale do not include the U.S. Gulf of Mexico, so they would not occur in Charlotte Harbor. Finally, elkhorn and staghorn coral, rough cactus coral, pillar coral, and the lobed, mountainous and boulder star corals, and Johnsons seagrass do not occur in Charlotte Harbor. In addition, with the exception of smalltooth sawfish, none of the designated critical habitats considered in this Opinion occur in Charlotte Harbor.

Atlantic sturgeon, shortnose sturgeon, North Atlantic Right Whale, leatherback sea turtles, Nassau Grouper, elkhorn and staghorn coral, rough cactus coral, pillar coral, and the lobed, mountainous and boulder star corals, and Johnson's seagrass do not occur in Charlotte Harbor, so exposures to stressors associated with eutrophic conditions promoted by the Tidal Peace River NNC would have no effect. In addition, other than potential effects on the critical habitat of smalltooth sawfish discussed below, stressors associated with eutrophic conditions promoted by the Tidal Peace River NNC would have no effect on designated critical habitats.

Species that Occur in Charlotte Harbor, but Rarely use the Tidal Peace River Segment

Hawksbill, green, Kemp's ridley, and loggerhead sea turtle species are highly mobile and, while they may be sighted in Tidal Peace River, they are likely in transit, perhaps feeding opportunistically (A. Brame, NMFS SERO, pers. comm. to P. Shaw-Allen, NMFS OPR, May 25, 2016).

The NNC are not likely to adversely affect individual Hawksbill, green, Kemp's ridley, and loggerhead sea turtles because these species do not

frequently use the Tidal Peace River, such that their exposures to stressors associated with eutrophic conditions promoted by the Tidal Peace River NNC would be insignificant. These species will not be considered further in this opinion.

Species and Critical Habitat that Occur in the Tidal Peace River Segment of Charlotte Harbor

The Tidal Peace River is part of the designated critical habitat for smalltooth sawfish. The Charlotte Harbor portion (~1134 km2) accounts for a quarter of the total designated critical habitat, with the Tidal Peace segment amounting to about 63 km2 (about five percent of the estuary). About half of the ISED reports within designated critical habitat are from the Charlotte Harbor estuary.

NMFS concludes that individual smalltooth sawfish and the essential features of their designated critical habitat may be affected by stressors resulting from eutrophic conditions promoted by the Tidal Peace River NNC. For this reason, the Response Analysis of this opinion will evaluate the responses of this species to eutrophy stressors.

Risk Hypotheses Affected by these Conclusions

Having concluded that eutrophic conditions are supported by NNC for the Tidal Peace River, and understanding that the Tidal Peace River segment of the Charlotte Harbor Estuary is in the upper portion of the harbor, it is helpful to consider whether a *K. brevis* bloom would reach this inner estuary segment and be sustained by the nutrients under NNC that promote eutrophication. The impact of the Tidal Peace River NNC on algal toxin exposure is dependent on the probability that a *K. brevis* bloom generated offshore reaches the interior of Charlotte Harbor and is extended by nutrient loads from the Tidal Peace River. HAB monitoring data for the years 2007 to 2014 include both routine monitoring and bloom response events. Observations above the background of 1,000 *K. brevis* cells/L occurred most frequently in 2013. Observations as high as nearly 5 million cells per liter occurred at the mouth of Charlotte Harbor and within Pine Island Sound and San Carlos Bay, both to the south of Charlotte Harbor proper (Figure 26). *Karenia brevis* was "not present" in more than 90 percent of the observations within Charlotte Harbor proper and the tidal reaches of the rivers that drain into the bay. Detection of *K. brevis* in these waters were associated with stations closest to the mouth of Charlotte Harbor at background levels of 333-1000 cells /L. The mouth of estuary is protected by Gasparilla and Lacosta Islands. The elevated *K. brevis* occurred between the islands and Charlotte Harbor, so they are not a barrier to the blooms. Nutrient cycling in sediments trapped within Gasparilla Sound and Pine Island Sound by the islands may be contributing to *K. brevis* support.

NMFS concludes that a K. brevis bloom event is not expected to arrive within Charlotte Harbor to be influenced and sustained by nutrient loads from the Tidal Peace River under the NNC. Exposures of smalltooth sawfish and essential features of smalltooth sawfish designated critical

habitat are discountable and are not likely to adversely affect the species or its critical habitat. For this reason, the effects of brevitoxin on smalltooth sawfish and its critical habitat will not be further evaluated in this opinion.

SUMMARY

Taken with the FDEP trends analyses requirement (Chapter 62-303, F.A.C.) to detect adverse trends in water quality in order to trigger protection of downstream conditions, when necessary, the Florida NNC approved by EPA are, for the most part, expected to result in nutrient levels in estuarine and coastal waters that result in healthier systems as indicated by seagrass recovery and reduced frequency and intensity of algal blooms, including sustenance of coastal *K. brevis* HABs. However, data for the Tidal Peace River segment of Charlotte Harbor suggests that the NNC approved by EPA may not be sufficiently protective to avoid adverse effects to smalltooth sawfish and smalltooth sawfish critical habitat. The Peace River watershed contributes significant nitrogen loads, four times that of the Myakka River to Charlotte Harbor (Tomasko undated) and phytoplankton blooms in the Tidal Peace River and Upper Charlotte Harbor approach Chl-levels indicative of eutrophic conditions (Southwest Florida Water Management District 2001). While NMFS concluded brevitoxin exposures due sustenance of *K. brevis* blooms under the NNC are discountable, the implication of other stressors caused by eutrophic conditions within Tidal Peace River, and Charlotte Harbor proper, will be evaluated in the response analysis. The outcome of the exposure analysis is summarized in Figure 26 and Table 11.

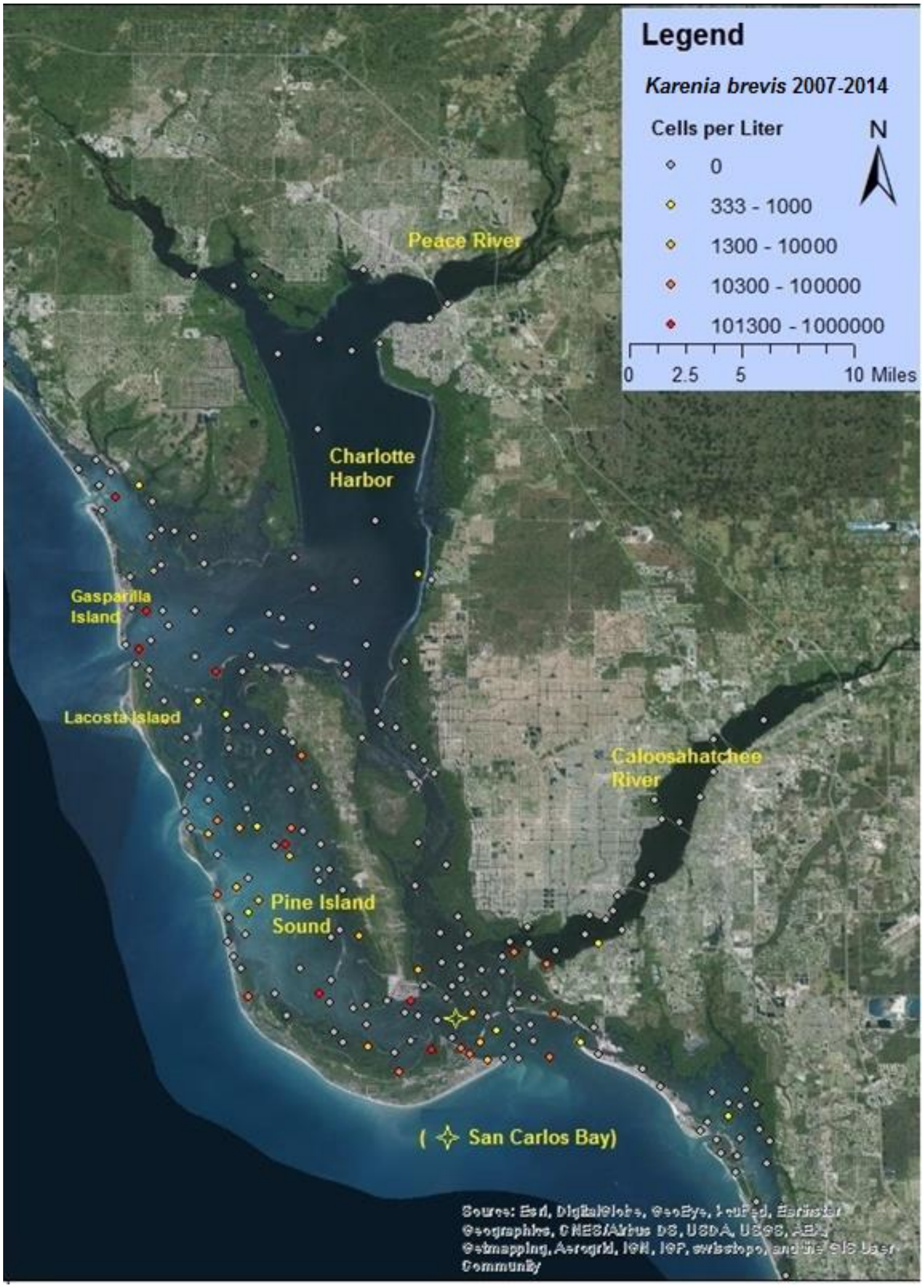

Figure 26. *Karenia brevis* Detected in Charlotte Harbor Estuary Between 2007 and 2014.

Table 11. No Effect, Not likely to Adversely Affect, and May Effect (✓) Determinations Resulting from the Exposure Analysis for the NNC.

<table>
<tr><th></th><th>smalltooth sawfish</th><th>Atlantic and shortnose sturgeon, and Nassau grouper, North Atlantic right whale, elkhorn and staghorn corals, boulder lobed and mountainous star corals, pillar coral, and rough cactus coral, Johnson's seagrass</th><th>Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles</th></tr>
<tr><td colspan="4">Hypotheses: NNC will support eutrophic conditions that affect the survival and fitness of individuals or indirectly through:</td></tr>
<tr><td>lethal and sublethal exposures to ammonia</td><td>✓</td><td rowspan="10">No Effect: Species do not occur in waters with criteria evaluated in this opinion that promote eutrophication: exposures will not occur

in waters with criteria evaluated in this opinion that promote eutrophication</td><td rowspan="10">Not likely to Adversely Affect: Species occur in the estuary, but they do not use the estuary segment where criteria promote eutrophic conditions (Tidal Peace River): exposures are insignificant</td></tr>
<tr><td>lethal and sublethal exposures to algal toxins</td><td>Not likely to Adversely Affect: A Karenia brevis bloom unlikely</td></tr>
<tr><td>lethal and sublethal DO extremes</td><td>✓</td></tr>
<tr><td>lethal and sublethal infections</td><td>✓</td></tr>
<tr><td>lethal and sublethal smothering by algae</td><td>No Effect: are mobile</td></tr>
<tr><td>altered turbidity/light penetration</td><td>No Effect: not light dependent</td></tr>
<tr><td>altered substrate</td><td>No Effect: not substrate dependent</td></tr>
<tr><td>reduction in extent of inhabitable habitat</td><td>✓</td></tr>
<tr><td>reduction in extent of useful habitat</td><td>✓</td></tr>
<tr><td>reduction in prey species</td><td>✓</td></tr>
</table>

4.2.2 Exposure: DO Criteria

Extremes in DO content of water, typically insufficient DO, may directly affect those species that obtain oxygen from water (sturgeon, sawfish, coral, and seagrass). Sea turtles breathe air and may be indirectly affected by DO conditions through changes in prey species and the structure and function of the coral reef and seagrass habitats they rely upon. The exposure analysis for Florida's DO criteria overlays the criteria with areas where ESA-listed species and designated critical habitat occur. Florida's DO criteria are based on natural background levels of oxygen saturation after methodology described in the Technical Support Document: *Derivation of DO Criteria to Protect Aquatic Life in Florida's Fresh and Marine Waters (FDEP 2013)*. The technical support document includes a section on Consideration of Threatened and Endangered Species that discusses smalltooth sawfish, shortnose sturgeon and Gulf sturgeon, but does not address Atlantic sturgeon, ESA-listed corals, or Johnson's seagrass. Appendix I of the document, Protection of Threatened and Endangered Species in Portions of the Suwannee, Withlacoochee, Santa Fe, New, and St. Johns Rivers, addresses Atlantic and shortnose surgeon.

The FDEP freshwater Florida's DO criteria were based on reference conditions identified through the use of a land development index, which classifies basins by the intensity of human impact and the stream condition index (SCI). The SCI classifies streams based on the disturbance-tolerance of the macroinvertebrates present (FDEP 2013). The SCIs for reference sites were regressed against observed percent DO saturation. The use of DO percent saturation, rather than DO concentration, takes into account the effect of salinity and temperature on DO solubility. FDEP arrived at region-specific saturation-based Florida's DO criteria using regression analysis to identify the percent DO saturation necessary to support a healthy macroinvertebrate community as indicated by an SCI score of greater than 40.

FDEPs approach to saturation-based Florida's DO criteria for marine waters is adapted from the EPA Virginian Province Approach (FDEP 2013). There are three components to Florida's DO criteria:

- A concentration above which continuous exposure is not expected to result in adverse chronic effects in sensitive biological communities[17] (Criterion continuous concentration, or CCC);
- A minimum daily average concentration below which any exposure for 24 hours or longer would result in unacceptable effects to sensitive organisms (Criterion minimum concentration, or CMC); and
- A function defining the maximum allowable exposure duration at DO levels between the CCC and CMC necessary to prevent unacceptable reductions in seasonal larval recruitment for sensitive species (under the "most species, most of

[17] For example, coral reefs, seagrass meadows, wetlands.

the time" expectation specified in Stephen et al, 1985), with allowable durations decreasing with decreasing DO (Final Recruitment Curve, or FRC).

The Virginian Province Approach was developed for species in cooler northern waters. It is expected to be conservative because, in cooler waters, the recruitment season is shorter and larval development takes longer than in warmer waters (USEPA 2000, Thursby 2003). That is to say, individuals mature more quickly and more larvae are expected to be produced over a given season, for those species capable or more than one reproduction per season. In adapting the method, the criteria were calculated using only those species present in Florida waters. The criteria were calculated as percent DO saturation, rather than a fixed DO concentration to be consistent with the freshwater criteria. The freshwater criteria are saturation-based because freshwater data indicated a slightly better correlation between biological response and DO saturation than between biological response and DO concentration.

The DO saturation-based criteria in marine waters can result in DO concentrations ranging from 2.9-4.5 mg/L for the annual criteria of 42 percent saturation or below in no more than 10 percent of daily averages over one year, 3.6-5.6 mg/L for the seven day standard of 51 percent or below in no more than 10 percent of weekly averages over one year, and 3.8-6.2 mg/L for the 30 day standard of 56 percent saturation or below in no more than 10 percent of monthly averages over one year.

Table 12 provides a summary of FDEPs Florida's DO criteria, which represent values below which no more than 10 percent of the daily average percent DO saturation values should fall (FDEP 2013). Waterways with DO saturation conditions naturally better than the criteria (i.e., higher saturation and an absence of super-saturation excursions) will be considered impacted if there has been a statistically significant decreasing trend in DO levels, or an increasing trend in the range of daily DO fluctuations, at the 95 percent confidence level and a causative pollutant is identified. FDEP specifies that such conditions are to be identified using a frequentist statistical procedures after controlling for or removing the effects of confounding variables, such as climatic and hydrologic cycles, quality assurance issues, and changes in analytical methods.

Natural freshwater systems in Florida that are subject to low DO include those receiving significant organic matter in drainage from wetlands or marshes, waterbodies downstream of springs or other groundwater sources, and many streams during low or no flow periods. Natural estuaries especially subject to low DO include those receiving significant drainage from wetlands or marshes, those in areas surrounded by mangrove forests or tidal marshes, or those estuaries where salinity stratification occurs (Hendrickson et al. 2003, FDEP 2013). Waters with dense seagrass beds have DO regimes characterized by dramatic diel swings in DO concentration due to photosynthetic during daylight hours and respiration at night. DO levels in grassbeds can decline to below 2 mg/L (McClanahan 1992, Holmer and Olsen 2002, Yarbro and Carlson 2008, Long et al. 2015). Salinity also plays a role in DO solubility of marine waters, in that higher salinity waters are proportionately lower in DO saturation (McClanahan 1992).

To avoid incorrectly listing those waterbodies with a natural DO regime that includes periods of DO saturation below the standard, FDEP applied an EPA-sanctioned provision to maintain that natural regime by not allowing more than a 0.1 mg/L deviation below the DO concentration associated with the natural background DO levels. For marine waters, no more than a 10 percent deviation from the natural background DO can be allowed if it is demonstrated that sensitive resident aquatic species will not be adversely affected. Each adoption of a revised criterion will be reviewed by the EPA to ensure that all of the requirements for State revision have been met and each of individual action will be considered for future consultation.

Table 12. Summary of Florida's Regional DO Criteria.

Location	No more than 10 percent of the daily average DO saturation values shall be below the following values:	Anticipated DO range at standard (estimated from Figure 1)
Panhandle West Bioregion	67%	4.9-8.2
Peninsula and Everglades Bioregions	38%	2.9-4.5
Northeast and Big Bend Bioregions	34%	2.5-4.2
Marine waters	42% 51% weekly[a] average more than once over 12 weeks 56% monthly[b] average more than once over one year	2.9-4.5 3.6-5.6 3.8-6.2
Water body-specific Florida's DO criteria		
Suwannee, Withlacoochee (North), and Santa Fe Rivers used by the Gulf Sturgeon	DO shall not be lowered below the baseline distribution of the water[c]	
St. Johns River used by the Shortnose or Atlantic Sturgeon	DO shall not be below 53 percent saturation during February and March and criteria for the pertinent bioregions apply for the remainder of the year	

[a] A minimum of three full days of diel data collected within the seven-day period, or at least ten grab samples collected over at least three days within that period, with each sample measured at least four hours apart.

[b] A minimum of three full days of diel data, with at least one day of data collected in three different weeks of the 30-day period, or grab samples collected from a minimum of ten different days of the 30-day period.

[c] Median oxygen saturation levels for these waters at 53.6 percent to 78.2 percent (see (FDEP 2013), Appendix I, Table 3)

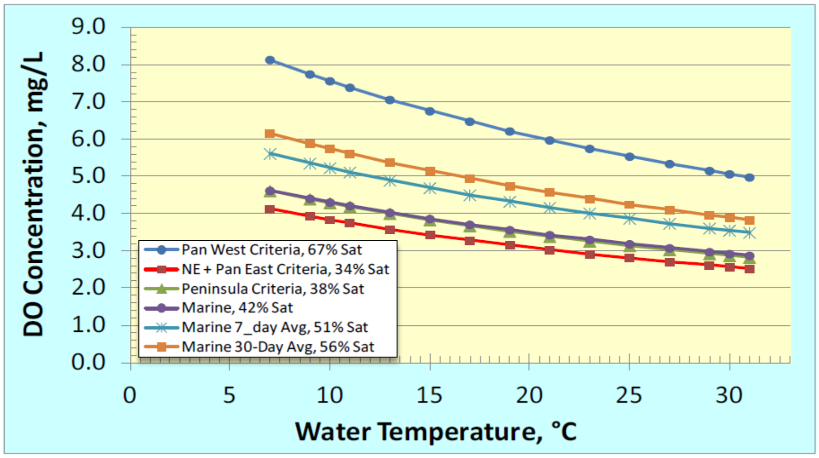

Figure 27. Relationship Between Dissolved Oxygen Concentration and Water Temperature for Florida Dissolved Oxygen Criteria (from Technical Support Document, Figure 35).

Among the criteria listed in Table 12, this exposure assessment evaluates criteria in those areas where ESA-listed species and designated critical habitat occur:

- Northeast and Big Bend criteria for Atlantic and shortnose sturgeon exposures in the St. Johns and St. Marys Rivers, including the St. Johns-specific standard of 53 percent saturation for the months of March and February
- Marine/Estuarine criteria for all four fish species, and sea turtles and marine waters for the ESA-listed corals, Johnson's seagrass, and designated critical habitat for the smalltooth sawfish, loggerhead sea turtle, the staghorn and elkhorn corals

DO criteria for Freshwaters Where Atlantic and Shortnose Sturgeon Occur

Atlantic and shortnose sturgeon are sympatric, associated with the St. Johns and St. Marys Rivers in northeast Florida. Capture of young-of-year Atlantic sturgeon in the St. Marys River suggests that this species spawns in that river. The species is not known to spawn in these waters (i.e., egg mats have not been observed), but are known to occur there (J. Kahn, NMFS OPR, pers. comm. to P. Shaw-Allen, NMFS OPR, June 29, 2015). DO levels of 5 mg/L and above are considered protective of sturgeon (Kahn and Mohead 2010, Collins et al. 2000, Secor and NiMitschek 2001, Campbell and Goodman 2004) and serve as our "No Effect" standard. DO levels meeting the minimum 53 percent saturation standard for February and March ranged from 4.4 to 5.3 mg/L while DO levels at the 34 percent minimum DO saturation standard for the remaining months in St. Johns ranged from 2.6 to 3.5 mg/L. Since we are interested in effects of Florida's DO criteria, not the effects of oxygen depletion or super-saturation, we use a "perfect compliance" subset of the STORET sampling events where the DO saturation standards were met within waterbodies that are not identified as impaired by excursions in DO or excess nutrients which may lead to DO excursions (Table 13).

Among the 20 planning units in the dataset, only eight of the 17 units from the St. Johns River met these screening criteria. In sampling events from these areas, the actual observed February and March DO levels averaged between 5.8+/-0.6 mg/L for the South Mainstem Unit of the Lower St. Johns to 7.8+/-1 mg/L for the Lake Woodruff Unit of the Middle St. Johns. Over the remaining months, observed DO conditions averaged between 4.1+/-0.7 mg/L for the Lake George Unit in the Middle St. Johns and 8.8+/-2.7 mg/L for the Lake Monroe Unit of the Middle St. Johns.

Table 13. Observed DO Concentrations in Sampling Events from Waters Not Impaired by DO Excursions or Excess Nutrients and Meeting Oxygen Saturation Levels within Florida's DO Criteria.

Segment	Planning Unit	Observed mg/L DO at or above saturation standard of 34 percent[a]	Observed mg/L DO at or above saturation standard of 53 percent (St. Johns, February-March)
Lower St. Johns	North Mainstem Unit	5.6+/-1.9 (2.9-10.2, n=20)	6.9+/-1.9 (4.7-8.5, n=3)
	Ortega River	5.5+/-2.1 (2.7-9.5, n=47)	6.8+/-1.3 (4.6-9, n=9)
	South Mainstem Unit	4.6+/-1.6 (2.9-8.3, n=18)	5.8+/-0.6 (5.1-6.6, n=4)
Middle St. Johns	Lake George Unit	4.1+/-0.7(3.4-5.4, n=14)	
	Lake Monroe Unit	8.8+/-2.7(3.2-14.4, n=29)	
	Lake Woodruff Unit	5.8+/-2.3 (2.6-9.3, n=10)	7.8+/-1 (6.8-9.1, n=4)
Ocklawaha	Rodman Reservoir Unit	5.2+/-1.7(3-11, n=221)	7.0+/-1.2 (5.3-10.1, n=49)
Upper St. Johns	Lake Poinsett Unit	6.3+/-2.9 (2.9-15.3, n=44)	7.5+/-2.1 (5.1-11.6, n=14)

[a]Average +/- 1 standard deviation (range, n=number of observations)

Continuous monitoring data for stations within the lower St. Johns River and the St. Marys River that were not screened for Florida's DO criteria compliance show that very few DO observations actually approach the saturation-based Florida's DO criteria (Figure 28). The standard itself is a lower limit below which no more than 10 percent of the daily average DO saturation values may fall, which would be influenced by monitoring timing and frequency data (i.e., 30 days of data each season versus 10 days of data in winter). Data for the St. Johns River, but not the St. Marys River indicate periods of super-saturation suggestive of a DO regime expected under eutrophic conditions (Figure 28, panels C and D). The lower St. Johns River is impaired based on elevated Chl-a and Trophic State Index levels in the freshwater and marine portions of the river and the TMDL was implemented in 2008 (Magley and Joyner 2008). At this time EPA's water quality assessment report indicates that 573 km of the Lower St. Johns is impaired by low DO.

For freshwaters, FDEP provided data demonstrating that DO measurements collected anytime 8:00 am and 5:00 pm would be expected to be within 7 percent of the daily mean. Therefore, if continuous data are not available, instantaneous grab samples collected during the workday could be substituted as an estimate of the 24-hour average and used to assess compliance with the proposed criteria with minimal error (FDEP 2013). Our purpose is to explore the potential for adverse conditions under the saturation-based Florida's DO criteria, not to demonstrate DO impairment of a waterbody.

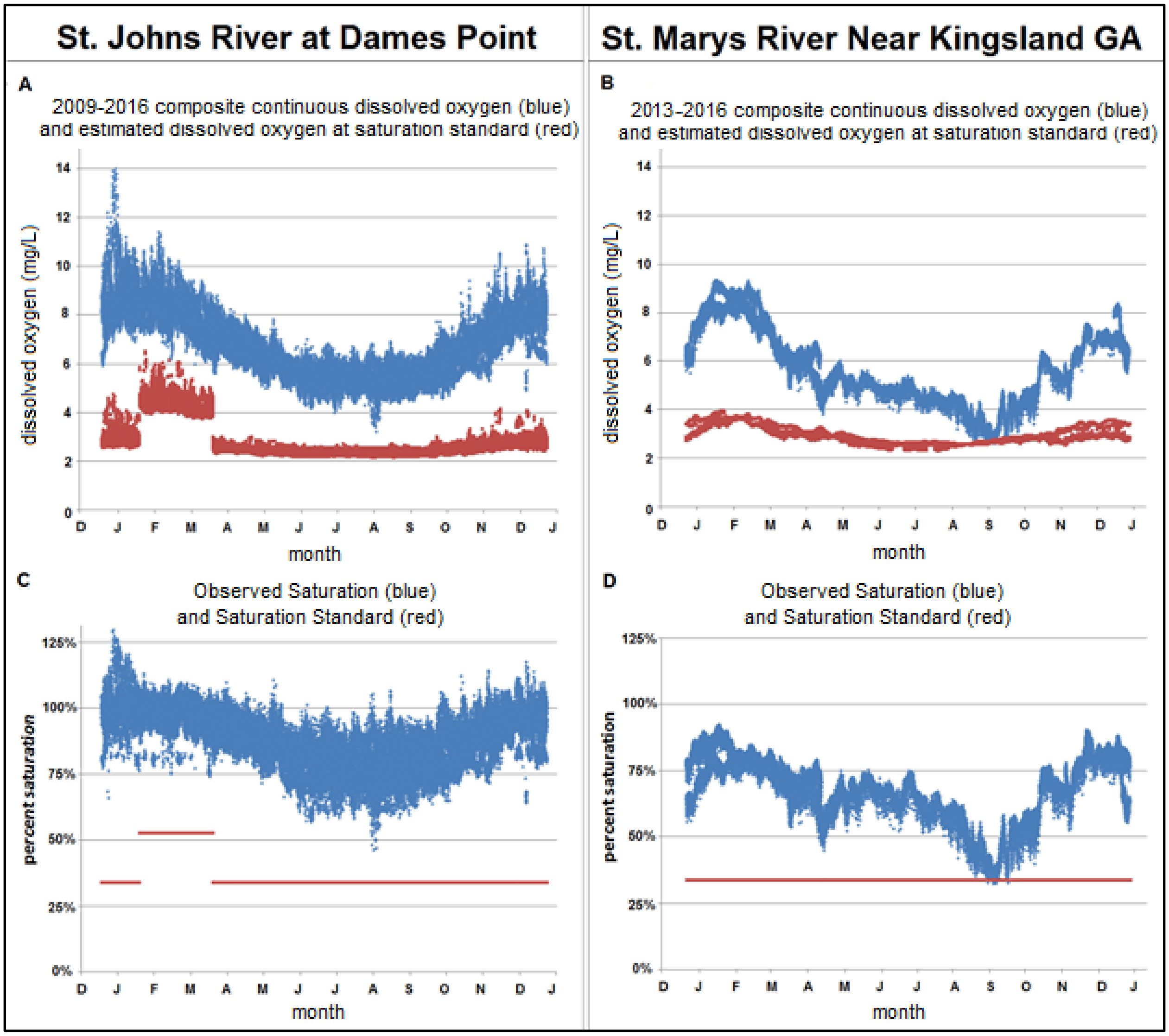

Figure 28. Scatterplots for Dissolved Oxygen (panels A and B) and Percent Saturation (Panels C and D) from Continuous Monitoring Observations for U.S. Geological Survey Stations in St. Johns and St. Marys Rivers Showing Observed DO Concentration and Saturation Levels (Blue) and Concentration and Saturation Levels under the DO Criteria (Red).

Many observations are below original DO criterion of 5 mg/L. The frequency, duration, and severity of DO suppression is an important factor in stress resulting from low DO conditions (Figure 29).

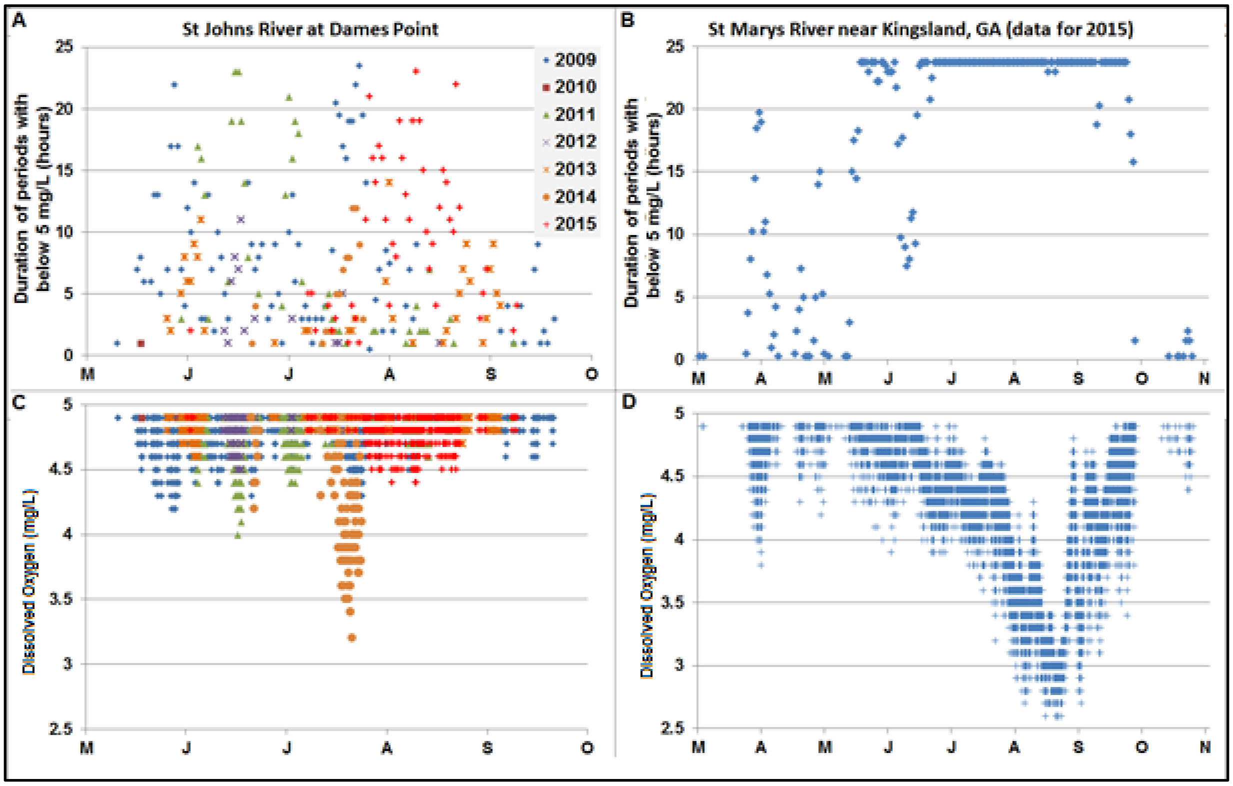

Figure 29. Subset of U.S. Geological Survey Continuous Monitoring Data for Stations in St. Johns River and St. Marys River Showing the Time of Year and Duration Of Periods of DO Excursions Below 5 mg/L (Panels A and B) and the Severity of the DO Excursions Below 5 mg/L (Panels C And D).

NMFS concludes that the continuous monitoring in the St. Johns and St. Marys Rivers where Atlantic and shortnose sturgeon may be present indicate periods of low DO levels under Florida's DO criteria that may affect Atlantic and shortnose sturgeon. For this reason, the implications of low DO levels allowed under these criteria are evaluated for shortnose and Atlantic sturgeon in the Response Analysis of this opinion.

DO criteria for Florida's Marine and Estuarine Waters where Smalltooth Sawfish, Nassau grouper, Sea Turtles, Johnson's Seagrass, and Corals Occur

Eight of the 14 recovery regions for smalltooth sawfish occur along the Atlantic and Gulf coasts of Florida and within associated estuaries (NMFS 2009). Designated critical habitat for smalltooth sawfish occurs along the southwest coast of Penninsular Florida from Charlotte Harbor to Estero Bay and along the Ten Thousand Islands region of the southern tip of Florida from Naples to Key Largo. The 5 species of sea turtles considered in this opinion occur throughout Florida's coastal waters, with loggerhead nearshore reproductive and breeding designated critical habitat along portions of the coastline (Figure 9). Johnson's seagrass occurs along Florida's Atlantic coast from the Canaveral National Seashore just south of Daytona beach and southward to Key Largo, with designated critical habitat in Ft. Pierce Inlet, Sabastian Inlet, St. Lucie Inlet, Hobe Sound and Jupiter Inlet, Lake Worth Lagoon, Lake Wyman, and Biscayne Bay.

A general summary of DO observation meeting at least 42 percent saturation in estuarine and coastal waters is provided in Table 14. Those specifically within designated critical habitat for ESA-listed species are summarized in Table 15. Values below the original DO criterion of 5 mg/L are frequent in some waters, and to some extent these are likely influenced by natural organic inputs (e.g., Everglades West Coast). The implications within the range of ESA-listed species and within their designated critical habitat will be discussed in the effects assessment.

Table 14. Summary of Daily Average DO Observations Among Florida Coastal and Estuarine Waters Meeting at Least 42 percent Saturation (2007-2015).

Estuary/Marine Region	DO Average mg/L (range)	Number of Observations	percent Observations Below 5 mg/L
Apalachicola – Chipola	5.96 (3.05-11.48)	322	30%
Caloosahatchee	6.49 (3.2-9.62)	265	11%
Charlotte Harbor	6 (2.67-10.18)	683	20%
Choctawhatchee - St. Andrew	6.33 (2.73-10.19)	761	16%
Everglades West Coast	5.64 (2.6-8.5)	300	30%
Florida Keys	6.15 (3.15-9.3)	376	11%
Indian River Lagoon	5.69 (2.7-9.4)	2291	28%
Lower St. Johns	6.66 (5.75-7.99)	7	0%
Nassau - St. Marys	6.44 (4.05-8.5)	16	19%
Ochlockonee - St. Marks	5.68 (3.1-9.34)	180	36%
Pensacola	6.19 (3.33-9)	84	23%
Perdido	6.08 (4.6-7.75)	12	8%
Sarasota Bay - Peace - Myakka	6.12 (2.6-8.96)	217	11%
Southeast Coast - Biscayne Bay	5.81 (3.45-8.31)	261	15%
Springs Coast	6.45 (2.63-10.75)	473	11%
St. Lucie – Loxahatchee	5.87(2.95-9.3)	481	20%
Suwannee	6.43 (3.8-10.15)	519	11%
Tampa Bay	6.09 (2.9-9.2)	1444	15%
Tampa Bay Tributaries	6.11 (3.65-9.1)	83	17%
Upper East Coast	5.23 (2.7-7.63)	35	43%

Table 15. Summary of daily average DO observations among Florida coastal and estuarine waters within designated critical habitat for ESA-listed species under NMFS' jurisdiction and meeting at least 42 percent saturation (2007-2015).

Species Estuary/Marine Region	DO Average mg/L (range)	Number of Observations	percent Observations Below 5 mg/L
Acropora designated critical habitat			
Florida Keys	6.5 (4.33-7.32)	25	4%
Acropora & loggerhead sea turtle designated critical habitat co-occur			
Florida Keys	6.58 (4.4-7.54)	103	1%
Southeast Coast - Biscayne Bay	6.39 (4.31-7.34)	31	3%
Johnson's seagrass designated critical habitat			
Southeast Coast - Biscayne Bay	5.51 (3.1-7.39)	105	25%
loggerhead sea turtle designated critical habitat			
Charlotte Harbor	4.79 (2.6-8.1)	41	56%
Choctawhatchee - St. Andrew	5.34 (3.15-7.43)	12	25%
Everglades West Coast	5.86 (3.17-8.5)	76	33%
Florida Keys	6.59 (4.64-7.6)	61	2%
Indian River Lagoon	4.95 (2.8-8.35)	99	55%
Sarasota Bay - Peace - Myakka	5.98 (3.22-7.83)	21	10%
St. Lucie – Loxahatchee	6.19 (3.3-9.3)	251	16%
smalltooth sawfish designated critical habitat			
Caloosahatchee	6.49 (3.2-9.62)	265	11%
Charlotte Harbor	5.95 (2.8-9.25)	506	20%
Everglades West Coast	5.53 (2.6-8.18)	205	32%
Florida Keys	5.61 (3.15-9.3)	104	27%
smalltooth sawfish & loggerhead sea turtle designated critical habitat co-occur			
Everglades West Coast	4.96 (2.8-7.15)	28	43%

The typical range in natural diel fluctuations in Florida estuaries and marine waters having minimal human impact are greater than observed for Florida lakes and streams, averaging 2.4 mg/L. The daily average DO concentration in estuaries and marine waters typically occurs about mid-day with the minimum at around 8:00 am and the maximum near 5:00 pm. An analysis of diel DO data collected in estuaries and marine waters in different parts of the State as part of the

National Estuary Research Reserve Program indicates that DO measurements collected anytime during the normal 8:00 am to 5:00 pm workday would, on average, be expected to be within approximately 20 percent of the daily mean. It is important to note that only 5 percent of the data were collected prior to 9:00 am, so DO minima are not well represented. The level of diel fluctuation in marine waters vary considerably with presence of seagrass, level of freshwater input, tidal flushing, amount of organic input, and sediment type. Data used for surface water assessments are typically "found data" and more in-depth evaluation of any effects of sampling time would be conducted before proposing a water as impaired by DO. For example, Data collected early in the day that meet criteria are likely to reflect site that does not have an a DO impairment. Data collected late in the day that do not meet criteria would indicate a likely DO impairment (FDEP 2013). The DO levels at under the worst case saturation standard for marine waters: no more than 10 percent of the daily average DO saturation values shall be below 42 percent saturation translates to allowable periodic DO concentrations as low as 2.6 mg/L.

> ***NMFS concludes that periods of low DO levels under Florida's DO criteria may affect the survival and fitness of individuals of ESA-listed species and designated critical habitat under NMFS' jurisdiction: shortnose sturgeon, Atlantic sturgeon, smalltooth sawfish, designated critical habitat for smalltooth sawfish, elkhorn coral, staghorn coral, designated critical habitat for elkhorn coral, staghorn coral, lobed star coral, boulder star coral, mountainous star coral, pillar coral, rough cactus coral, Johnson's seagrass, designated critical habitat for Johnson's seagrass, and the Nassau grouper. Further, the DO criteria may indirectly affect green, hawksbill, Kemp's ridley, leatherback, loggerhead sea turtles and designated critical habitat for loggerhead sea turtles through effects to prey species. For this reason, the implications of low DO levels allowed under these criteria are evaluated for these species in the Response Analysis of this opinion.***

OVERARCHING CONCLUSIONS ON EXPOSURE ANALYSIS FOR FLORIDA'S DO CRITERIA APPROVED BY EPA

As indicated in the *Risk Hypotheses* section, the North Atlantic right whale breathes air and does not forage in Florida's waters, for this reason the effects if the EPA-approved DO criteria were determined to have no effect on this species. Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles also breathe air, but do forage these waters, so the DO criteria may have indirect effects on this species. Finally, the determination for the implications of the DO criteria on Johnson's seagrass as "No Effect" because they photosynthesize and generate DO. Since the available data indicate low DO levels at the DO saturation levels specified by the criteria, the implications of the criteria for the remaining DO-dependent species are evaluated in the *Response Analysis* of this opinion. This is summarized in Table 16.

Table 16. No Effect and May Effect (✓) Determinations Resulting from the Exposure Analysis for DO Criteria for ESA-listed Species and, Where Designated, Critical Habitat.

<table>
<tr><th></th><th>North Atlantic right whale</th><th>Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles</th><th>Atlantic and shortnose sturgeon[a], smalltooth sawfish, and Nassau grouper</th><th>Elkhorn and staghorn corals, boulder lobed and mountainous star corals, pillar coral, and rough cactus coral</th><th>Johnson's seagrass</th></tr>
<tr><td colspan="6">Hypotheses: DO concentrations Under Florida's saturation-based criteria will result in DO concentrations that directly and indirectly affect the survival and fitness of individuals through:</td></tr>
<tr><td>Reduced survival</td><td colspan="2" rowspan="4">No Effect: breathe air</td><td>✓</td><td>✓</td><td rowspan="5">No Effect: generates oxygen, not reliant on nursery areas, and is autotrophic</td></tr>
<tr><td>reduced survival of eggs, neonates, or breeding adults</td><td>✓</td><td>✓</td></tr>
<tr><td>reduced nursery area</td><td>✓</td><td>No effect: does not use nurseries</td></tr>
<tr><td>reduction in the extent of usable of habitat</td><td>✓</td><td>✓</td></tr>
<tr><td>Reduction in prey species</td><td>No Effect: do not forage in Florida waters</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>

4.2.3 Exposure: Turbidity Limits under Florida's JCP Activities Involving Beach Nourishment

As a direct stressor, an exposure analysis for a turbidity criterion would evaluate whether exposure of ESA-listed species to turbidity concentrations at that criterion would cause adverse effects. However, the turbidity limits that EPA has approved do not specify a turbidity criterion. EPA approved a limit on the size of a mixing zone for turbidity resulting from the beach nourishment activities and additional requirements for determining the permittable size and locations of mixing zones. The limits are:

- Establishment that the boundary of a turbidity mixing zone for beach nourishment shall not be more than 1000 meters from the point of discharge into the waterbody.
- Additional standards for determining the appropriate size of a turbidity mixing zone for sediment plumes resulting from the beach nourishment under the JCP. These standards include:
    - Minimize the magnitude and duration of turbidity to the maximum extent practicable

- Mixing zones shall be kept to the minimum size necessary to meet the turbidity standard
- Mixing zones shall not encompass hard bottom communities, coral resources, or submerged aquatic vegetation beds outside of the authorized impact sites unless those areas are also evaluated as impact sites.

The original mixing zone standard specified in F.A.C. Subsection 62-4.244 (5) was specific to dredge and fill permits. It originally read: *"In no case shall the boundary of a dredge and fill mixing zone be more than 150 meters downstream in flowing streams or 150 meters in radius in other bodies of water."* Prior to the revision, no mixing zone limits had been identified by name or placed on JCPs at all and provisions for the protection of sensitive substrates were absent from the regulations at 62-304, F.A.C. However, with the current revisions and based on the supporting information provided by the State, EPA interpreted the revision as an expansion of the maximum allowable mixing zone distance to allow mixing zones greater than 150 meters in the case of beach nourishment, in addition to codifying the requirements necessary for protection of sensitive substrates. Because the approval of the maximum extent of a mixing zone that can be applied in a permit is neither place-based or stressor threshold-based, the action area for this approval is the extent of Florida's coastline and estuaries to which these permits apply.

Florida's JCPs are required for beach restoration or nourishment; construction of erosion control structures such as groins and breakwaters; public fishing piers; maintenance of inlets and inlet-related structures; and dredging of navigation channels that include disposal of dredged material onto the beach or in the nearshore area. The JCP activities under consideration in this opinion is the beach nourishment. These projects occur over the extent of Florida's coastline. Current and planned activities are identified in Figure 30. While the period of actual dredging is temporary, the time frames that the permits provide for these activities are broad. For example, the cover letter for the dredging of Clam Pass, located on the gulf coast just south of Naples, Florida, was written in 2009. The permit was issued in 2012 with an original expiration date in 2022, but a minor modification was issued extending the permit to 2027. Permit expirations can be extended by up to 15 years. The permit for Clam Pass requires monitoring at background and compliance check locations twice daily during all dredging and sand placement operations, when the highest turbidity levels reach the edge of the mixing zone (USACE 2014). The compliance locations are considered the limits of the temporary mixing zone for turbidity allowed during construction. If monitoring reveals turbidity levels at the compliance sites that are greater than 29 nephelometric turbidity units[18] above the corresponding background turbidity levels, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels. The permit for Clam Pass serves as an example of a JCP-

[18] A nephelometer is an instrument that measures light scattered by particles suspended in solution. The greater the scatter, the higher the turbidity. The data produced by nephelometers is expressed in terms of nephelometric turbidity units.

authorized beach nourishment. Other permits have different monitoring frequencies and location-specific background and compliance delineations.

An evaluation of the quantitative turbidity levels to which ESA-listed species may be exposed would not be feasible for evaluating the EPA-approved turbidity limits because the limits are for the extent and location of mixing zones associated expressed narratively in terms of local baseline turbidity levels used to determine the maximum extent of a mixing zone. The JCP application materials each include the following statement:

> *DISTRIBUTION TO THE U.S. ARMY CORPS OF ENGINEERS: When activities are proposed in, on or over wetlands or other surface waters, the Department shall forward a copy of the application to the United States Army Corps of Engineers (USACE). The USACE will advise you of any additional information that may be required to complete the federal dredge and fill portion of the permit application. The information requested in this application form may be more than required to make a complete application to the USACE. However, it is useful and may be essential for subsequent evaluation. Please provide measurements in both English units and metric equivalents for projects that require a federal permit.*

The JCP actions that involve the discharge of sediment into waters of the U.S. require permitting from the USACE under Section 404 of the Clean Water Act, and are subject to ESA consultation requirements when USACE determines that ESA-listed species may be affected. The mixing zone, turbidity thresholds, and background determination for an individual project that involves beach nourishment would be a case and site-specific analysis, as is appropriate. The limits approved by EPA and guidance from NMFS Southeast Region for actions that may affect sea turtles and smalltooth sawfish are additional measures integrated into the determination by USACE on whether ESA-listed species may be affected.

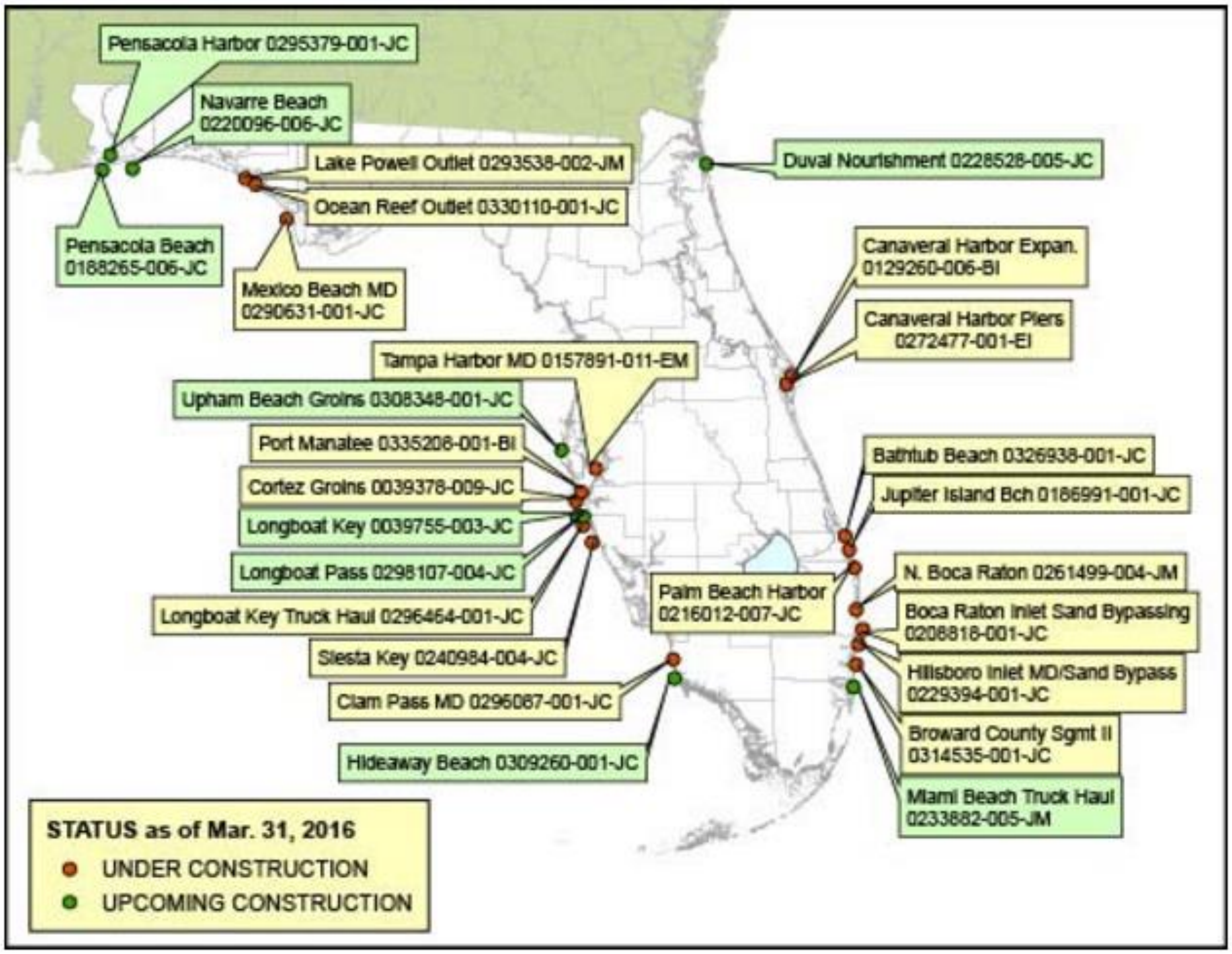

Figure 30. Active and Planned JCP Activities (FDEP 2016).

Species for Which ESA Section 7 Consultation Would be Triggered Under the EPA-Approved Limits

The mixing zone limits approved by EPA prohibit mixing zones over hard bottom, coral, and seagrass habitats unless these areas are specifically included in the impact area assessed. The applicant must demonstrate that the size of the mixing zone has been minimized, and if the mixing zone still encompasses such resources, then it must be deemed an impact site and mitigation would be required. These requirements mean the approved standard requires a mixing zone of zero (i.e., no stressor exposure) in these areas, or an assessment which would trigger ESA-section 7 consultation for ESA listed species associated with these habitats in the action area, such as the Nassau grouper, Johnson's seagrass, elkhorn and staghorn coral, rough cactus coral, pillar coral, and the lobed, mountainous, and boulder star corals.

Sea Turtles and Smalltooth Sawfish

NMFS Southeast Region developed guidance for construction activities that may affect smalltooth sawfish: *Sea Turtle Smalltooth Sawfish Construction Conditions*, published 2006. The guidance is not incorporated by reference into existing permitting for these projects, so the protections in the guidance are not required. However, the guidance is included in the USACE online regulatory guidelines (http://www.saj.usace.army.mil/Missions/Regulatory/Source-Book/). Review of public notices for permitting indicates that the guidelines are considered in the USACE assessment of permit applications. In cases where USACE determine that a given action may affect and ESA-listed species, their conclusions state that ESA section 7 consultation with NMFS will be requested[19].

Conclusion: EPA-Approved Turbidity Limits

Although sand is relatively heavy and drops out faster, the sheer volume of dredging can often lead to sediment transport to other areas outside the dredging footprint (L. Carrubba, NMFS SERO, pers. comm. to P. Shaw-Allen, NMFS OPR, June 7, 2016). The JCP actions that involve the discharge of sediment into waters of the U.S. require permitting from the USACE and are therefore subject to ESA section 7 consultation with NMFS when actions may affect ESA-listed species under NMFS' jurisdiction. The mixing zone, turbidity thresholds, and determination of local background turbidity levels for an individual project are a case and site-specific analysis, as is appropriate, and is evaluated individual consultations with USACE. The requirement to include any hard bottom communities, coral resources, or submerged aquatic vegetation beds within a permit application's evaluation of impact sites will trigger USACE request for ESA section 7 consultation, where appropriate: corals and Johnson's seagrass, and by extension, Nassau grouper since they are associated with coral and seagrass habitats.

> ***NMFS concludes that impacts of turbidity plumes resulting from JCP-authorized beach nourishment will undergo ESA section 7 consultation when impact sites include hard bottom communities, coral resources, or submerged aquatic vegetation beds where ESA-listed species under NMFS' jurisdiction occur. For this reason, effects of turbidity plumes from such activities on ESA-listed corals, Nassau grouper, and Johnson's seagrass will be addressed in individual consultations triggered by the limits and will not be considered further in this opinion.***

Turbidity plumes will occur along the coastline in waters used by North Atlantic right whale, green, hawksbill, Kemp's ridley, and loggerhead sea turtles, smalltooth sawfish and Atlantic and shortnose sturgeon. While, there are no specific protections for these species under the turbidity

[19] Search term used for authroizations
http://search.usa.gov/search?utf8=%E2%9C%93&affiliate=saj&query=public+notice+sawfish+consultation

standards approved by EPA, activities involving the discharge of sediment into waters of the U.S. require permitting from the USACE under Section 404 of the Clean Water Act, and are subject to ESA consultation requirements when USACE determines that ESA-listed species may be affected.

> ***NMFS concludes that impacts of turbidity plumes resulting from JCP-authorized beach nourishment will undergo ESA section 7 consultation when impact sites may affect ESA-listed North Atlantic right whales, green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles, and Atlantic and shortnose sturgeon under NMFS' jurisdiction. The effects of turbidity plumes from such activities on these species will be addressed in individual or programmatic tiered consultations and will not be considered further in this opinion.***

The beach nourishment may also occur at the mouths of the St. Johns and St. Marys River, which serve as nursery habitat for shortnose and Atlantic sturgeon. Critical habitat recently proposed for these species identified the St. Marys as a spawning river, and effects to shortnose sturgeon in St. Johns were evaluated in the Jacksonville Harbor Navigation Study (USACE 2012). USACE is aware of sturgeon use of these waters. While there are no specific protections for access to these rivers by these species under the turbidity standards approved by EPA, the USACE consults on activities that may affect ESA-listed species under NMFS' jurisdiction.

> ***NMFS concludes that impacts of turbidity plumes resulting from JCP-authorized activities will undergo ESA section 7 consultation when impact sites affect access to rivers used by shortnose and Atlantic sturgeon. For this reason, effects of turbidity plumes on these species will be addressed in individual consultations and will not be considered further in this opinion.***

The beach nourishment produce short-term turbidity plumes, with continuous erosion over time requiring these activities to be iterative, occurring every few years. Due to the weight of the sand and the action of ocean currents, turbidity plumes subside shortly after dredging ceases and materials settling out of the water column are redistributed, along with natural deposits, by current and tides over time. These iterative actions are not expected to have aggregate effects over time.

> ***NMFS concludes that aggregate impacts over time of turbidity plumes resulting from iterative JCP-authorized beach nourishment are expected to be discountable and are thus not likely to adversely affect ESA-listed species under NMFS' jurisdiction that use areas where these activities occur. For this reason, the effects of temporally aggregate impacts of these activities will not be further considered in this opinion.***

With regard to the aggregate effects of more than more than one activity located in the same area, the baseline analysis for individual actions address the current condition of the environment and expected stressor regimes that will occur/exist during the action (e.g., bycatch, NPDES discharges, existing impairments). ESA section 7 consultations for individual actions requested by USACE when the activities it authorizes may affect ESA-listed species are expected to include any other activities that may affect the baseline conditions of the action, whether or not they specifically involve the beach nourishment considered in this opinion.

> ***NMFS concludes that aggregate impacts of turbidity plumes resulting from JCP-authorized beach nourishment that overlap in time and are conducted in the same area will be incorporated into the analyses of the most recently-initiated ESA section 7 consultation when these actions may affect ESA-listed species under NMFS' jurisdiction. For this reason, the effects of aggregate impacts of activities that overlap in location and time therefore will not be further considered in this opinion.***

Table 17. Determination for the Effects of Florida's Turbidity Limits on ESA-listed Species, and Where Designated, Critical Habitat, Based on Exposure Analysis.

<table>
<tr><th></th><th>Atlantic and shortnose sturgeon</th><th>North Atlantic right whale</th><th>Green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles</th><th>Elkhorn and staghorn corals, boulder lobed and mountainous star corals, pillar coral, and rough cactus coral</th><th>smalltooth sawfish, and Nassau grouper</th><th>Johnson's seagrass</th></tr>
<tr><td colspan="7">Hypotheses: Turbidity limits will have direct or indirect effects on the survival or fitness of individuals through:</td></tr>
<tr><td>Smothering</td><td colspan="6" rowspan="4">ESA section 7 consultation on actions to which the EPA-approved turbidity limits will be applied will occur either as consultations for individual actions. Aggregate effects of more than one activity involving the beach nourishment located in the same area and overlapping in time are not expected because the analysis of such effects are integrated into most recently initiated consultation. Aggregate effects of iterative actions (i.e., occurring in the same location every few years) are not expected because the impacts are ephemeral in nature and separated in time.</td></tr>
<tr><td>reduced light penetration</td></tr>
<tr><td>altered substrate</td></tr>
<tr><td>restriction in usable habitat due to mixing zone avoidance</td></tr>
</table>

4.2.4 Summary of the Exposure Analysis

This opinion concluded in the exposure analysis that the TN and TP NNC for Tidal Peace River promote eutrophic conditions that may affect smalltooth sawfish and the essential features of their designated critical habitat. The DO criteria allow for periods of low DO that may affect Atlantic and shortnose sturgeon, smalltooth sawfish, elkhorn coral, staghorn coral, lobed star coral, boulder star coral, mountainous star coral, pillar coral, rough cactus coral, Johnson's seagrass, and the Nassau grouper and indirectly affect green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles through effects to prey species. The implications of these stressor exposures will be addressed in the Response Analysis.

4.2.5 Response Analysis: Eutrophic Stressors in the Tidal Peace River

The FDEP NNC are intended to remediate or prevent eutrophication, so the exposure analysis first determined whether the NNC will promote eutrophic conditions. In the exposure analysis Chl-a observations provided evidence that most NNC supported healthy conditions. However, data for the tidal portion of the Peace River indicated that the TP and TN NNC for that segment supported high Chl-a levels. The response analysis for EPA's approval of Florida's NNCs will therefore evaluate the effects of stressors generated under eutrophic conditions on smalltooth sawfish and the essential features of smalltooth sawfish designated critical habitat. Referring back to Figure 25 and Table 11, a number of hypotheses are removed from consideration, and this analysis focuses on species and designated critical habitat that occurs in the Charlotte Harbor estuary: smalltooth sawfish and their designated critical habitat.

Charlotte Harbor and associated rivers are included in the designated critical habitat for smalltooth sawfish (Figure 31). For designated critical habitat, the effects analysis examines whether the cascading effects of nutrients in the Tidal Peace River have reduced or will reduce the quality of habitat for the conservation of smalltooth sawfish. The Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their their function of providing refugia and diverse and abundant forage that facilitate recruitment of juveniles into the adult population. The ISED indicates that, among 2500 reported sightings between 2010 and 2015, 121 smalltooth sawfish sightings were reported for the Peace River and about a third of these observations occurred in 2015. The ISED confirms that the species is present in and is using waters of the Tidal Peace River. It is important to note that observations in the ISED are voluntary reports from the public and contributions from various researchers. They are not the result of systematic surveys that can be used to characterize population size and structure. Further, observations within the estuary are primarily juveniles, making the data unusable for estimating population metrics (e.g., age structure, abundance, etc.). We must also consider that the density of observers, which include researchers, anglers, and recreational boaters, is likely greater within the Charlotte Harbor than in the Ten Thousand Islands portion of the designated critical habitat.

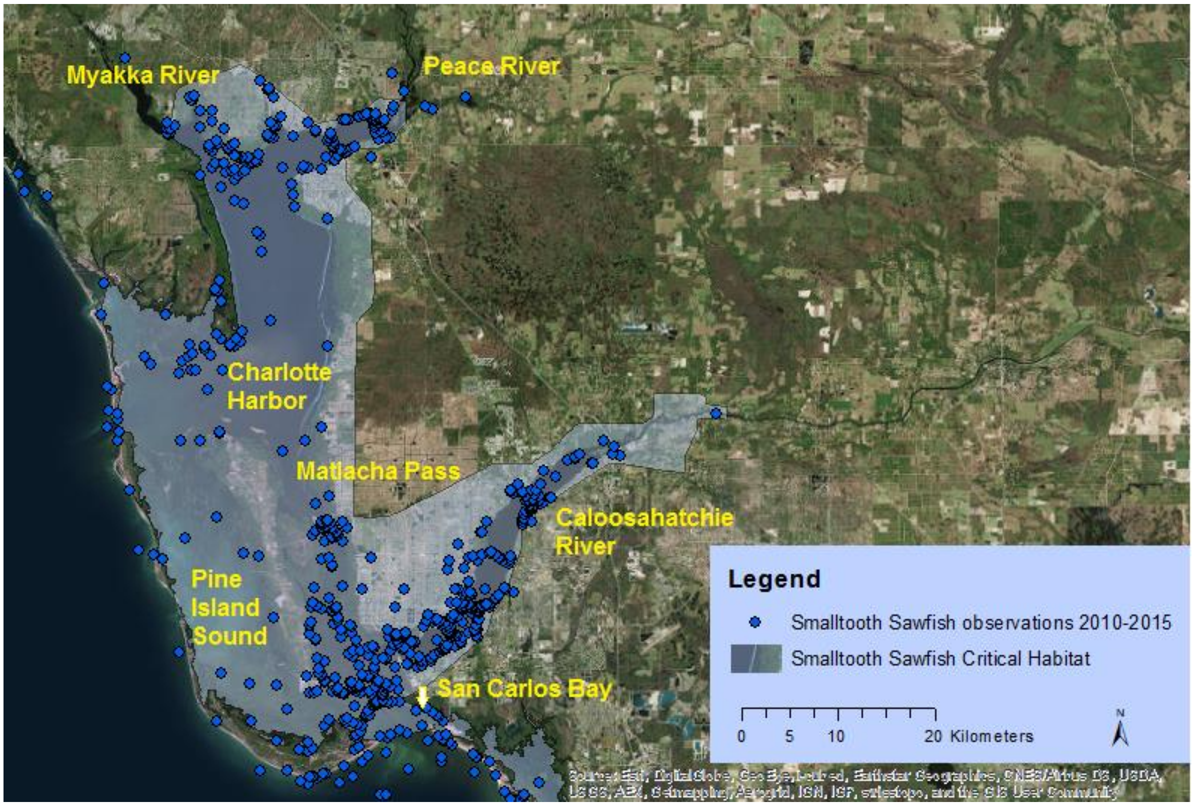

Figure 31. Charlotte Harbor Detail of Smalltooth Sawfish Designated Critical Habitat and Reported Encounters Between 2010 and 2015 (Poulakis 2016).

Ammonia

The risk hypotheses addressing the effects of ammonia on smalltooth sawfish include:

- NNC will support eutrophic conditions that affect the survival of individuals through the lethal effects of ammonia
- NNC will support eutrophic conditions that affect the fitness of individuals through the sublethal effects of ammonia
- NNC will support eutrophic conditions that have indirect effects to survival and fitness through reduction in prey species (through ammonia toxicity)

Ammonia is a primary product of microbial breakdown of organic nitrogen. Ammonia does not accumulate, as it is taken up by algae and plants for growth or oxidized to nitrate and nitrite. Open estuarine and near shore coastal waters that are not near point sources of ammonia such as sewage outfalls and agricultural operations have typical ammonia concentrations ranging from below detection limits to 0.014 to 0.07 mg total ammonia nitrogen (TAN = NH_4^+ and NH_3) per liter (mg TAN/L), predominantly in the form of ionized ammonia (NH_4^+)(USEPA 2001). There are a number of point sources contributing nitrogen to the Peace River watershed. The lower reaches of the Peace River are urbanized. Portions of the Peace River watershed are used for the land application of domestic residuals, septage, and food establishment sludge. Agriculture, consisting of mostly cattle ranching and citrus orchards, accounts for 42.5 percent of the Peace River watershed land use (Southwest Florida Water Management District 2001). Sampling events in the Tidal Peace River reporting TP and TN concentrations that were consistent with the estuarine NNC averaged 0.09 mg TAN/L and ranged from 0.01 to 0.51 mg TAN/L (n=109 events with ammonia data). About 60 percent of these observations were below 0.07 mg TAN/L.

Ammonia speciation in water and ammonia toxicity is first discussed in general before addressing implications for smalltooth sawfish and its designated critical habitat. Ionized (NH_4^+) and unionized (NH_3) ammonia species exist in water in dynamic equilibrium. It is the unionized form of ammonia, NH_3 that is toxic. Speciation is determined by water temperature, pH, and salinity. EPA's water quality guidelines for the protection of aquatic life (USEPA 1989 and 2013) incorporate the speciation effects of pH and temperature in the freshwater ammonia guidelines and the effects of pH, temperature, and salinity in the saltwater ammonia guidelines. As discussed in *Use of Toxicity Data and EPA Water Quality Guidelines in this Biological Opinion* (Section 3.1.1), for biological opinions, EPA water quality guidelines must be used with caution. Where they can be applied, they are useful for:

- Evaluating indirect effects to ESA-listed species through effects to prey species, provided new data do not suggest the guidelines need adjustment; and
- Identifying exposures that would certainly be harmful to exposed species.

A general summary of the CWA is provided in Appendix A.

Ammonia Effects on Aquatic Life

EPA revised its freshwater ammonia guidelines in 2013 to take into account the latest freshwater toxicity data, including toxicity studies for sensitive unionid mussels and gill breathing snails (USEPA 2013). Since publication of 1989 EPA's ammonia guideline for saltwater, only two studies on ammonia toxicity in marine organisms were added to EPA's toxicity database (ECOTOX). A literature search using the Web of Science (Thompson-Reuters) identified 14 studies examining ammonia toxicity in marine species published after the guideline development. The 1989 marine water quality guidelines for ammonia are based on LC50s ranging from 0.23 to 43 mg NH_3/L (USEPA 1989). Data from ECOTOX and the 14 studies report LC50s at concentrations that are greater than the lowest LC50 used in development of the marine ammonia guidelines (Parra and Yufera 1999, Xu et al. 2004, Kater et al. 2006, Perez-Landa et al. 2008, Carneiro et al. 2009, Ferretti and Calesso 2011, Maas et al. 2012, Azpeitia et al. 2013, Lee et al. 2013, Rodrigues et al. 2014, Sinha et al. 2015a, Sinha et al. 2015b, Wang et al. 2015). Recent data would not lower the standard, as derived by EPA under its 1985 guidance (Stephen et al. 1985). Chronic toxicity data were available for inland silverside and mysid shrimp, providing No Observed Effects Concentrations (NOECs) of 0.05 and 0.163 mg NH_3/L and Lowest Observed Effects Concentrations (LOECs_ of 0.075 and 0.331, respectively. The level of effects associated with these concentrations (e.g., percent reduction in growth or egg production) were not reported.

The standard toxicity tests recommended in Stephen et al. (1985) use rested and unfed organisms. There are conflicting perspectives on how this affects results because ammonia is a metabolic byproduct of digestion and exertion. On one hand, unfed animals may be at their least vulnerable to the effects of external ammonia. Animals who have eaten or are swimming freely generate endogenous ammonia which must be detoxified while also compensating for external ammonia (Randall and Tsui 2002, Eddy 2005). On the other hand, fed animals may be better equipped to compensate for ammonia toxicity. Diricx et al. (2013) exposure of fed and unfed carp to 1 mg TAN/L produced the opposite result. Over all the fed fish were more tolerant of ammonia exposure. Under stress, feeding can provide benefits in mounting a defense against the toxic effects of ammonia (Sinha et al. 2015a, Sinha et al. 2015b). The exposure concentrations at which the effects of fed and unfed conditions were evaluated were very high, at 20 mg NH4+/L. Considering these studies, it is NMFS' opinion that any effect of using unfed organisms in the toxicity tests used to derive EPA's ammonia water quality guidelines will not influence the outcome of this assessment.

According to the guidelines, saltwater aquatic organisms should not be affected unacceptably if the four-day average concentration of does not exceed 0.035 mg NH_3/L more than once every three years on the average and if the one-hour average concentration does not exceed 0.233 mg NH_3/L more than once every three years on average. Using modeling to account for hydrolysis of ammonium ions in seawater, EPA's guidelines for TAN at pH 7, water temperature of 20^{o}C, and salinity of 20 $^{o}/_{oo}$ are 64 mg TAN/L for acute exposures and 9.7 mg TAN/L for chronic exposures. At face value, the guidelines appear to be an order of magnitude greater than the TAN levels observed in Tidal Peace River sampling events where TP and TN were consistent with NNC. Taking ammonia speciation into consideration for each sampling event, the actual applicable acute guidelines range from 0.54 to 71 mg TAN/L and the chronic guidelines range from 0.08 to 11 mg TAN/L. Comparison of the observed ammonia concentrations with guidelines calculated for each sampling event did not identify any observations exceeding either the acute or chronic ammonia guidelines.

Response to Ammonia: Survival and Fitness of Individual Juvenile Smalltooth Sawfish

Toxicity data for smalltooth sawfish exposure to ammonia, or taxonomically related species that would serve as a reasonable surrogate for smalltooth sawfish, were not found in EPA's ECOTOX database or searches of Web of Science or Elsevier Science Direct. However, elasmobranchs like the smalltooth sawfish are ureotelic[20]. Ureotelic species are expected to be less vulnerable to ambient ammonia than the species used in the derivation of the water quality guidelines. Sharks, which are also elasmobranchs, have low gill permeability to ambient ammonia relative to non-ureotelic aquatic species (Cameron 1986). Ureotelic aquatic species regulate the ion concentrations in their body fluids to maintain osmotic balance with their external environment

[20] In ureotelic species, ammonia is converted to urea and native tri-methyl amine oxide (TMAO) counteracts its toxicity.

(Nawata et al. 2015, Deck et al. 2016). This reduces the influx of ammonia from the external environment. For example, the freshwater sawfish, *Pristis microdon*, is able to adjust its blood ion concentration when moving between waters of differing salinities by increasing urine flow to reduce blood urea content (Smith 1961). Similarly, plasma ion balance in spiny dogfish exposed to extremes in salinity shifted to approximately match the ambient environment within 18 to 24 hours (Deck et al. 2016).

NMFS concludes that ammonia concentrations under the Tidal Peace River NNC are not likely to adversely affect the survival or fitness of individual smalltooth sawfish because responses to anticipated ammonia concentrations under the NNC are expected to be insignificant based on what is known about nitrogen metabolism and ion regulation for ureotelic elasmobranch species like the smalltooth sawfish. These responses will not be evaluated further in this opinion.

Response to Ammonia: Essential Features of Smalltooth Sawfish Designated Critical Habitat

Sawfish designated critical habitat in the Tidal Peace River centers on its function as juvenile nursery habitat. Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their their function of providing refugia and diverse and abundant forage that facilitate recruitment of juveniles into the adult population. The presence of ammonia in the water column will not alter the structural aspects of designated critical habitat (i.e., shallow euryhaline habitats and refugia) but may affect the abundance and diversity of species smalltooth sawfish prey upon (e.g., crabs, shrimp, and small fish) and the health of red mangroves.

Total ammonia nitrogen levels in Tidal Peace sampling events that were consistent with the NNC did not exceed the national water quality guidelines for the protection of aquatic life (USEPA, 1989 and 2013) and new data would not change the ammonia guideline to a lower value.

NMFS concludes that ammonia concentrations under the Tidal Peace River NNC are not likely to adversely modify the designated critical habitat role in providing diverse and abundant forage for smalltooth sawfish because responses of prey species to anticipated concentrations at the NNC would have insignificant effects on abundance and diversity of prey. These responses will not be evaluated further in this opinion.

Ammonia is the dominant form of nitrogen supporting mangrove growth in the acidic, saline, and frequently inundated low-oxygen soils of mangrove forests (Reef et al. 2010). While the work of (Lovelock et al. 2009) suggests nutrient enrichment leads to imbalanced growth of shoots relative to root mass, that work is based on artificially fertilized natural mangrove forests, does not report nutrient concentrations or loadings, and does not indicate whether the fertilization rates used were environmentally realistic. The studies described in (Lovelock et al. 2009) likely represent extreme nutrient enrichment conditions relative to Florida's NNC.

> ***NMFS concludes that ammonia concentrations under the Tidal Peace River NNC are not likely to adversely modify the designated critical habitat feature of "red mangroves" for smalltooth sawfish and is discountable because ammonia enhances mangrove growth and unbalanced growth is not expected under the Tidal Peace NNC. These responses will not be evaluated further in this opinion.***

Response to Ammonia: Indirect Effects for Smalltooth Sawfish

The indirect effects of ammonia on smalltooth sawfish result from ammonia toxicity to the species they rely on (e.g., crabs, shrimp, small fish). Since the prey species and the red mangrove habitats relied upon by smalltooth sawfish are components of the designated critical habitat for this species, these have already been discussed context of designated critical habitat. Longer term effects of ammonia concentrations under the Tidal Peace NNC, such as changes in abundance and distribution of species in the aquatic community, are not anticipated because concentrations observed at the NNC are below EPA's guideline for the protection of aquatic life.

> ***NMFS concludes that ammonia concentrations under the Tidal Peace River NNC are not likely to result in adverse indirect effects to smalltooth sawfish because anticipated concentrations are below EPA's guideline for the protection of aquatic life, so long-term influences on the structure and function of the aquatic community are expected to be insignificant and are not likely to adversely affect smalltooth sawfish. These responses will not be evaluated further in this opinion.***

DO Extremes Under Eutrophic Conditions

The risk hypotheses addressing the effects of DO extremes are:

- NNC will support eutrophic conditions that affect the survival of individuals through the lethal effects of DO extremes,
- NNC will support eutrophic conditions that affect the fitness of individuals through the sublethal effects of DO extremes, and
- NNC will support eutrophic conditions that have indirect effects to survival and fitness through reduction in prey species.

All three hypotheses apply to smalltooth sawfish. Before discussing the potential for exposure to harmful DO extremes at Tidal Peace NNC, it is necessary to first establish whether DO extremes may occur at the TP and TN NNC concentrations. The elevated Chl-a levels observed in sampling events where TP and TN were consistent with the Tidal Peace NNC suggest the potential for extreme fluctuations in DO. Increased algal biomass increases oxygen generation through enhanced photosynthesis during daylight hours and increases biological oxygen demand from decomposing organic matter and algal oxygen consumption at night time, when photosynthesis is paused. The DO concentration in sampling events where TP and TN were consistent with Tidal Peace NNC averaged 6.5 mg/L (range: 1.38 to 10.19 mg/L), with DO saturation averaging 84 percent (range 20-116 percent, n=128 events). These data were collected during daylight hours, so detection of super-saturation, instances where DO concentrations exceed DO solubility, is more indicative of a DO regime with DO extremes than are observations of low DO levels. Super-saturation occurred in 26 of the NNC-consistent 128 events (20 percent).

Super-saturation, coupled with high Chl-a levels would suggest that DO levels would decline to low levels during nighttime when photosynthesis pauses and respiration and organic matter decomposition continues to consume oxygen. Yet elevated Chl-a was not consistently associated with super-saturation. The association between Chl-a and supersaturated DO is confounded by the time of day these sampling events occurred. Chl-a peaked mid-day, and declined thereafter (Figure 32). FDEP (2013) reported that the daily average DO concentration in estuaries and marine waters typically occurs about mid-day, with the minimum at around 8:00 am and the maximum near 5:00 pm. Among events with elevated Chl-a (n=45 events), eight had supersaturated DO levels (18 percent) and six of these events occurred after noon-time. Meanwhile 33 percent of sampling events with reference Chl-a levels had supersaturated DO, with a greater proportion of these events conducted after noon-time.

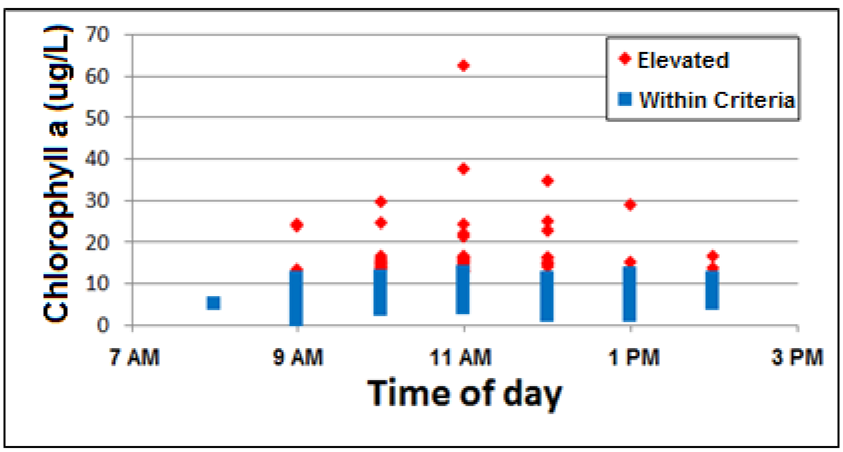

Figure 32. Effect of Time of Day on Chl-a Data in Tidal Peace River Sampling Events with TP and TN Consistent with NNC.

Taken with the frequency of DO super-saturation in 20 percent of sampling events where TP and TN were consistent with NNC, and a plausible mechanism to explain why elevated Chl-a was not well associated with super-saturation, it is NMFS' opinion that the TP and TN NNC will result in a DO regime involving extremes in DO levels. Expecting that the Tidal Peace River NNC result in DO extremes, we discuss the adverse effects of on aquatic organisms before addressing implications for smalltooth sawfish and the essential features of smalltooth sawfish designated critical habitat.

As explained previously, EPA's water quality guidelines are suitable for evaluating indirect effects through prey species and identifying exposures that are clearly harmful to aquatic organisms. The current EPA water quality guidelines for marine waters in the Virginian Province (Cape Cod to Cape Hatteras) are a chronic protective value for growth of 4.8 mg/L and a lower limit for adult and juvenile survival of 2.3 mg/L (USEPA 2000). In contrast to the laboratory studies used to derive DO minima for EPA guidelines, marine and estuarine organisms avoid poor DO conditions. Hypoxia in estuary systems is defined by some as DO concentrations below 2.0 mg/L (Pinckney et al. 2001). Meanwhile concentrations of 2.5-3 mg/L are considered mild hypoxia (Carlson and Parsons 2001, 2003). Hypoxia tolerance and DO preferences differs among estuarine species (Wannamaker and Rice 2000, Craig 2012), can be influenced by factors such as fish density tolerance, competition, predation risk, and food resources (Eby and Crowder 2002, Froeschke and Stunz 2012, Brady and Targett 2013) and life stage/size (Poulakis et al. 2011, Campbell and Rice 2014). Campbell and Rice (2014) examined the implications of habitat compression due to hypoxic events. Fish behavior was tracked in response to hypoxic events occurring on the scale of hours and recurring repeatedly over several months. Spot (a species of fish) occupying oxygenated refugia during periods of hypoxia-compressed habitat had significantly reduced stomach contents. They estimated that growth was reduced by 17 percent during these events, with chronic hypoxic events over the summer months amounting to an overall 4 percent reduction in growth rate.

Response to DO Extremes: Survival and Fitness of Individual Smalltooth Sawfish

Data were not found for the effects of low DO or extreme DO fluctuations on smalltooth sawfish. The few studies on the responses of other elasmobranchs to low DO suggest the species group has lower oxygen demands than bony fish and adapts to hypoxia through modulating ventilation rates without effects to blood chemistry. Sharks appear to have lower oxygen demands than other fish. Increased swimming speed and doubling of the mouth gape in tuna under hypoxia would not support the respiratory demands of the swimming speed according to physiological modeling (Bushnell and Brill 1991). Mouth gape is important for species that rely on ram ventilation. Ram ventilation is the movement of water through the mouth of a fish as it swims to keep oxygenated water flowing over their gills. Ram ventilating bonnethead and blacknose sharks survived DO levels of 2.5-3.4 mg/L for the 4 hour duration of exposures in a Carlson and Parsons (2001) study while oxygen of 4.0 mg/L were tolerated by skipjack tuna for only 20–155 min (Gooding et al. 1981). A study of white shark reported that dive depth was constrained by DO levels of approximately 1.5 mg/L, but recorded infrequent dives to waters as deep as 1000 meters and DO levels of 0.3 mg/L (Nasby-Lucas et al. 2009).

Exposure of bonnethead sharks to ambient DO concentrations of between 3 and 6 mg/L resulted in increased ventilation rates and mouth gape at the lower DO exposures, but no changes in oxygen consumption rate, blood oxygen content, or hematocrit (Carlson and Parsons 2003). In another study, swimming speeds, mouth gape, and oxygen consumption rates in bonnethead and blacknose sharks increased at ambient DO of 2.5–3.4 mg/L. Carlson and Parsons (2001) suggest that the ability to tolerate moderate hypoxia in ram ventilating sharks may allow them to forage in areas where other species do not. For example, the bonnethead forages on benthic organisms in shallow estuarine waters (Cortes et al. 1996, Heupel et al. 2006, Belcher and Jennings 2010, Froeschke et al. 2010) primarily at night when photosynthesis and oxygen production is paused (Parsons 1987).

Carlson and Parsons (2001) report that hypoxic conditions did not affect the oxygen consumption rates of Florida smoothhound shark, but did reduce swimming speed. Florida smoothhound sharks are bucchal ventilators, pumping oxygenated water over the gills by rhythmic compression and expansion of throat muscles. Dogfish, which are also bucchal ventilators, exhibited similar activity reductions and increased ventilation frequency under hypoxic conditions (Metcalfe and Butler 1984). The authors concluded that the reduction in energy expenditure reduces oxygen demand and may be a trade-off to allow increased respiration.

Under bucchal ventilation, hypoxia is expected to result in reduced activity. This would restrict foraging activity and chronic low DO events could affect growth. Reliance on bucchal ventilation would also affect the ability so smalltooth sawfish to escape a predator under low DO conditions. However, smalltooth sawfish employ both ram and bucchal ventilation (G. H. Burgess, University of Florida, pers. comm. to P. Shaw-Allen, NMFS OPR, June 7, 2016), so such effects are not expected. This flexibility would allow the juvenile sawfish to remain still to avoid detection by a predator, and to swim to pursue prey, escape a predator, or escape a hypoxic front.

Predation vulnerability is an important consideration. Simpfendorfer et al. (2011) fitted smalltooth sawfish with acoustic tags and tracked their movement. Results indicate that the salinity and temperature preferences of smalltooth sawfish were related to fish size, with larger individuals being more responsive to salinity changes and smaller individuals having a stronger preference for shallower waters. In their discussion, Simpfendorfer et al. (2011) reasoned that the preference of shallow waters by neonates was a tradeoff to avoid predation because their smaller body size increases the metabolic cost of maintaining their blood ion balance with the external environment. This conclusion is supported by behavioral choices that lead to higher energetic costs of other elasmobranch species (Yates et al. 2015).

The FDEP technical support document (FDEP 2013) provides a review of water chemistry in waters where smalltooth sawfish have been observed. FDEP relies on the Waters et al. (2011) report of encounters of small to very small sawfish at depths from less than 1 meter to over 150 meters, salinities from 1.98 to 38.60 ppt, DO concentrations from 3.5 to 9.1 mg/L, and water temperatures from 20.9 to 33.2°C. FDEP concluded that, because most of these observations came from small to very small juvenile fish and most species are most sensitive to low DO conditions at this life stage, this limited information suggests that the smalltooth sawfish is not more sensitive to low DO levels than the sensitive species used to derive Florida's proposed DO criteria. They support their conclusion using unpublished data for research efforts at the Rookery Bay National Estuarine Research Reserve in the Ten Thousand Islands area of the Southwest Florida coast. This area is a portion of the designated critical habitat for smalltooth sawfish. The Ten Thousand Islands area is located adjacent to Everglades National Park. FDEP considers this area to be one on the most pristine estuarine areas in Florida with little anthropogenic input. Sawfish were captured from areas with DO concentrations ranging from 3.2 to 7.6 mg/L. Temperatures in these areas ranged from 18.6 to 33.8°C and salinities ranged from 5.5 to 38.6 ppt. Approximately 38 percent of the sawfish captures occurred at DO concentrations below 5.0 mg/L with 15 percent of the captures occurring at DO levels below 4.0 mg/L. Additionally, the Rookery Bay National Estuarine Research Reserve maintains continuous diel data recorders that have measured DO levels in both Faka Union and Fakahatchee Bays since 2002. Data from both bays indicate daily average DO levels below 5.0 mg/L occur commonly, especially in the summer months. In Faka Union Bay, where the majority of the sawfish captures occurred, 44 percent of the daily average DO levels were below 5.0 mg/L.

Smalltooth sawfish commonly occur in the more urbanized Charlotte Harbor and Caloosahatchee River estuaries. These estuaries are also part of the species designated critical habitat. Poulakis et al. (2011) studied the abiotic affinities of the smalltooth sawfish in the Charlotte Harbor and Caloosahatchee River estuaries. Based on their captures, they reported that sawfish had an affinity for high DO levels above 6.0 mg/L. The authors also indicate increasing electivity index values (i.e., degree of preference), for DO levels up to 12 mg/L. FDEPs interpretation of the Poulakis data cautioned that the study:

- *did not take into account the influence of other variables that contribute to preferences such as water velocity, amount of shading, color, and depth associated with the nutrients and organic material that influence DO levels*
- *The enhanced primary productivity in Charlotte Harbor and Caloosahatchee River estuaries due to nutrient enrichment can artificially raise DO levels*
- *The study did not link DO affinities to physiological requirements of the species*
- *Based on Florida's discussions with the authors (Gregg Poulakis and Philip Stevens personal communication) the DO measurements reported were often taken later in the day when the highest DO levels typically occur*

FDEP noted that at temperature and salinity levels typically found in this area, DO concentrations above 8 mg/L represent supersaturated DO conditions characteristic of nutrient enriched areas, but not often found in more pristine areas. FDEP further explained that in nutrient-enriched waters such as the Caloosahatchee River estuary, the diel DO fluctuation is commonly more than 3 mg/L. FDEP concluded that the results of this study, in conjunction with the data from more pristine areas, suggest that sawfish have an affinity for areas with greater primary production resulting from anthropogenic nutrient inputs.

If the Poulakis et al. (2011) DO data were collected during peak periods of photosynthesis, it is reasonable to expect they could reflect DO super-saturation. This is consistent with the DO regime of a eutrophic system that would also include periods of low DO. Our own analysis of U.S. Geological Survey and STORET DO data, and DO data provided in the technical support document (FDEP 2013) confirm the diel cycles in both urbanized and less developed Florida marine waters.

Smalltooth sawfish are dependent on shallow waters of estuarine systems, particularly red mangrove, and DO may not be a primary factor in site preference. Simpfendorfer et al. (2011) found that salinity and temperature were important environmental factors influencing the movement and location of smalltooth sawfish. Salinity and temperature are important factors in the solubility of DO in water, yet that study did not include DO level as a variable. Studies of other elasmobranchs did evaluate DO, salinity, and temperature affinities. Hopkins and Cech (2003) also reported that salinity and temperature were the critical factors in site affinity. They measured, but did not include DO in their model because it was always above stressful levels (>75 percent oxygen saturation). Considering evidence for other elasmobranchs, salinity and temperature were the most important factors in the occurrence of coastal bull, bonnethead, and blacktip sharks in a study that also reported broad DO concentrations ranging from 0.6 to 28.5 mg/L (Froeschke et al. 2010). Belcher and Jennings (2010) report that sandbar sharks and bonnethead sharks have different depth preferences, but the presence of subadults of both species was actually correlated with high salinities and low DO (4.34 mg/L).

> ***NMFS concludes that any effects on smalltooth sawfish of DO extremes apparent at Tidal Peace River NNC are expected to be insignificant and are not likely to adversely affect the survival and fitness of smalltooth sawfish based on: (1) what is known about the relative hypoxia tolerance and compensatory behaviors of other elasmobranch species, (2) the use of both ram and buccal ventilation in smalltooth sawfish allows rest for predator avoidance and continued activity for foraging during hypoxic events, and (3) the expected DO conditions within the habitats smalltooth sawfish typically occupy. These responses will not be evaluated further in this opinion.***

Response to DO Extremes: Essential features and Nursery Function of Designated Critical Habitat for Smalltooth Sawfish

Sawfish designated critical habitat in the Tidal Peace River centers on its function as juvenile nursery habitat. Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their function of providing refugia and diverse forage that facilitate recruitment of juveniles into the adult population. DO extremes will not alter the structural aspects of designated critical habitat (i.e., shallow euryhaline habitats and refugia) and will not affect red mangrove, as they are aquatic plants which photosynthesize and produce oxygen (Knight et al. 2013). Prey species are affected by water quality and the DO regime in the tidal segment of the upper Charlotte Harbor has already had its influence on the species assemblages currently present (Fraser 1997) and continues to mold the community. The spatial distribution of prey species would change during periods of hypoxia (Eby and Crowder 2002, Craig 2012, Froeschke and Stunz 2012, Brady and Targett 2013). Species adapted to conditions in Tidal Peace/Upper Charlotte Harbor, but are more sensitive to DO than sawfish, survive by moving to areas with acceptable DO (Fraser 1997). While NMFS does not expect the spatial extent of habitat for sawfish to be affected during periods of hypoxic events, the make up distribution of its prey species would become restricted (Bell et al. 2003, Bell and Eggleston 2005, Craig 2012, Brady and Targett 2013, Campbell and Rice 2014). Smaller individuals which do not range broadly (<1 km^2) would be most severely affected (Simpfendorfer 2003). The work of Campbell and Rice (2014) estimated 4 percent reduced growth in the fish species, spot, as a result of chronic hypoxia avoidance, suggesting that hypoxia also affects prey species for smalltooth sawfish.

> ***NMFS concludes that DO extremes under Tidal Peace River NNC-promoted eutrophy is likely to adversely affect the diverse and abundant forage function of smalltooth sawfish designated critical habitat by periodically changing the localized availability of prey species seeking refuge from affected areas during periods of low DO levels and hypoxia. The implications of this adverse effect to critical habitat will be evaluated in the Risk Characterization of this opinion.***
>
> ***NMFS concludes that DO extremes under Tidal Peace River NNC-promoted eutrophy are not likely to adversely affect the "red mangrove" essential feature of smalltooth sawfish designated critical habitat and is discountable because mangroves produce oxygen. These responses will not be evaluated further in this opinion.***

Indirect Effects of DO Extremes on Smalltooth Sawfish

The indirect effects of DO extremes on smalltooth sawfish result from adverse effects on the species they rely on along with reduced spatial extent of inhabitable area due to avoidance. Since the prey species and the red mangrove habitats relied upon by smalltooth sawfish are components of the designated critical habitat for this species, they were discussed in context of designated critical habitat above. NMFS previously found that sawfish are relatively tolerant to hypoxia, so a reduction inhabitable area is not expected due to DO extremes under NNC-supported eutrophication. The work of Campbell and Rice (2014) suggests that smalltooth sawfish growth would be indirectly affected through prey redistribution during low DO events (Wannamaker and Rice 2000, Eby and Crowder 2002, Craig 2012, Froeschke and Stunz 2012, Campbell and Rice 2014) and reduced quality of prey species due to chronic hypoxia (Campbell and Rice 2014). The species may suffer high mortality rates due to starvation considering the energy demands of rapid growth for young-of-year, which double in size in the first year of life

(Simpfendorfer et al. 2008) and the work of Lowe (2002) suggesting high starvation mortality in scalloped hammerhead shark pups, a species that also has high energy demands.

NMFS concludes that any effect of DO extremes under Tidal Peace River NNC-promoted eutrophy on the extent of inhabitable area for smalltooth sawfish is expected to be insignificant because of what is known about the relative hypoxia tolerance and compensatory behaviors of related elasmobranch species. These responses will not be evaluated further in this opinion.

NMFS concludes that the effect of DO extremes under Tidal Peace River NNC-promoted eutrophy is expected to result in indirect effects to the fitness and survival of smalltooth sawfish through reductions in growth due to chronic redistribution prey species to DO refugia from affected areas during periods of low DO and hypoxia. The population-level implications of this adverse indirect effect will be evaluated in the Risk Characterization of this opinion.

Infections and Disease

Information on infections in wild marine fish associated with eutrophication is not available. Such data are available for freshwater species, for example (Morozinska-Gogol 2011, Zargar et al. 2012, Budria and Candolin 2015) and marine fish farming (Diamant 2001, Taranger et al. 2015). While strong correlations between eutrophication and disease occur, our ability to establish a causal linkage is limited, with changes in host and vector abundance, infection resistance, alteration of pathogen virulence or toxicity, or the direct supplementation of pathogens among plausible mechanisms or components of etiology (Johnson et al. 2010). Detection of disease in the wild is confounded by increased predation on weakened and sick individuals. Disease may affect one or a subset of species in a community, potentially restructuring the types and abundance of species present.

Response to Infections: Smalltooth Sawfish and Smalltooth Sawfish Designated critical habitat

An assessment of the implications of Tidal Peace NNC on the prevalence of infections in smalltooth sawfish or prey species and consequent effects on the abundance and species composition of prey, that comprise their designated critical habitat represents an uncertainty in the assessment. Despite the uncertainties, there is sufficient evidence to warrant further consideration of such possible effects in the *Risk Characterization* of this opinion.

NMFS concludes that the effects of infections under Tidal Peace River NNC-promoted eutrophy may occur in smalltooth sawfish resulting in reduced survival and fitness. The population-level implications of this adverse effect will be evaluated in the Risk Characterization of this opinion.

NMFS concludes that infections in marine prey species that are essential features of the designated critical habitat of smalltooth sawfish may restructure the community of prey species but the effect is insignificant and not likely to adversely affect smalltooth sawfish because it is not expected to reduce overall forage availability. These responses will not be evaluated further in this opinion.

Smothering Associated with Algal Blooms

Eutrophication and associated algal blooms may result in sedimentation of dead algae and coating of benthos, plants, and animals. Sawfish are mobile and are not expected to be directly affected by smothering.

NMFS concludes that smothering by algal blooms under Tidal Peace River NNC-promoted eutrophy is discountable and not likely to adversely affect smalltooth sawfish because they are mobile and would not become coated with algae. These responses will not be evaluated further in this opinion.

Our discussion of smothering is therefore limited to effects on sawfish designated critical habitat.

Response to Smothering: Essential Features of Smalltooth Sawfish Designated Critical Habitat

Sawfish designated critical habitat in the Tidal Peace River centers on its function as juvenile nursery habitat. Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their function of providing refugia and diverse forage that facilitate recruitment of juveniles into the adult population. Sedimentation of algal biomass is not expected to appreciably alter the structural aspects of designated critical habitat (i.e., shallow euryhaline habitats and refugia). There is only anecdotal evidence for adverse effects of algal bloom mats on mangroves. Alga mats covered the breathing roots and lower leaves of mangroves during a bloom event in Gulf of Kachchh in Gujarat, India. The report did not include information on whether or not mangrove health was affected. Mangrove-associated fish species were not found dead and appeared to avoid the area (Adhavan et al. 2015). The diet of young-of-year juvenile sawfish in nursery habitats is expected to include mangrove-dependent small fish, crustaceans and shrimp (G. H. Burgess, University of Florida, pers. comm. to P. Shaw-Allen, NMFS OPR, June 14, 2016). All mobile species are expected to avoid algal bloom areas and associated low DO. The effects of DO extremes under the Tidal Peace NNC have already been evaluated, and the physical effects of smothering are not expected to affect prey species for smalltooth sawfish.

NMFS concludes that smothering of substrate by algal mats under Tidal Peace River NNC-promoted eutrophy is discountable and is not likely to adversely affect the diverse and abundant forage function or the "red mangrove" essential feature of designated critical habitat because the

smalltooth sawfish prey upon mobile species and effects of mangrove systems are not expected. These responses will not be evaluated further in this opinion.

4.2.6 **Response: Florida's Saturation-Based DO Criteria**

As explained previously, EPAs water quality guidelines are suitable for evaluating indirect effects through prey species and identifying exposures that are clearly harmful to aquatic organisms. The current EPA water quality guidelines for marine waters in the Virginian Province (Cape Cod to Cape Hatteras) are a chronic protective value for growth of fish of 4.8 mg/L and a lower limit for adult and juvenile survival of 2.3 mg/L (USEPA 2000). The guideline document indicates that the Virginian Province approach may be applied to other areas with appropriate modifications. FDEP adapted the approach to be specific to Florida species. The resulting Florida's DO criteria are saturation-based standards. They allow for DO concentrations ranging from 2.9-4.5 mg/L, not to be exceeded in more than 10 percent of daily averages over one year, 3.6-5.6 mg/L not to be exceeded in more than 10 percent of weekly averages over one year, and 3.8-6.2 mg/L not to be exceeded in more than 10 percent of monthly averages over one year. DO LC50s used in the derivation of the guidelines ranged from 0.43 to for Atlantic surfclam and 2.17 mg/L for the scaled sardine. Data used to derive the chronic criteria ranged from 1.34 for Gulf killifish to 5.86 for the say mud crab (FDEP 2013). The actual percent reduction in growth observed at these concentrations was not reported.

Extremes in DO content of water, typically insufficient DO, directly affect those species that obtain oxygen from water (sturgeon, sawfish, coral, and seagrass). Indirect effects to species that breathe air, like sea turtles, include adverse changes in prey species and the coral reef and seagrass habitats they rely upon. Florida's DO criteria are intended to provide for DO levels that reflect natural conditions and are presumed to be protective of aquatic organisms. The analysis is driven by whether Florida's DO criteria adversely affect ESA-listed species or essential features of their designated critical habitat using the risk hypotheses below:

- DO concentrations at FDEP saturation-based criteria will result in DO extremes that affect the survival of individuals

- DO concentrations at FDEP saturation-based criteria will result in DO extremes that affect the fitness of individuals through:
    - reduced survival of eggs, neonates, or breeding adults
    - reduced nursery area

- DO concentrations at FDEP saturation-based criteria will result in oxygen extremes that cause indirect effects to survival and fitness through:
    - reduction in habitat extent due to DO conditions
    - reduction in prey species

The individual risk hypotheses do not necessarily apply to each of species addressed in this opinion. For example; and sea turtles breathe air. Since these species will not be directly affected by DO concentrations in water, this section will only consider indirect effects risk hypotheses for such species. These considerations are summarized for the species groups in Table 16. Where the table contains a check mark, the risk hypothesis applies to the species in question. Where there is not a check mark, text in the table explains why the hypothesis is not applicable to that species.

RESPONSE OF ATLANTIC AND SHORTNOSE STURGEON TO DO CONDITIONS UNDER FLORIDA'S DO CRITERIA

Sturgeon basal metabolism, growth, consumption and survival are all very sensitive to changes in oxygen levels, which may indicate their relatively poor ability to oxyregulate. Based on bioenergetics and behavioral responses of young of the year juveniles aged 30 to 200 days, productivity losses occurred at oxygen saturation levels below 60 percent, which corresponds to 5 mg/liter at 25^{o}C (Secor and NiMitschek 2001, Niklitschek and Secor 2010). Accordingly, DO levels of 5 mg/L and above are considered protective of sturgeon (Kahn and Mohead 2010) and serve as our 'No Effect" standard.

The DO protections for spawning adults do not accommodate the year-round DO needs of the most sensitive life stage, young-of-year and early life stage individuals and could lead to year-class recruitment failures. Jenkins et al. (1993) found that juvenile shortnose sturgeon experienced relatively high mortality (86 percent) when exposed to DO concentrations of 2.5 mg/L. Older sturgeon (>100 days) could tolerate DO concentrations of 2.5 mg/L with <20 percent mortality, indicating an increased tolerance for lowered oxygen levels by older fish. Never-the-less, the occurrence of 20 percent mortality due to DO conditions, integrated with other mortality sources in the natural environment, would present a substantial impact to fitness. Campbell and Goodman (2004) reported a 24 h LC_{50} of 2.7 mg/L for 77-d old fish tested at 2 ppt salinity and 25° C; an estimated LC_{50} of 2.2 mg/L was obtained for 134-d old fish tested at 4.5 ppt and 26° C. According to this latter study, shortnose sturgeon may be more tolerant of low DO levels in high ambient water temperatures (i.e., low DO solubility). A test with 100-d old fish at 2 ppt salinity and a temperature of 30° C yielded a 24 h LC_{50} of 3.1 mg/L. The opposite trend was reported by Flournoy et al. (1992b) where shortnose sturgeon were less tolerant of low DO levels in high ambient water temperatures and show signs of stress in water temperatures higher than 28° C. The capture of sturgeon in St. Marys River waters with DO levels as low as 2.7 mg/L should not necessarily be taken to mean that these are tolerable conditions. For example, the individuals may have been unable to evade capture due to the physiological stress caused by those low DO conditions.

Florida's DO criteria in the St. Marys and St. Johns Rivers where sturgeon occur are well below observed DO saturation levels and are below DO concentration of 5 mg/L that is considered protective of sturgeon (Figure 29). Sturgeon historically have not been known to spawn in these waters, but recently young-of-year were captured in the St. Marys. Florida's DO criteria inlcude minima for the St. Johns for the months of February and March that are not to be below 53 percent saturation, and for the remaining months, not to be below 34 percent of the saturation in more than 10 percent of daily averages over a year (i.e., if there are 100 daily average observations in a given year, no more than 10 of these may be below 34 percent saturation). There is no restriction on whether these must be interspersed or are permissable in consecutive monitoirng events. By this reasoning, the standards would allow excursions in oxygen concentrations below 5 mg/L protection standard which could occur for prolonged periods of time depending how many observations and the distribution of the pemitted 3 percent of daily average observations are applied (Figure 29). Further daily averages could attenuate eutrophic diel fluctuations whichwuld be observed through continuous monitoring. However, in the southeast U.S., Atlantic sturgeon appear to spawning in the fall, so DO protections in February and March would not meet the goal of protecting the adult Atlantic sturgeon during spawning (J. Kahn, NMFS OPR, pers. comm. to P. Shaw-Allen, NMFS OPR, June 28, 2015).

While sturgeon have been captured in waters with DO concentrations as low as 2.7 mg/L, this is around or slightly below LC50s. DO concentrations below 5.0 are hypoxic, causing mortality in some cases and in others causing sublethal effects.

The marine saturation-based standards allow for DO concentrations ranging from approximately 2.9 to 6.0 mg/L. STORET data DO in waters off of St. Johns and St. Marys Rivers were not available. It is not unreasonable to expect that under the standards prolonged periods of low DO could occur.

Niklitschek and Secor (2010) demonstrated in controlled laboratory choice experiments that juvenile Atlantic and shortnose sturgeon select among water quality conditions for dissolved oxygen, salinity, and temperature that significantly optimize growth and metabolism. Both species actively avoided 40 percent oxygen saturation when given the option to move to water with 70 percent oxygen saturation. The strength of DO preference appears to be influenced by the severity of the low DO conditions and the resources available under these low DO conditions. For example when pinfish and Atlantic croaker were given the choice between vegetated experimental chambers at 1 mg/L DO and a nonvegetated chanblers with 2 mg/L DO, both species preferentially selected the chamber with higher DO conditions. Yet the preference for either DO condition was insiginificant when given the choice between vegetated habitat at 2 mg/L DO and nonvegetated habitat at 4 mg/L DO (Froeschke et al, 2012). Niklitschek and Secor (2010) noted that "...the minimum level of discrimination among water quality levels remains an unknown but relevant issue given the continuous nature of water quality conditions in the wild." In the wild, movement to preferred conditions are not unexpected (Niklitschek and Secor 2010, Schlenger et al 2013). Farrae et al. (2014) tracked seasonal movements of shortnose sturgeon in the Ogeechee River and its tributary the Canoochee River and found that during the summer months (June-August), the fish aggregated at the confluence of the two rivers, but moved freely about the estuary during the rest of the year. This seasonal pattern was repeated during June–September of both study years, 2008 and 2009, even though the water quality data suggested suitable habitat was available in over 80 percent of the estuary (temperature at 30^{o}C, dissolved oxygen at 4.0 mg/L, and salinity at 10 ppt). A similar seasonal pattern is evident for the St. Johns and St. Marys Rivers in Figure 28. It is reasonable to expect that, all other things being equal, sturgeon may avoid habitable portions of these rivers that are consistent with Florida's DO criteria, but given the freedom to move to DO optima, the DO conditions in and of themselves are not harmful to individuals. The indirect effects on the spatial extent of optimal or survivable DO conditions will be discussed separately.

NMFS concludes that DO conditions in the St. Johns and St. Marys Rivers under Florida's DO criteria may cause individual Atlantic and shortnose sturgeon to preferentially move to waters with higher DO concentrations, but DO conditions alone do not determine habitat preference. The direct effects of DO conditions under Florida's DO criteria on the survival and fitness of Atlantic and shortnose sturgeon individuals are therefore expected to be insignificant and not likely to adversely affect individuals. These responses will not be evaluated further in this opinion.

Indirect effects of DO Conditions Under Florida's DO Criteria on Atlantic and Shortnose Sturgeon

Indirect effects of Florida's DO criteria on Atlantic and shortnose sturgeon include influences of the criteria on the extent of usable habitat and effects to prey species. Niklitschek and Secor (2010) suggested that the selection behavior demonstrated in their choice experiments could, in the wild, periodically concentrate individuals to limited suitable or optimal habitats based on water quality conditions. This may increase trophic demand and vulnerability to predation, fishing or other deleterious factors within patches of water with optimal DO conditions. Florida's DO criteria allow persistent DO concentrations that do not support spawning. The acute and chronic DO thresholds for some of the expected prey items of shortnose sturgeon (e.g., *crabs, mysid shrimp, amphipods*) range from 0.7 to 3.0 mg/L (Sprague 1963, Poucher 1997, USEPA 2000, Bell and Eggleston 2005) and Florida's DO criteria are generally supportive of these conditions.

NMFS concludes that DO conditions in the St. Johns and St. Marys Rivers under Florida's DO criteria are expected to indirectly affect Atlantic and shortnose sturgeon through reduction in the extent of usable habitat because individuals are expected to avoid areas of low DO and Florida's DO criteria allow for extended periods of low DO concentrations in waters where these species occur (Figure 39). The population-level implications of this adverse indirect effect will be evaluated in the Risk Characterization of this opinion.

NMFS concludes that indirect effects of reduction in prey species on Atlantic and shortnose sturgeon due to DO conditions in the St. Johns and St. Marys Rivers under Florida's DO criteria would be insignificant

because their prey are more tolerant to low DO conditions than sturgeon are. These responses will not be evaluated further in this opinion.

Response of Smalltooth Sawfish to Florida's DO Criteria

The physiological tolerance and behavioral adaptations of smalltooth sawfish to low DO concentrations were discussed previously in context of the DO extremes under the Tidal Peace River NNC. Florida's DO criteria for marine waters and for the freshwaters of the Peninsula and Everglades Regions are between 38 and 56 percent saturation, with corresponding limits in duration. These saturation levels can result in DO concentrations ranging from 2.9 to 6.2 mg/L, which is consistent with the expected tolerance of smalltooth sawfish discussed previously.

NMFS concludes that responses of smalltooth sawfish to DO conditions under Florida's DO criteria will be insignificant and are not expected to result in adverse effects to survival and fitness of individuals based on what is known about the relative hypoxia tolerance and compensatory behaviors of other elasmobranch species. Sublethal energetic costs and behavioral changes for adapting to DO extremes are not expected to affect foraging behavior or predator evasion because the species uses both buccal and ram ventilation and can adapt to activity needs while compensating for low DO. These responses will not be evaluated further in this opinion.

Response of Essential Features of Designated Critical Habitat for Smalltooth Sawfish to DO Conditions Under Florida's DO Criteria

The conservation value of sawfish designated critical habitat centers on its function as juvenile nursery habitat. Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their function of providing refugia and diverse forage that facilitate recruitment of juveniles into the adult population. DO levels under Florida's DO criteria will not alter the structural aspects of designated critical habitat (i.e., shallow euryhaline habitats and refugia) and will not affect red mangrove, as they are aquatic plants with photosynthesizing leaves above water. Prey species of smalltooth sawfish would be affected by water quality and the DO regime. McFarlane et al. (2015) evaluated coastal fishery monitoring data to determine the influence of temperature, salinity, DO, and turbidity for 64 species of shoreline fishes, shrimps and crabs and found that those species with negligible effects dominate the estuarine community of the Gulf Coast of Texas. Any changes in the DO regime in designated critical habitat of the smalltooth sawfish due to compliance with DO criteria would avoid hypoxic conditions and the redistribution of prey. Compliance with the DO criteria may change the types of prey species present, but based on the work of McFarlane et al. (2015), NMFS does not expect this would reduce the overall availability of prey within designated critical habitat.

NMFS concludes that the effects of DO conditions under Florida's DO criteria on the diverse forage essential feature of designated critical habitat

for smalltooth sawfish are insignificant and not likely to adversely the species because shifts in community composition due to changes in DO conditions are not expected to alter the overall availability of prey species. These responses will not be evaluated further in this opinion.

NMFS concludes that the effects of DO conditions under Florida's DO criteria on the "red mangrove" essential feature of designated critical habitat for smalltooth sawfish are discountable and not likely to affect the species because mangrove are expected to withstand low DO concentrations. These responses will not be evaluated further in this opinion.

INDIRECT EFFECTS OF FLORIDA'S DO CRITERIA ON SMALLTOOTH SAWFISH

In our analysis of DO extremes under the Tidal Peace NNC, we determined that redistribution of prey species to refugia during periods of hypoxia are expected to affect the survival and fitness of neonate and young-of year smalltooth sawfish because of their small home ranges and high-energy demands. Compliance with Florida's DO criteria would avoid hypoxic events, and thus would not result in the prey redistribution that would affect survival and fitness of neonate and young-of-year smalltooth sawfish.

NMFS concludes that DO conditions under Florida's DO criteria are not expected to result in indirect adverse effects to smalltooth sawfish through reduced energy resources because compliance with these criteria would avoid hypoxic conditions that would redistribute prey into refugia.

RESPONSE OF ELKHORN AND STAGHORN CORALS, BOULDER, LOBED AND MOUNTAINOUS STAR CORALS, PILLAR CORAL, AND ROUGH CACTUS CORAL TO DO CONDITIONS UNDER FLORIDA'S DO CRITERIA

EPA concluded that Florida's DO criteria are likely to adversely affect the seven species of hard corals and the designated critical habitat designated for elkhorn and staghorn coral. The species that occur within Florida waters and are listed as threatened under the ESA are: elkhorn coral, staghorn coral, boulder star coral, lobed star coral, mountainous star coral, pillar coral, and rough cactus coral. EPA arrived at this determination based on direct testing of DO levels on coral health that indicated a concentration level of 4 mg/L or less results in an adverse impact to the corals tested (Haas et al. 2009, Haas et al. 2013, Haas et al. 2014). Exposure to initial DO concentrations at 4 mg/L declining overnight to 2 mg/L resulted in loss of most tissue and decline in photosynthesis rates within three days. Meanwhile corals were able to tolerate DO concentrations between 4 and 6 mg/L. This study did not account for other factors that may have influenced the DO threshold at which coral responded, such as the accumulation of ammonia and changes in pH within the volume of the study vessels used: mason jars equipped with stir bars. The results of the Haas et al. (2014) study is not consistent with a field study of coral metabolism at a reef flat site that was described as supporting "diverse and extensive coral communities."

Pre-dawn ambient DO levels at this reef, measured in 20 minute intervals declined from 4 to 1.7 mg DO/L between 1:00 am and 4:00 am (Ohde and van Woesik, 1999). Other studies of water quality effects that include DO conditions on coral typically evaluate adverse effects of combined stressors, including algal mat effects, reduced light penetration, and altered water pH and ammonia levels (Hauri et al., 2010, Martinez et al, 2012, Murphy and Richmond, 2016). Strong diurnal forcing (i.e., light stimulation of photosynthesis, hydrodynamic changes with the tides) are expected in coastal systems and differences in tidal exposure, water depth, and community metabolism result in strong spatial variability in temperature, pH, and DO along reefs. Back reefs (i.e., reef facing land) with their typically shallower water and longer residence times typically have larger variability in biogeochemical parametes than deeper, highly flushed forereefs (i.e., reef facing ocean). DO shifts are more dramatic closer to land and in shallower water (i.e., the reef flat) with daily shifts as high as 8 mg/L observed 10 meters from shore and 6 mg/L 25 meters from shore (Guadayol et al. 2014). Meanwhile along the slope of the forereefs (>25 meters from shore) daily DO fluctuations decclined from 3 mg/L to about 1 mg/L seaward.

Florida's marine saturation-based DO criteria under expected temperatures based on Figure 1 result in acceptable DO minima ranging from 2.9 to 6.2, with corresponding limits on the frequency at which the minima may be breached. The average weekly and monthly minima Florida's DO criteria for reef areas are 3.6 and 3.8 mg/L, respectively.

NMFS exposure analysis focused on STORET observations that were consistent with the worst case DO standard (42 percent saturation). STORET DO data for sampling events in the Florida Keys that met or exceeded the minimum standard of 42 percent saturation indicate DO concentrations ranging from 3.15 to 9.3 (average of 6.15, Table 14). This means that the criteria allow periodic excursions in DO concentrations to levels that resulted in significant tissue loss and declines in rates of photosynthesis over 3 days of exposure in the laboratory (Haas et al. 2014). However these DO levels were not associated with adverse effects in the field (Ohde and van Woesik, 1999, Guadayol et al. 2014).

NMFS concludes that, taken with expected variability in reef environments, responses of elkhorn and staghorn corals, boulder, lobed and mountainous star corals, pillar coral, and rough cactus coral to DO conditions under Florida's DO criteria are insignificant and not likely to adversely affect survival and fitness. While the criteria allow DO excursions at which significant tissue loss and decline in photosynthesis rates were reported in a laboratory study, these effects are not expected in the field based on reports of DO conditions consistent with the criteria in reef environments considered to be healthy. These responses will not be evaluated further in this opinion.

Response of Essential Features of Designated critical habitat for Elkhorn and Staghorn Coral to DO conditions under Florida's DO Criteria

The essential features specified in the designation of designated critical habitat for that staghorn and elkhorn coral (73 FR 72210) include substrate of suitable quality and availability to support successful larval settlement and recruitment, and reattachment and recruitment of fragments. These are physical characteristics that would not be affected by DO levels.

> ***NMFS concludes that DO conditions under Florida's DO criteria are not likely to affect designated critical habitat for elkhorn coral or staghorn coral because the essential features are physical properties of substrates that are not affected by ambient DO. These responses will not be evaluated further in this opinion.***

Indirect Effects of Florida's DO Criteria on Elkhorn and Staghorn Corals, Boulder, Lobed and Mountainous Star Corals, Pillar Coral, and Rough Cactus Coral

Indirect effects to coral species would include reduction in light penetration for photosynthesis and availability of plankton for feeding. Ambient DO concentrations would not affect light penetration. Information on the effect of DO concentration on zooplankton on predation was only available for predation by fish. The available data suggest that marine zooplankton are more tolerant of hypoxia than coral. A study of hypoxia effects on survival and egg production in *Acartia tonsa* was undertaken to evaluate the impacts coastal hypoxia on a copepod. The study exposure concentrations were equivalent to oxygen concentration of 1 mg/L representing hypoxic conditions and 2.14 mg/L, which was considered normoxic (Marcus et al. 2004). A review by Marcus (2001) indicates that mortality in zooplankton increases markedly at DO concentrations < 1.43 to 2.0 mg/L. These response thresholds are well below the expected worst-case concentrations under Florida's DO criteria.

> ***NMFS concludes that indirect effects of DO conditions under Florida's DO criteria on ESA-listed corals through impacts on plankton will be insignificant and are not likely to adversely affect the species because response thresholds for plankton are expected to be below the minimum expected DO concentrations under Florida's DO criteria. These responses will not be evaluated further in this opinion.***

Indirect Effects of Florida's DO Criteria on Green, Hawksbill, Loggerhead, Leatherback, and Kemp's Ridley Sea Turtles, and Sea Turtle Critical Habitat

Sea turtles are only expected to be indirectly affected by water DO levels through effects to prey species because they breathe air. Effects to prey species have been discussed in context of prey species for sturgeon and smalltooth sawfish and effects on seagrasses for green sea turtles in context of effects to Johnson's seagrass. Effects to forage availability for sturgeon and sawfish were not expected under Florida's DO criteria. This supports a conclusion that effects to prey species (see section 4.1.2) for omnivorous and carnivorous sea turtles would not indirectly affect loggerhead, hawksbill, leatherback and Kemp's ridley sea turtles.

> ***NMFS concludes that DO conditions under Florida's DO criteria will be insignificant and are not likely to adversely affect the survival and fitness of green, hawksbill, loggerhead, leatherback, and Kemp's ridley sea turtles through indirect impacts to prey because, while any associated change in DO conditions may restructure the community, overall availability of prey species is not expected to change. For the same reasons, DO conditions under Florida's DO criteria are not likely to adversely affect the essential feature of designated critical habitat for loggerhead sea turtles that is associated with prey availability: the sargassum that occurs along Florida's coastline. These responses will not be evaluated further in this opinion.***

RESPONSE OF NASSAU GROUPER TO DO CONDITIONS UNDER FLORIDA'S DO CRITERIA

Data on Nassau grouper response to low DO or DO extremes were not found. Juvenile goliath grouper, a closely related species, were reported to avoid DO concentrations of 3.0 mg/L or below (Koenig et al. 2007). DO concentrations in the waters where Nassau grouper would be expected to occur[21] meeting at least the 42 percent DO saturation standard ranged between 2.7 to 9.3 mg/L (Table 14) with the lowest concentrations occurring in Upper East Coast.

> ***NMFS concludes that responses of Nassau grouper to DO conditions under Florida's DO criteria is not likely to adversely affect the survival and fitness of individuals because the expected response threshold for a taxonomically related species, taken with the duration and frequency limits applied to Florida's DO criteria (i.e., no more than 10 percent of the daily average values shall be below), suggests that effects due to avoidance of areas during periods of low DO would be insignificant. These responses will not be evaluated further in this opinion.***

INDIRECT EFFECTS OF FLORIDA'S DO CRITERIA ON NASSAU GROUPER

Indirect effects of Florida's DO criteria on Nassau grouper include influences of the criteria on the extent of usable habitat and effects to prey species. The influence of low DO and anoxia on the behavior of prey species was described in context of DO extremes and hypoxia under eutrophic conditions promoted by the Tidal Peace River NNC. The DO criteria themselves are not expected to result in anoxia, but would result in redistribution of those prey species with response thresholds at about 3 mg/L. Unlike juvenile smalltooth sawfish, Nassau grouper are not expected to remain in limited home ranges.

[21] Southeast Coast - Biscayne Bay, Florida Keys, Indian River Lagoon, St. Lucie - Loxahatchee, and Upper East Coast

NMFS concludes that indirect effects to Nassau grouper due to the response of prey to DO conditions under Florida's DO criteria are insignificant and not likely to adversely affect the species because prey redistribution to DO refugia is not expected to result in significant reduction in the overall accessibility of prey for this species. These responses will not be evaluated further in this opinion.

4.3 Risk Characterization

The results of our exposure and response analyses concluded the following:

- For Florida's NNC Criteria:
  - The DO extremes under Tidal Peace River NNC-promoted eutrophy will result in indirect effects to the fitness and survival of smalltooth sawfish through reductions in growth due to chronic redistribution prey species to DO refugia during periods of low DO.
  - The DO extremes under Tidal Peace River NNC-promoted eutrophy is likely to adversely affect the diverse and abundant forage function of smalltooth sawfish designated critical habitat by periodically changing the localized availability of prey species seeking refuge from affected areas during periods of low DO levels and hypoxia.
  - The effects of infections under Tidal Peace River NNC-promoted eutrophy may occur in smalltooth sawfish resulting in reduced survival and fitness.
- For Florida's DO Criteria:
  - The DO conditions under Florida's DO criteria are expected indirectly affect Atlantic and shortnose sturgeon through reduction in the extent of usable habitat because individuals are expected to avoid areas of low DO and Florida's DO criteria allow for extended periods of low DO concentrations

The population and colony-level implications of these effects, and the associated uncertainty, are evaluated in this Risk Characterization.

4.3.1 Risk Characterization for the Tidal Peace River NNC

The risk analyses for FDEP NNC addresses the influence of DO extremes on smalltooth sawfish designated critical habitat and fitness due to forage availability. For clarity, we review the pathway by which our analysis arrived at this conclusion (Figure 33). Eutrophication is the consequence of, and has cascading effects upon, ecosystem biogeochemistry and community structure at numerous levels and through numerous pathways. The assumptions made in linking the monitoirng data we had representing the NNC (TN, TP, and Chl a observations, shapes with red borders in Figure 33) to population-level adverse effects requires linkages along the pathways illustrated (solid and dashed red lines). These linkages required informed assumptions along the pathways (i.e, shapes with purple borders in Figure 40) to indirect and direct effects to species. Each assumption introduces uncertainty in the assessment.

Pathways lacking monitoring data are shaded in gray. For example, turbidity data does not distinguish between the contributions of suspended mineral matter and contributions of algae under eutrophic conditions and data for microbial metabolism and macrophyte communities that can be associated with STORET monitoring stations and events are not available. Pathways having monitoring data, but eliminated by the analysis from further consideration, are indicated by dashed red lines and bold red "Xs" in Figure 33. For example, ammonia toxicity under the NNC was eliminated because ammonia levels in sampling events that were consistent with the Tidal Peace NNC were below concentrations expected to cause effects in smalltooth sawfish or their prey. The effects of algal biomass on benthic substrate was eliminated because sawfish and their prey are mobile/not substrate dependent and would not be smothered or significantly affected by smothered substrate. The pathway for algal toxins and disease combine a stressor that was eliminated during the exposure analysis (i.e., algal toxins) and a stressor for which a causal association with eutrophication had not been established (i.e., disease). The potential for effects due to algal toxins is eliminated because it is extremely unlikely that a bloom of *K. brevis*, the principal HAB species for the region, would reach the interior of Charlotte Harbor and be influenced by nutrient loads under the Tidal Peace NNC. Exposures to brevitoxin would therefore be discountable and not likely to adversely affect smalltooth sawfish. Meanwhile, a causal association between eutrophication and disease has not been established, so that pathway remains uncertain.

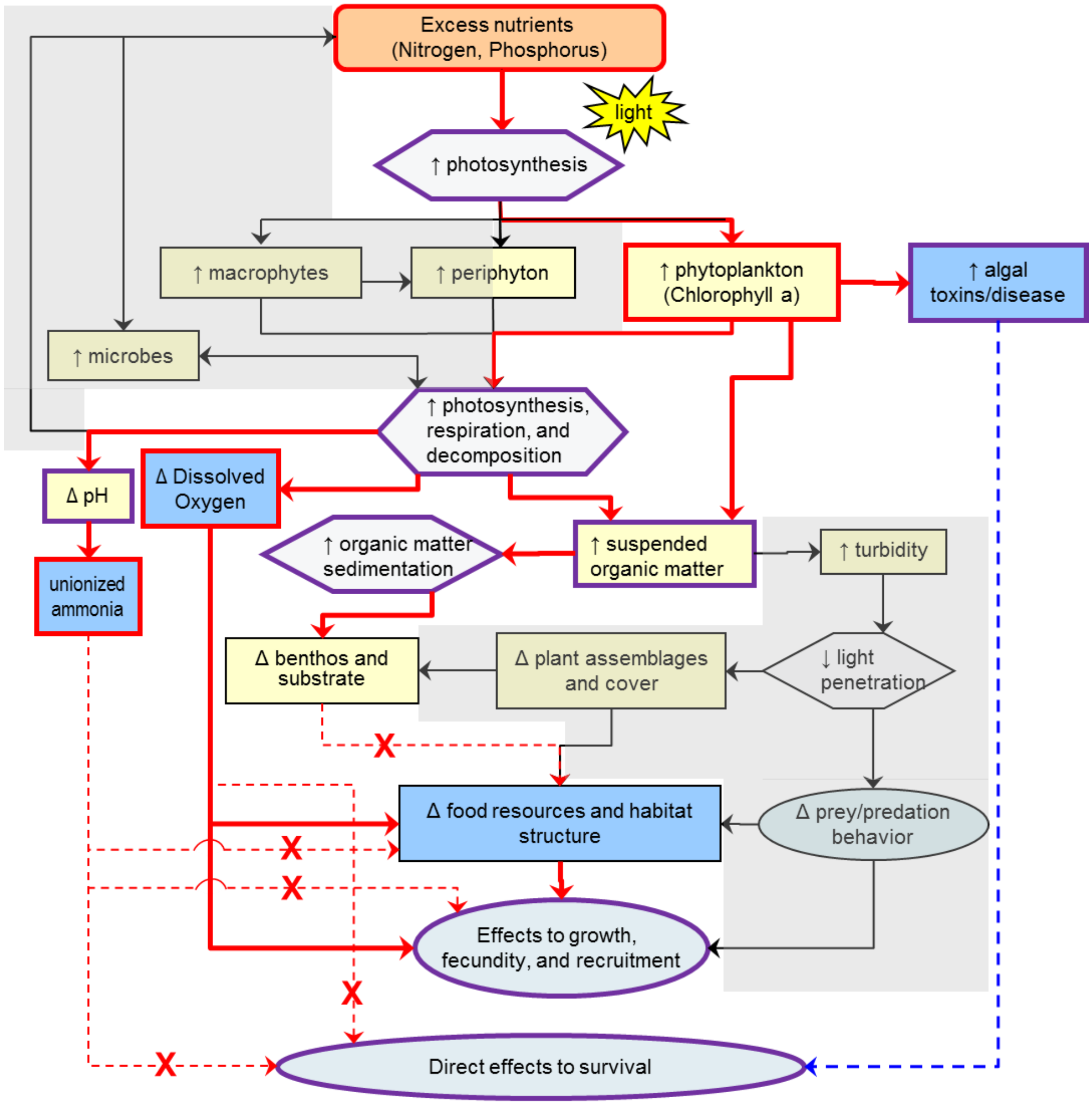

Figure 33. Pathways Linking Excess Phosphorus and Nitrogen to Adverse Effects on the Survival and Fitness of Smalltooth Sawfish.

While DO extremes under the Tidal Peace NNC are not expected to directly affect smalltooth sawfish, our path of supporting evidence (i.e., solid red lines in Figure 33) indicated indirect effects on individuals of DO extremes as well as effects on their designated critical habitat via effects on prey species, and prey species availability, which, under chronic conditions, affects the growth and survival of juvenile sawfish. So the implications of these effects on the smalltooth sawfish population are addressed here. We also characterize risk of eutrophication-mediated infection or disease given existing understanding of causal linkages. Finally, we evaluate the impact of data limitations on the conclusions made in this opinion.

POPULATION RISK OF EXTREMES IN DO CONCENTRATIONS FOR SMALLTOOTH SAWFISH

Our analysis indicated that DO extremes under the Tidal Peace River NNC are expected to indirectly affect smalltooth sawfish through chronic redistribution of prey species and consequent effects to survival and fitness due to reduced growth and risk of starvation in neonates and young-of-year individuals. Neonates and young-of-year individuals are vulnerable to these effects because of their small home ranges, greater site affinity, and high energy demands. This is indicated by the energy demands of rapid growth (Simpfendorfer et al. 2008), and the work of Lowe (2002) reporting high starvation mortality in scalloped hammerhead shark pups, a species that also has high energy demands.We conclude that population-level effects will result from the Tidal Peace NNC in that recruitment success from this estuary segment would be reduced.

> ***NMFS concludes that the effects DO extremes under the Tidal Peace NNC on temporal and localized prey distribution within this estuary segment is expected to reduce recruitment of smalltooth sawfish from the Tidal Peace River due to reduced growth and increased starvation mortality of neonate and young-of-year individuals residing in these waters. These effects will be integrated with the status of the species, baseline conditions, and future cumulative effects in the Integration and Synthesis section of this opinion.***

RISK CHARACTERIZATION FOR THE EFFECTS OF EXTREMES IN DO CONCENTRATIONS ON DESIGNATED CRITICAL HABITAT FOR SMALLTOOTH SAWFISH

Charlotte Harbor Estuary is important to the conservation of smalltooth sawfish. About half of the ISED reports within designated critical habitat are from the Charlotte Harbor estuary. The estuary represents about one quarter of the species' designated critical habitat, and the tidal segment of the Peace River segment accounts for 5 percent of that estuary. Physical and biological features identified in the designated critical habitat designation (74 FR 45353) are red mangroves and adjacent shallow euryhaline habitats, due to their function of providing refugia and diverse forage that facilitate recruitment of juveniles into the adult population.

> ***NMFS concludes that the effects DO extremes under the Tidal Peace NNC are expected to affect the diverse prey function of smalltooth sawfish designated critical habitat by periodically reducing the localized availability of prey species seeking refuge from affected areas within the segment during periods of low DO levels and hypoxia. These effects will be integrated with the status of the species, baseline conditions, and future cumulative effects in the Integration and Synthesis section of this opinion.***

RISK OF INFECTIONS CAUSED BY EUTROPHICATION PROMOTED BY TIDAL PEACE NNC

NMFS concluded that infections associated with eutrophication could be promoted by the Tidal Peace NNC and result in reduced survival and fitness. Infections in marine prey species may restructure the community by reducing or eliminating individual species, but are not expected to reduce forage availability for smalltooth sawfish. The absence of a verified causal relationship between eutrophic conditions estuaries and effects to marine species is a considerable uncertainty.

A review by Johnson, et al. (2010) describes plausible mechanisms for the indirect effects of nutrient enrichment on disease. Relating eutrophication with disease is often complicated with co-occurring environmental disruptions (e.g., development, water withdrawal, drought), the nonlinear, cyclical nature of nutrient impacts on environmental processes, and the influence of seasonal shifts. Mechanisms include changes in host density (e.g., fish densities in oxygenated refugia during hypoxic events), pathogen densities influenced by host densities and system turnover, and nutrient stimulation of bacterial pathogens, such as the heterotrophic bacteria associated with black band and yellow band disease in coral (Voss and Richardson 2006, Bruno et al. 2003). NMFS did find reports of disease among porpoises within Charlotte Harbor (Rowles et al. 2011) and dermo in oysters (Lafferty et al. 2015) associated with Tidal Peace River or Charlotte Harbor, but did not find reports of diseases in other marine life. Given the indirect and complicated etiology of diseases among wildlife, the evidence associating disease in marine life specifically with nutrients under the Tidal Peace River NNC at this time would be tenuous at best.

> ***NMFS concludes that eutrophy under the Tidal Peace River NNC, independent of other contributing factors (e.g., hydrologic changes, pathogen and host densities), is not expected to result in a detectable increase in infections or disease in smalltooth sawfish. The effects of eutrophication-associated disease under the Tidal Peace NNC on smalltooth sawfish and smalltooth sawfish designated critical habitat will not be evaluated in the Integration and Synthesis of this opinion.***

UNCERTAINTY ANALYSIS FOR THE NNC EVALUATION

The limited availability of data for most estuary segments also contributes uncertainty in our assessment of the FDEP NNC. The data available to test whether the TP and TN NNC would result in reference Chl-a levels (i.e., the Chl-a NNC) was heavily weighted towards Charlotte Harbor and the Tidal Peace River segment. While there were data gaps among the estuaries, taken together, the data for NNC-compliant events in these estuaries contrast markedly with Tidal Peace River sampling events that were compliant with the TN and TP NNC. The magnitude of the Tidal Peace TN and TP NNC relative to the NNC for other segments, taken with the frequency and magnitude of Chl-a responses in Tidal Peace TN and TP NNC-compliant sampling events, indicate that the Tidal Peace TN and TP NNC are set at levels that promote eutrophication. Meanwhile NMFS believes that the Chl-a profiles of TN and TP NNC-compliance sampling events in other estuary segments are more suggestive of background fluctuations. The Tidal Peace River's problematic TP and TN NNC derivation served to challenge the application of NNC to area wide annual means evidenced by the "as implemented" analysis illustrating the importance of Chl-a data.

4.3.2 Risk Characterization for Florida's DO Criteria

Florida's saturation-based DO criteria specify that no more than 10 percent of the daily average DO saturation values shall be below a region specific saturation level, with exceptions for specific waterbodies and times of the year. The criteria do not specify the distribution of daily averages, so theoretically excursions could occur within the same area and time period (e.g., all observed excursions occurring during the months of August and September). Based on this expectation and observed DO conditions under the saturation based criteria, population risk to sturgeon in the St. Johns and St. Marys Rivers must be evaluated.

POPULATION RISK OF FLORIDA'S DO CRITERIA ON ATLANTIC AND SHORTNOSE STURGEON

NMFS found that extended low DO conditions under Florida's DO criteria is expected to result in avoidance during periods of low DO, which results in a reduction in the extent of inhabitable area for Atlantic and shortnose sturgeon (Figure 28, Figure 29). This potentially affects growth (i.e., fitness) of migrants foraging in St. Marys and St. Johns Rivers and the fraction contribution of these waters to recruitment of juveniles into the adult population. The presence of migrants may lead to the species regaining breeding populations in the region (81 FR 36077)).

NMFS understanding of the extent to which sturgeon use these rivers and coastal waters is growing. The St. Marys was recently identified as a spawning river in the proposed critical habitat for Atlantic sturgeon. This is based on the capture of young-of-year Atlantic sturgeon in sampling efforts between May 19 and June 9, 2014, suggesting a slow and protracted recovery in the St. Marys (see 81 FR 36077). We expect sturgeon to occur in the St. Johns and St. Marys Rivers and Florida's saturation-based DO criteria will alow DO conditions that do not support survival of young-of-year sturgeon and likely juvenile migrants.

NMFS concludes that the extended low DO conditions under Florida's saturation-based DO criteria are expected to cause reduced recruitment from the St. Marys and St. Johns River through avoidance and the reduction in usable habitat for young-of-year Atlantic sturgeon in the St. Marys River and juvenile migrant Atlantic and shortnose sturgeon in the St. Marys and St. Johns Rivers. These effects on recruitment will be integrated with the status of the species, baseline conditions, and future cumulative effects in the Integration and Synthesis section of this opinion.

5 CUMULATIVE EFFECTS

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

Florida's population has grown steadily throughout the past several decades. From 2000 to 2012 Florida's population grew at an annual average rate of 1.5 percent, adding on average 259,600 residents annually (U.S. Census Bureau 2012). Florida is currently the fourth most populous state in the U.S. (~ 20 million residents) and is expected to continue to grow in the decades to come (FDOT 2014). In addition to the large and growing resident population, Florida is the top travel destination that attracts large numbers of tourists and vacationers each year. In 2015 an estimated 101.5 million people visited Florida, an increase of 19 percent since 2011 (Visit Florida official website http:// http://www.visitflorida.org/). General resource demands in Florida are expected to increase as a result of population growth (both resident and visitors), as well as the anticipated increase in the average standard of living in Florida. These demands are particularly high in coastal areas which have higher population densities and greater resource consumption compared to other parts of the state.

The future intensity of specific non-Federal activities in the action area is molded by difficult-to-predict future economy, funding levels for restoration activities, and individual investment decisions. However, due to their additive and long-lasting nature, the adverse effects of non-Federal activities that are stimulated by general resource demands, and driven by changes in human population density and standards of living, are likely to compound in the future. Specific human activities that may contribute to declines in the abundance, range, and habitats of ESA-listed species in the action area include the following: urban and suburban development; shipping; infrastructure development; water withdrawals and diversion; recreation, including off-road vehicles and boating; expansion of agricultural and grazing activities, including alteration or clearing of native habitats for domestic animals or crops; and introduction of non-native species which can alter native habitats or out-compete or prey upon native species.

Activities which degrade water quality will continue into the future. These include conversion of natural lands, land use changes from low impact to high impact activities, water withdrawals, effluent discharges, the progression of climate change, the introduction of nonnative invasive species, and the introduction of contaminants and pesticides. Under Section 303(c) of the CWA individual states are required to adopt WQSs to restore and maintain the chemical, physical, and biological integrity of the nation's waters. EPA must approve of state WQSs and this approval is subject to ESA section 7 consultation, which is the purpose of this Opinion. While some of the stressors associated with non-federal activities which degrade water quality will be directly accounted for in section 7 consultations between NMFS and EPA, some may be accounted for only indirectly, while others may not be accounted for at all. In particular, many non-point sources of pollution, which are not subject to CWA NPDES permit and regulatory requirements, have proven difficult for states to monitor and regulate. Non-point source pollution have been linked to loss of aquatic species diversity and abundance, coral reef degradation, fish kills, seagrass bed declines and toxic algal blooms (Gittings et al. 2013). Non-point sources of pollution are expected to increase in Florida as the human population continues to grow. Florida will need to address increases in non-point source pollution in the future to meet the state's approved WQS and designated water body use goals. Given the challenges of monitoring and controlling non-point source pollution and accounting for all the potential stressors and effects on listed species, chronic stormwater discharges will continue to result in aggregate impacts.

Bycatch of ESA-listed species in commercial and recreational fishing gear (discussed in the "Baseline" section) will also continue into the future. The 1995 Florida net ban outlawed the use of entangling nets (i.e., gill and trammel nets) and restricted other forms of nets (i.e., seines, cast nets, and trawls) in state waters (nine nautical miles from the Gulf coast and three nautical miles from the Atlantic coast). This law has greatly reduced bycatch of listed species in state managed fisheries (USFWS & NMFS 2009). Sawfish and sturgeon may still occasionally be captured incidentally in Florida's state waters in pound nets, fyke/hoop nets, fish traps, shrimp trawls, hook and line fisheries, and other allowed gears types. However, considering the gear restrictions and other fishing regulations, the overall impact of fisheries bycatch in Florida's state managed fisheries on ESA-listed species is expected to be relatively minor. NMFS is not aware of any proposed or anticipated changes in non-federally managed fisheries that would substantially change the impacts each fishery has on listed species and the analysis in this opinion.

Commercial and recreational vessel activity in Florida waters is likely to increase in the future with increases in population size, tourism, and average standard of living. As a result, the cumulative effects of vessel strikes involving sturgeon are also expected to continue to increase.

6 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and designated critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action from the *Risk Characterization* section of this opinion (Section 4.3) to the environmental baseline (Section 4.1.3) and the cumulative effects (Section 5) to formulate the agency's opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and designated critical habitat (Section 4.1.2).

The results of the risk characterization analysis concluded the following:

- For Florida's NNC criteria:
  - The DO extremes under Tidal Peace River NNC-promoted eutrophy will reduce recruitment of smalltooth sawfish because from this segment through reduced growth and increased starvation mortality of neonate and young-of-year individuals
  - The DO extremes under Tidal Peace River NNC-promoted eutrophy will result in changes in the "diverse prey" function of smalltooth sawfish designated critical habitat, that is important to the recruitment of individuals into the adult population, by periodically reducing the localized availability of prey species seeking refuge from affected areas during periods of low DO levels and hypoxia.
- For Florida's DO criteria:
  - The extended DO conditions under Florida's saturation-based DO criteria pose current and future effects to recruitment through avoidance and reduction in usable habitat by young-of-year Atlantic sturgeon and juvenile migrant shortnose sturgeon in the St. Marys and St. Johns Rivers.

The following discussions separately integrate the exposure profiles presented previously (status of the species, baseline, and cumulative effects) with the results of our risk characterization for each of the actions considered in this opinion.

6.1 Integration and Synthesis of Effects of the Tidal Peace NNC on Smalltooth Sawfish

Our evaluation of the FDEP NNC identified one estuary segment, the Tidal Peace River, where the NNC are expected to promote eutrophic conditions based on Chl-a responses at the TN and TP NNC. The question before us is whether indirect effects of the DO extremes resulting from eutrophic conditions promoted by the Tidal Peace NNC on the fitness of smalltooth sawfish reduce appreciably the likelihood of both the survival and recovery the species by decreasing its numbers, reproduction, or distribution.

The primary natural threat to smalltooth sawfish survival is the species' low reproductive rate. In the face of reduced population sizes, this biological parameter means that recovery, at best, will be slow, and that catastrophic perturbations can have severe consequences to recovery. Bycatch of adults is the primary reason for the decline and, ultimately, the listing of smalltooth sawfish as endangered in 2003 (NMFS 2009). Recruitment of juveniles into the adult population is essential for the survival of the species.

EPA lists TMDLs and an impaired status for approximately 775 km^2 of the Charlotte Harbor Estuary and 61 km^2 of creeks within the estuary are listed as impaired. Nutrient related impairments within the estuary include fecal coliform (287 km^2), DO (192 km^2), and Chl-a (490 km^2). Creeks are also listed for nutrient-related impairments: DO for 44 km and Chl-a for 28 km. These impairments form the baseline of the Charlotte harbor estuary and the tidal segment of the Peace River, and these impairments will persist until pollutant sources are controlled.

Our baseline information indicates that the Tidal Peace River is listed as nutrient impaired and TMDL development was planned, but did not proceed. While the the TP and TN NNC are lower than most TN and TP observations in the Tidal Peace River, they will not achieve the goal of attaining reference Chl-a and are not likely to restore the water to an unimpaired status, therefore adverse effects to juvenile smalltooth sawfish will still occur. Our cumulative effects assessment indicates that Florida continues to undergo rapid development. Non-point sources of pollution, including those contributing to existing nutrient impairments, are expected to increase in Florida as the human population continues to grow. The tidal segment of the Peace River is currently listed as nutrient impaired, baseline and future conditions, unchecked, are expected to sustain, if not promote eutrophic conditions. Adherence to TN and TP NNC for the Tidal Peace River will not change this. Our "perfect compliance" analysis indicates that the Tidal Peace TN and TP NNC are associated with elevated Chl-a concentrations and the "as implemented" analysis, using those very TN and TP NNC, identifies the tidal segment of the Peace River as nutrient impaired, but only based on excursions over the Chl-a NNC. The TP and TN NNC do not achieve the goal of attaining reference Chl-a.

Hypoxic events resulting from eutrophic conditions under the current NNC are expected to redistribute prey species for juvenile smalltooth sawfish occupying these waters. Simpendorfer et al. (2011) reported smalltooth sawfish in the nursery areas to have mean daily activity space of about 100-1000 m^2, depending on age. Chronic localized prey reductions adversely affect recruitment because neonates and young-of-year have restricted home ranges and are likely to suffer high mortality rates due to starvation during a period of rapid growth. Chronic localized reductions in prey availability due to hypoxic events under the Tidal Peace NNC will adversely affect smalltooth populations because the response of juveniles to these conditions are expected to reduce recruitment of juveniles from within this segment into the adult population. The designated critical habitat for this species focuses on nursery area and nursery function because juvenile recruitment is critical for the survival and recovery of the species, and the essential features and function of the designated critical habitat is evaluated separately in the *Integration and Synthesis*. The Charlotte Harbor portion of smalltooth sawfish nursery accounts for a quarter of the total nursery area designated as critical habitat for this species, with the Tidal Peace segment making up 50 km^2, or 1.1 percent of total nursery area. This segment is already kown to be nutrient impaired. The 2010 five year review (NMFS 2010) report that the population is stable with a slight increasing trend in abundance for smalltooth sawfish in the Everglades National Park from 1989 to 2004 (Carlson et al. 2007). Recent data from the ISED indicate increases in juvenile sawfish encounters in Florida Waters since 2010 (Figure 10). NMFS took the following into considerationin making its determination:

- the small area of nursery habitat affected;
- the apparent population stability, if not slight population increase despite an existing nutrient-impaired status of the Tidal Peace River;
- the expectation that the current NNC would improve, but not restore, nutrient conditions and associated eutrophy stressors; and
- the anticipated periodic and localized nature of DO extremes within the Tidal Peace River under the current NNC;

NMFS concludes that periodic and localized areas of low DO levels within the tidal segment of the Peace River under eutrophic conditions supported by its NNC are likely to adversely affect the survival and fitness of smalltooth sawfish using this portion of its nursery habitat, reducing recruitment from this segment into the adult population. Given the relative extent of the affected nursery area, the localized and temporary nature of periods of low DO within that area, data suggesting stable, if not increasing, trends in overall population despite an existing nutrient impairment within the Tidal Peace River, and the expectation that compliance with the NNC will improve present conditions, but not restore reference Chl-a), NMFS concludes that while take will likely occur, the anticipated effects do not rise to the level of jeopardizing the continued existence of the species. Minimization of incidental take associated with the anticipated effects of the Tidal Peace River TN and TP NNC, will be addressed by the RPMs specified under the ITS of this opinion.

6.2 Integration and Synthesis of Effects of the Tidal Peace NNC on Smalltooth Sawfish Designated Critical Habitat

The designated critical habitat for this species focuses on the function of nursery habitat to promote recruitment of juveniles into the adult population to mitigate loss through bycatch. The question before us is whether the effects of DO extremes under the Tidal Peace NNC rise to the level of adversely modifying or destroying the designated critical habitat for smalltooth sawfish when considered as a whole, through appreciably diminishing the nursery functions of the designation that promote recruitment of juveniles into the adult population. Specifically, these essential features are red mangroves and adjacent shallow euryhaline habitats, due to their function of providing refugia and abundant and diverse forage that facilitate recruitment of juveniles into the adult population to provide protection from predation and forage species to prevent starvation and predation mortality and to support growth.

Our baseline information indicates that the Tidal Peace River is listed as nutrient impaired and TMDL development was planned, but did not proceed. Our cumulative effects assessment indicates that Florida continues to undergo rapid development. Non-point sources of pollution, including those contributing to existing nutrient impairments, are expected to increase in Florida as the human population continues to grow. Additional anthropogenic impacts result from habitat degradation and loss, including degradation of nursery habitat.

Our analysis indicated that DO extremes apparent at the Tidal Peace River NNC would result in hypoxic events that would result localized reductions in prey availability, a component of designated critical habitat for sawfish juveniles. The sampling events that were consistent with the TP and TN NNC and did not achieve the goal of attaining reference Chl-a and would be expected to result in eutrophy and associated DO extremes, but potentially at a lower intensity than under the existing nutrient impairment. Charlotte Harbor (~1134 km^2) accounts for a quarter of the total designated critical habitat, with the Tidal Peace segment amounting to about 50 km^2 (about 4.4 percent of the estuary and 1.1 percent of the total designated critical habitat). Localized and periodic redistribution of prey species within the tidal segment of the Peace River during low DO or hypoxic events under the NNC would result in reduced forage availability in affected areas during periods of low DO. Considering the localized and temporal nature of DO extremes within the Tidal Peace River and the small fraction of overall critical habitat where these events may occur under NNC (i.e. Tidal Peace River makes up 1.1% of designated critical habitat area), such effects are not expected to appreciably diminish the overall value of the designated critical habitat for the conservation of the species. Further the occurrence of localized and periodic DO extremes within the tidal segment of the Peace River will not eliminate the essential features of the species' designated critical habitat. Red mangroves and adjacent euryhaline features will continue to be present and provide foraging habitat and protection from predation. Thus the NNC will not adversely modify or destroy designated critical habitat.

> ***NMFS concludes that, while the Tidal Peace NNC will result in low DO conditions that are expected to redistribute prey species, such effects are not expected to appreciably diminish the conservation value of critical habitat because effects are expected to be localized and occur periodically within the Tidal Peace River, which constitutes a small fraction of the designated critical habitat. The NNC will also not eliminate the presence of red mangroves and adjacent shallow euryhaline waters, which will continue to be present and provide foraging habitat and protection from predation. Minimization of incidental take associated with the effects of the***

Tidal Peace River TN and TP NNC, will be addressed by the RPMs specified under the ITS of this opinion.

In the *Exposure Assessment* of this opinion, NMFS concluded that based on the best available scientific information, the NNC for waters other than the Tidal Peace River are not expected to promote or support eutrophic conditions because, relative to the Tidal Peace Chl-a response levels, the Chl-a exceedances over the Chl-a NNC in sampling events with NNC-compliant TN and TP concentrations were suggestive of background fluctuations.

6.3 Integration and Synthesis of Effects of the DO Criteria on Atlantic and Shortnose Sturgeon

NMFS found that avoidance of extended low DO conditions under Florida's DO criteria amounts to a reduction in the extent of inhabitable area for Atlantic and shortnose sturgeon (Figure 39). This potentially affects fitness (i.e., growth) of migrants foraging in St. Marys and St. Johns Rivers. Our understanding of the extent to which sturgeon use these rivers and coastal waters is limited. The species status in Florida's waters is currently described as: "extirpated or nearly extirpated, but migrants are occupying northeast Florida rivers." While the species is considered extirpated, the presence of migrants may lead to the species regaining breeding populations in the region. Since future population effects may occur, NMFS will consider these effects in its integration and synthesis.

EPA lists a total of 210 km of waters impaired by DO out of the 470 km of stream and rivers it is tracking within the St. Marys watershed. These impairments are based on the original DO criteria of 5 mg/L. Under the revised criteria, minimum DO levels in St. Marys could range from 2.5 to 4.6 mg/L. For St. Johns, DO levels meeting the minimum 53 percent saturation standard for February and March ranged from 4.4 to 5.3 mg/L and DO levels at the 34 percent minimum DO saturation standard for the remaining months in St. Johns ranged from 2.6 to 3.5 mg/L. These minima are applied as "not to be exceeded in more than 10 percent of daily average values." Observation of Shortnose and Atlantic sturgeon migrants in St. Marys, taken with the effects analysis indicating the sensitivity of sturgeon to low DO levels, it is NMFS' opinion that the standards limit shortnose and Atlantic sturgeon use of the St. Marys and St. Johns Rivers. Both rivers at the southern limit of the species ranges and do not support spawning. It is uncertain whether the St. Johns River ever supported spawning. No reproduction of sturgeon in the St. Johns River has ever been documented, and no large adults have been positively identified. Given the marginal spawning habitat, it is possible that shortnose sturgeon never actively spawned in the St. Johns. The St. Marys was identified as a spawning river for Atlantic sturgeon based on the capture of young of year Atlantic sturgeon. Nine Atlantic sturgeon were captured in sampling efforts between May 19 and June 9, 2014. Captured fish ranged in size from 293 mm (young of year) to 932 mm (subadult). This is a possible indication of a slow and protracted recovery in the St. Marys. The continued existence of the south Atlantic DPS of the Atlantic sturgeon, at this time, is dependent on spawning and recruitment from the Ashepoo, Combahee, Edisto, Port Royal, and Savannah Rivers in South Carolina and the Ogeechee, Altamaha, and Satlilla rivers in Georgia (see 81 FR 36077).

> ***NMFS concludes that, while DO conditions under Florida's DO criteria for the St. Marys and St. Johns Rivers result in reduction in the extent of inhabitable area for young-of-year and migrant juvenile Atlantic and shortnose sturgeon, these effects are expected to be insignificant such that anticipated take does not rise to the level of jeopardizing the continued existence of the species because these rivers are not expected to contribute significantly to recruitment. Minimization of incidental take associated with the effects of the DO conditions under Florida's DO criteria will be addressed by the RPMs specified under the ITS of this opinion.***

7 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence or recovery of North Atlantic right whale, green, hawksbill, Kemp's ridley, Leatherback, or loggerhead sea turtle, smalltooth sawfish, shortnose or Atlantic sturgeon, Atlantic sturgeon, Nassau grouper, elkhorn, staghorn, rough cactus, pillar, lobed star, mountainous star, or boulder star coral, or Johnson's seagrass or to destroy or adversely modify designated critical habitat for the North Atlantic right whale, smalltooth sawfish, loggerhead sea turtle, elkhorn or staghorn coral, or Johnson's seagrass. NMFS anticipates take of neonate and juvenile smalltooth sawfish is expected to result from DO extremes resulting from eutrophic conditions under the Tidal Peace NNC and take of young-of-year and migrant juvenile shortnose and Atlantic sturgeon as a result of the DO criteria EPA approved for the St. Marys and St. Johns Rivers.

8 ITS

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

8.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR § 402.14 (i)(1)(i).). A "surrogate (e.g., similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take provided that the biological opinion or ITS: Describes the causal link between the surrogate and take of the listed species, explains why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and sets a clear standard for determining when the level of anticipated take has been exceeded." (50 C.F.R. § 402.14).

The proposed action is anticipated to cause incidental take of smalltooth sawfish, an ESA-listed species under NMFS' jurisdiction in Tidal Peace, River where the NNC are expected to promote or sustain eutrophic conditions. The proposed action is also anticipated to cause incidental take of Atlantic and shortnose sturgeon in the St. Johns and St. Marys Rivers due to the effects of DO conditions under Florida's DO criteria. These incidental takes are anticipated because EPA's action establishes water quality criteria that would result in avoidance behaviors and redistribution of prey species. The types of incidental take from the proposed action are likely to include the following:

For smalltooth sawfish:

- Reduced recruitment to the adult population dues to reduced growth and potential starvation of juvenile smalltooth sawfish due to chronic redistribution of forage species to DO refugia in response to periods of low DO under eutrophy supported by the Tidal Peace River Numeric Nutrient Criteria.

For Atlantic and shortnose sturgeon:

- Periodic reduced spatial extent of usable habitat due to avoidance of areas within the St. Johns and St. Marys Rivers during periods of low DO.

Incidental take due to this action cannot be accurately quantified or monitored as a number of individuals because the action area includes all coastal and many of the estuarine waters within the state of Florida and data do not exist that would allow us to quantify how many individuals of each species and life stage exist in affected waters, especially considering that the numbers of individuals vary with the season, environmental conditions, and changes in population size due to recruitment and mortality over the course of a year. In addition, currently we have no means to determine which deaths or injuries in fish populations across the entire range of the listed species covered in this opinion are due to the water quality under Florida criteria and standards versus other environmental stressors, competition, and predation.

Finally, the waters where incidental take is likely to occur do not meet the NNC and DO criteria at this time, and it would be impossible in these waters to estimate which portion of the take is due to what is allowed under the criteria, and which portion is due to the exceedance of the criteria. Because we cannot determine the amount of take, we will use a habitat quality measure for the extent of take as a surrogate for the amount of take.

The following paragraphs identify the surrogates that NMFS will use for the amount of incidental take anticipated due to the proposed action.

1) The surrogate for incidental take of smalltooth sawfish is Chl-a. The role of Chl-a concentration as an indicator of nutrient condition is first discussed in section 2.1 of this opinion as part of the rationale behind deriving hierarchical NNC. Figure 5 and the associated narrative in the *Stressors of the Action* section (Section 4.1.1) of this opinion illustrate the relationship of Chl-a within the cascade of effects resulting from excess nutrients, that is, eutrophication and associated stressors on smalltooth sawfish such as DO extremes. Incidental take for RPM #1 is Chl-a conditions during two phases: the TMDL development and implementation phase followed by the recovery trajectory phase under the TMDL. This accommodates the expected lag time in recovery from nutrient impaired status, as described in this opinion's discussion of TMDL-based estuary NNC (Section 4.2.1) and illustrated by the biological responses for recovery of Danish estuaries in Figures 8 and 9 of Riemann et al (2016), and Tampa Bay in Figure 10 of Greening et al (2014).

   Phase 1: TMDL development and initial implementation. the period prior to approval of a TMDL for Tidal Peace River,, and up to five years after its implementation of the TMDL, the incidental take of smalltooth sawfish is Chl-a conditions in Tidal Peace River that are consistent with the data evaluated in this opinion. The thresholds for determining when the level of anticipated take has been exceeded are:

   - individual Chl-a observations larger than one standard deviation over the mean of individual Tidal Peace River Chl-a observations evaluated in this opinion (33 µg/L), and
   - area wide annual mean Chl-a levels are larger than one standard deviation over the mean of the annual means observed in this opinion for Tidal Peace River (18 µg/L).

   This reflects the existing impaired condition, but limits the duration of the impaired condition and ensures that conditions do not worsen.

   Phase 2: Recovery trajectory. Five years and afterward from the implementation of the Tidal Peace River TMDL, the incidental take of smalltooth sawfish is the trend in Chl-a conditions using methodology appropriate[22] to the monitoring data obtained by FDEP according to the USGS guidance: *Statistical Methods in Water Resources Techniques of Water Resources Investigations* (Helsel and Hirsch 2002). The

[22] The appropriate method to apply to a set of data is determined by the quantity and quality of the data, the amount of variability, the presence of outliers and extreme values, and the distribution of observations . The USGS guidance (Helsel and Hirsch 2002) outlines the identification and application of appropriate methodology for the analyses of trends in water quality parameters.

threshold for determining when the level of anticipated take has been exceeded is Chl-a conditions indicating that implementation of the TMDL is not bringing about a decreasing trend (i.e., reducing eutrophy).

2) The surrogate for Chl-a conditions in estuaries evaluated in this opinion other than the Tidal Peace River is Chl-a levels among TN and TP NNC-compliant sampling events that are consistent with conditions evaluated in this opinion. Since each estuary segment has its own Chl-a criterion, the metric for exceeding take for RMA #2 is expressed in terms of the ratio of an observed Chl-a concentration to its respective Chl-a criterion (Chl-a quotient). The incidental take threshold will be exceeded if individual Chl-a quotients are larger than one standard deviation over the mean of the Chl-a quotients observed in TN and TP NNC-compliant sampling events evaluated in this opinion. This threshold is 1.7 times the Chl-a criterion, reflecting an expected maximum Chl-a background variability for cases where both TN and TP are compliant with their NNC. The threshold ratio is one (1.0) for the area wide annual mean Chl-a quotients among TN and TP NNC-compliant sampling events. Given the data gaps in the analyses, it is prudent to verify the conclusion that the NNC are maintaining reference Chl-a levels.

3) The surrogate for incidental take of Atlantic and shortnose sturgeon is DO, and incidental take are DO conditions under two phases for RPM #3: Prior to reassessment and revision of DO criteria for the protection of Atlantic and shortnose sturgeon in the St. Marys and St. Johns Rivers and after establishment of DO criteria for the protection of Atlantic and shortnose sturgeon in the St. Marys and St. Johns Rivers.

Phase 1: Reassessment of the St. Marys and St. Johns River DO criteria. For up to 3 years pending reevaluation and revision of the DO criteria, the surrogate for incidental take of Atlantic and shortnose sturgeon is DO conditions that are compliant with the current criteria but below the no effect level of 5 mg/L for juvenile sturgeon. The 5 mg/L no effect level for DO is protective of high mortality rates under hypoxia, as discussed in section 4.2.6 of this opinion. These conditions are illustrated figure 27 and 28 of this opinion depicting continuous monitoring data from St. Johns River at Dames Point and St. Marys River at Kingsland GA. The threshold for determining when the level of anticipated take has been exceeded is the degree and temporal extent of DO conditions below levels indicated by the monitoring data in figures 27 and 28. This surrogate limits the duration of the take and ensures that conditions do not worsen.

Phase 2: After reevaluation and revision of the current DO criteria for the St. Marys and St. Johns Rivers. Incidental take under Florida's revised DO criteria is not anticipated if Florida revises the criteria for waters where shortnose and Atlantic sturgeon occur to match the no effect level of 5 mg/L or if Florida provides an analysis that adequately supports a value other than 5 mg/L as protective of juvenile shortnose and Atlantic sturgeon.

The surrogates described above are quantifiable and may be monitored, serving their intended role as clear reinitiation triggers. They are proportional to the amount of take of the species because the greater the extent of the impaired condition, the greater the take of the species.

For the Tidal Peace River, our analysis was based on Chl-a levels indicating eutrophy under conditions that were compliant with the existing TN and TP NNC. An increase in the extent or frequency of Chl-a excursions over Chl-a NNC would indicate eutrophic conditions that are expected to result in additional take due to the adverse effects of hypoxia as described in this opinion. In addition, a delay in implementation of the TMDL would have the effect of extending the occurrence of DO excursions to hypoxic conditions under the existing NNC and would result in additional take of ESA-listed species. These conditions would trigger reinitiation.

Existing data for other estuary segments did not indicate elevated Chl-a under their respective TN and TP NNC. With the exception of the Tidal Peace River, our overarching conclusion on Florida's NNC based on monitoring data, TMDLs, and remote sensing of Chl-a are not expected to promote or sustain eutrophic conditions, and therefore are not anticipated to adversely affect the ESA-listed species considered in this biological opinion. The NNC for these waters were not evaluated further in this opinion because the data in hand at the time of the analysis did not indicate eutrophicconditions would be promoted or supported. However, the current monitoring data are more limited, and in some instances absent, for estuaries other than Tidal Peace River. Additional data for these waters will be generated as Florida's strategic monitoring plan is carried out. An increase in the extent or frequency of Chl-a excursions over Chl-a NNC under nutrient conditions that are compliant with the TN and TP NNC would indicate the existing TN and TP NNC for these segments support eutrophy, and associated hypoxia, that is expected to result in take due to the adverse effects of hypoxia as described in this opinion. This would trigger reinitiation.

Our analysis of DO conditions for St. Johns and St. Marys River under the DO criteria indicated DO excursions below protective level of 5 mg/L for shortnose and Atlantic sturgeon using these waters. DO conditions under the DO criterion that are consistent with the analysis in this opinion and indicate an increase in the extent or frequency of excursions below the protective level or 5 mg/L for sturgeon species is expected to result in take. In addition, a delay in reassessment and revision of the DO criteria to levels protective of sturgeon in St. Johns and St. Marys Rivers would have the effect of extending the occurrence of DO excursions below protective levels and would result in additional take of ESA-listed species. These conditions would trigger reinitiation.

8.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of designated critical habitat.

8.3 RPMs

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

These RPMs are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species. If, during the course of the action and subsequent monitoring, incidental take is exceeded, as would be indicated by discover that NNC for other estuary segments where ESA-listed species occur promote elevated Chl-a, such incidental take represents new information requiring reinitiation of consultation and review of the RPMs provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with NMFS the need for possible modification of the RPMs.

NMFS believes all measures described as part of the proposed action, together with the RPMs described below, are necessary and appropriate to minimize the likelihood of incidental take of ESA-listed species due to implementation of the proposed action.

1) EPA must request that FDEP develop and implement a TMDL for the tidal segment of the Peace River.
2) EPA must coordinate with NMFS to evaluate the monitoring data FDEP collects under its Strategic Monitoring Plans for instances where the TN and TP appear to promote elevated Chl-a.
3) EPA must request that FDEP reassess and revise DO criteria for the St. Marys and St. Johns Rivers to ensure that daily average minima do not occur at a frequency or duration that would discourage residence by migrant sturgeon.

8.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the EPA must comply with the following terms and conditions, which implement the RPMs described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR 402.14 (i). These terms and conditions are non-discretionary. If EPA fails to ensure compliance with these terms and conditions and their implementing RPMs, the protective coverage of section 7(o)(2) may lapse.

The following terms and conditions implement reasonable and prudent measure 1:

> Within the next 3 months, EPA will write a letter to the FDEP, and copy NMFS, requesting that-FDEP begin development of a TMDL for the Tidal Peace River segment. EPA will request that FDEP initiate the TMDL development within 6 months of receipt of EPA's letter with an anticipated completion of the final TMDL within 2.5 years of initiation. If FDEP does not initiate TMDL development and complete a TMDL for the Tidal Peace River within 3 years of receipt of EPA's letter, EPA will pursue options for completion of the TMDL.

The following terms and conditions implement reasonable and prudent measure 2:

> EPA will coordinate with NMFS, starting one year after signature of this opinion and continuing annually upon request by NMFS until all basins in Florida have been assessed for NNC under the 5 year Strategic Plan or until a mutually agreed upon termination by EPA and NMFS, to support NMFS's review and evaluation of monitoring data from waters where ESA-listed species and designated critical habitat under NMFS' jurisdiction occur. These data will include, at a minimum, date, time, monitoring station identification, monitoring station coordinates in decimal degrees, Chl-a, TP, TN (or constituent nitrogen species), and DO. The monitoring data will be used to proactively identify emerging or masked issues and evidence of eutrophy (i.e., elevated Chl-a) under TN and TP levels that are compliant with NNC. In the event that an analysis indicates eutrophic conditions under the NNC, EPA will coordinate with NMFS to communicate these concerns and make recommendations to the state regarding the criteria and how to bring the waterbody back into compliance with the Chl-a NNC.

The following terms and conditions implement reasonable and prudent measure 3:

> Within the next 3 months, EPA will write a letter to FDEP, and copy NMFS, requesting that FDEP consider updated scientific information regarding the expected presence of Atlantic and shortnose sturgeon juveniles in the St. Marys River, the designated critical habitat proposed for Atlantic sturgeon in the St. Marys River [81 FR 36077] and the presence of migratory sturgeon in the St. Johns River along with additional scientific information contained in the biological opinion regarding the State's freshwater DO criteria and their implications for these species to ensure that daily average minima do not occur at a frequency or duration that would discourage residence or use of these habitats by Atlantic and shortnose sturgeon. EPA will request that FDEP complete reassessment of these DO criteria, and any corresponding revisions that result, within three years from the date of EPA's letter. If FDEP does not conduct this reassessment and make corresponding revisions, if necessary to protect Atlantic and shortnose sturgeon, EPA will conduct an analysis to decide if further action under the CWA is needed.

8.5 Conservation Recommendations

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

The following conservation recommendations would provide information for the refinement of water quality criteria for the protection of ESA-listed species under NMFS' jurisdiction:.

- Recommend permit conditions to FDEP or recommend that FDEP amend its turbidity limits to include requirements that a mixing zone must not block or otherwise impede access the St. Marys or St. Johns Rivers by migrating Atlantic and shortnose sturgeon.
- Coordinate with NMFS, when requested, to support NMFS's review and communication with FDEP about the State's conclusions regarding possible future 303(d) listings for chlorophyll a in segments where threatened and endangered species and/or their designated critical habitat occur.
- Conduct or support research expanding scientific understanding of DO regimes in coral ecosystems and interaction of water quality parameters (e.g., salinity, temperature, light penetration, DO, etc.) on disease, bleaching, resilience to injury, and anticipated consequences of climate change.
- Conduct or support research expanding scientific understanding of the linkages between eutrophication in marine ecosystems and disease.
- Conduct or support research expanding scientific understanding of the use of the St. Johns and St. Marys Rivers by migrant Atlantic and shortnose sturgeon and identify ways to restore the species to these waters.

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

9 Reinitiation of Consultation

This concludes formal consultation for EPA's approval of Florida's NNC, DO Criteria, and Turbidity Limits. As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect ESA-listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or designated critical habitat that was not considered in this opinion, or (4) a new species is ESA-listed or designated critical habitat designated that may be affected by the action.

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APPENDIX A: SUMMARY OF THE CLEAN WATER ACT (CWA)

The stated objective of the CWA is to "…restore and maintain the chemical, physical and biological integrity of the Nation's waters." The Act further states: "…it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited." Identification of toxic pollutants in toxic amounts is provided for by §304 (a)(1) of the CWA which requires that EPA develop National Water Quality Criteria (WQC) that accurately reflect the latest scientific knowledge about the effects of priority chemical pollutants on aquatic life. These criteria represent numeric limits on the amounts of specific pollutants that can be present in waters of the United States without causing "harm"[23] to aquatic life. The WQC were developed for the 120 priority pollutants listed in section 307 of the CWA and an additional 47 non-priority pollutants. These WQC are applied through the basic framework of programs, such as NPDES, established by the CWA to control sources of pollutants that may impair or threaten water quality. The recommended WQC are intended to be protective of the majority of aquatic communities in the U.S. Individual States may adopt these criteria directly or they may adjust them, with EPA's approval, to suit State needs or designated uses for specific bodies of water.

The EPA's *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses (*National Guidelines[24])(Stephen et al. 1985) describe an objective way of deriving national criteria intended to provide an appropriate level of protection for aquatic organisms. Aquatic life criteria are based on the National Guidelines and consist of two metrics: 1) The Criterion Maximum Concentration (CMC) intended to protect against severe acute effects; and 2) The Criterion Continuous Concentration (CCC) intended to protect against longer-term effects on survival, growth and reproduction. The acute criterion limits peak exposures by requiring that 1-hour averages of exposure concentrations not exceed the CMC more often than once in three years on average. The chronic criterion limits more prolonged exposures by requiring that 4-day averages of exposure concentrations not exceed the CCC more often than once in three years on average. The CMC and CCC are calculated using endpoints derived from standard toxicity tests in which organisms are exposed to a range of concentrations of a toxicant. These tests use standard surrogate species to represent large groups of taxa. For example, rainbow trout (*Oncorhynchus mykiss*) are considered acceptable surrogates for coldwater fish (Dwyer, 1995).

The results of the exposures are then analyzed to produce standardized endpoint values described in the following paragraphs. The acute criterion is based on available acute endpoint values:

[23] For the purposes of the CWA, EPA defines the term "harm "to include increased mortality or reductions in growth or reproduction as well as the accumulation of harmful levels of toxic chemicals in the tissues of aquatic organisms that may adversely affect consumers of such organisms. This usage should not be confused with how NMFS has defined "harm" for the purposes of the ESA.

[24] http://water.epa.gov/scitech/swguidance/waterquality/standards/criteria/aqlife/upload/85guidelines.pdf

median lethal concentrations (LC_{50}[25]) or median effect concentrations (i.e., cocnetration at which half of exposed individuals die) for severe acute effects such as immobilization from acute toxicity tests (48- to 96-hours long) meeting certain data quality requirements. To compute an acute criterion, EPA's *National Guidelines* require that acceptable acute values be available for at least eight families to address a range of taxonomic diversity. These minimum data requirements include three vertebrates (a salmonid, another bony fish and another vertebrate) and five invertebrates (a planktonic crustacean, a benthic crustacean, an insect, a species from a phylum other than *Chordata* or *Arthropoda* and a species from another order of insect or another phylum not already represented.

For each genus, the EPA calculates a Genus Mean Acute Value by first taking the geometric mean of the available acute values within each species (Species Mean Acute Value, [SMAV]) and then the geometric mean of the SMAVs within the genus. The Genus Mean Acute Values are then ranked and a regression analysis is performed on the four most sensitive Genus Mean Acute Values resulting in an estimate of the concentration of the pollutant corresponding to a cumulative probability of 0.05 (the 5^{th} percentile of the species sensitivity distribution). This is the Final Acute Value (FAV). When appropriate, the EPA may lower the FAV to equal the SMAV of an important, sensitive species. The FAV is then divided by two to derive the acute CMC value that is expected to fall below where any acute adverse effects to organisms are observed.

Chronic tests for invertebrate species are required to include the entire life-cycle, but for fish species partial life-cycle and/or early life-stage tests may be accepted. Sufficient data for chronic toxicity are rarely available for deriving criteria as described for acute criterion above. When such data are available, the CCC is calculated in the same manner as the FAV. If chronic values are available for at least one fish, one invertebrate and one acutely sensitive species, then the chronic criterion may be estimated by dividing the FAV by a Final Acute to Chronic Ratio based on the available paired acute and chronic values. A chronic criterion may not be calculated if fewer chronic values are available. Alternatively, the chronic criterion may be based on plant toxicity data if aquatic plants are more sensitive than aquatic animals.

The Use of EPA Water Quality Guidelines in this Opinion

Before proceeding with an analysis of effects, the appropriate use of EPA's water quality guidelines in a opinion must be clearly understood. These guidelines are derived using a methodology intended to protect most aquatic ecosystems under most circumstances (Stephen et al. 1985). The guidance states:

> *"Because aquatic ecosystems can tolerate some stress and occasional adverse effects, protection of all species at all times and places it is not deemed necessary for the derivation of a standard. If acceptable data are available for a large number of*

[25] LC_{50} = concentration at which 50% of exposed organisms die.

> *appropriate taxa from an appropriate variety of taxonomic and functional groups, a reasonable level of protection will probably be provided if all except a small fraction of the taxa are protected, unless a commercially or recreationally important species is very sensitive."*

EPA's water quality guidelines clearly cannot be assumed to be protective of lethal and sublethal effects to threatened and endangered species. A number of studies proposed correction factors based on the sensitivity of threatened and endangered species relative to common laboratory species (Sappington et al. 2001, Besser et al. 2005, Dwyer et al. 2005a, Dwyer et al. 2005b). These adjustment factors do not account for how the loss of one individual affects the persistence of the population it belongs to. In addition, laboratory studies used to derive the guidelines do not address many sublethal responses that are important to survival of individuals in the wild such as swimming speed, predator/prey detection, and predator avoidance. It is also important to note that most chronic toxicity data studies were designed to identify the tested concentration that does not differ significantly from the control (i.e., NOEC), and the lowest tested concentration that does differ significantly from the control (i.e., LOEC). The resulting chronic values and their biological relevance are highly dependent on the statistical resolution provided by the study design. A study with few exposure concentrations and few replicates may only have the statistical power to result in a NOEC reflecting a 30 percent decline in reproduction or growth in the tested species. As a result, a relatively high underlying "level of effect" may be associated with NOECs, LOECs, and the associated "Minimum Acceptable Toxicant Concentration" which are the geometric mean of the NOECs and LOECs. For example, Suter et al. (1987) reported that the calculated Minimum Acceptable Toxicant Concentrations for fish fecundity, on average, corresponded to a 42 percent level of adverse effect. Some workers addressed these shortcomings by using regression to calculate point estimates, such as the EC_{10}, where such data are suitable. This approach may not be appropriate when there is a high amount of variability in the data.

For opinions, EPA water quality guidelines must be used with caution. Where they can be applied, they are useful for:

- Evaluating indirect effects to ESA-listed species through effects to prey species, provided new data do not suggest the guidelines need adjustment; and
- Identifying exposures that would be harmful to any exposed species.

National Pollution Discharge Elimination System (NPDES)

Among the programs established by the CWA to control sources of pollutants, Section 402 of the CWA authorizes the EPA to issue permits for the discharge of pollutants under NPDES. Permits establish effluent limitations that are designed to prevent the discharge of toxic pollutants in toxic amounts such that pollutant levels in receiving water do not violate WQC or other permit-specific standards. An NPDES permit is required for entities that discharge pollutants from a point source on, over or near waters of the United States. An individual permit is specifically tailored to an individual discharger, while a general permit covers multiple dischargers within a specific category. According to the NPDES regulations (40 CFR l22.28), general permits like the PGP may be written to cover categories of point source discharges that have common elements. General permits may only be issued to dischargers within a specific geographical area. This allows EPA to cover a large group of individual without putting forth the resources necessary to review applications and issue permits on a case-by-case basis. When developing and issuing general NPDES permits, the EPA generally collects data to demonstrate that a category of dischargers has enough similar attributes to warrant a general permit, such as:

1. The number of dischargers or facilities to be authorized.
2. Any similarities in production processes or activities among dischargers.
3. Any similarities in the pollutants to be discharged among dischargers.

The EPA then develops the draft general permit and fact sheet and makes it available for public comment. After the public comment period, EPA addresses the comments and makes any necessary changes before the final general permit is issued. After issuance of the final general permit, entities that wish to be authorized under the general permit may submit an NOI to the EPA. The EPA then has the authority to request additional information. After review of the additional information, the applicant is notified either that their planned activities are authorized under the general permit or that they must apply for an individual permit.

The EPA is authorized to directly implement the NPDES program or to authorize States, Territories or Tribes to implement all or parts of the national program. Any State, Territory or Tribe may seek the authority to implement the NPDES program. The EPA no longer administers NPDES permits or administers any parts of this program once a State, Territory or Tribe is authorized to conduct these activities. The EPA does reserve the right to review each permit issued by the State, Territory or Tribe and may object to elements that conflict with Federal requirements. Once a permit is issued through a government agency, it is enforceable by the approved State, Territorial, Tribal and Federal agencies with authority to implement and enforce the permit. If the State, Territory or Tribe does not have approval for administering the NPDES program, the EPA will operate the NPDES program. Once a permit is issued, it is enforceable by the approved State, Territorial, Tribal and Federal agencies with authority to implement and enforce the permit.

All NPDES permits consist of at least five general sections:

4. A Cover Page: A statement with the name and location of the facility or discharger, a description of the permitted activity and the specific locations where discharges are authorized.
5. Effluent Limits: A statement describing the means for controlling discharges of pollutants based on applicable standards.

6. Monitoring and Reporting Requirements: A statement that characterizes streams and receiving waters, evaluates pollution reducing efficiency and determines compliance with permit conditions.
7. Special Conditions: A statement describing measures to supplement effluent limit guidelines such as: Best Management Practices, additional monitoring activities, surveys and toxicity reduction evaluations.
8. Standard Condition: A statement describing the legal, administrative and procedural requirements of permit conditions that apply to all NPDES permits.

While monitoring and reporting requirements set forth in a permit are the primary component of compliance monitoring, the permitting authority may also conduct inspections to verify that permit requirements are being met. Specifically, inspections are conducted to: determine if permittee is in compliance with regulations, permit conditions and other program requirements, verify the accuracy of information submitted and verify the adequacy of sampling and monitoring. An inspection may also be conducted to obtain information that supports the permitting process, gather evidence to support enforcement actions, or to assess compliance with orders or consent decrees.

EPA oversight of permits, both those it administers and those administered by non-Federal authorized agencies, includes collection of compliance information. Depending on the State or territory of origin, this data is entered into one of two national databases: the Permit Compliance System and the Integrated Compliance Information System for the National Pollutant Discharge Elimination System. These databases track information on the number of self-reported violations, the number of compliance evaluations performed, the number of non-compliances found, the number of formal and informal enforcement actions taken and the penalties assessed.

Water Quality Standards

Water Quality Standards are mandated by the CWA and define the goals for a water body by designating that waterbody’s uses, setting criteria to protect those designated uses and preventing degradation of water quality through antidegradation provisions.

Designated Uses

Designated uses are statements of management objectives and expectations for water bodies under State or Tribal jurisdiction. As defined in 40 CFR 131.3, designated uses are specified for each water body or water body segment regardless of whether or not they are being attained. Designated uses include, but are not limited to: water supply (domestic, industrial and agricultural); stock watering; fish and shellfish uses (salmonid migration, rearing, spawning and harvesting; other fish migration, rearing, spawning and harvesting); wildlife habitat; ceremonial and religious water use; recreation (primary contact recreation; sport fishing; boating and aesthetic enjoyment); and commerce and navigation.

The WQS regulation requires that States and Tribes specify which water uses are to be achieved and protected. These uses are determined by considering the value and suitability of water bodies based on their physical, chemical and biological characteristics as well as their geographical settings, aesthetic qualities and economic attributes. Each water body does not necessarily require a unique set of uses. Rather, water bodies sharing characteristics necessary to support a use can be grouped together. If WQS specify designated uses of a lower standard than those that are actually being attained, the State or Tribe is required to revise its standards to reflect these uses. Only California and Puerto Rico explicitly address threatened or endangered species as part of their designated uses. Other states have revised their designated uses to incorporate the specific needs of certain threatened or endangered species (e.g., Oregon and Washington adopted designated uses for the protection of Pacific salmon). Washington's designated uses explicitly denote the following categories of aquatic life uses: char spawning and rearing; core summer salmonid habitat; salmonid spawning; rearing and migration; salmonid rearing and migration only and several others (WAC 173-201A-200).

ANTIDEGRADATION

The WQS regulation also requires that States and Tribes establish a three-tiered antidegradation program. The specific steps to be followed depend upon which tier or tiers apply. These tiers are listed below:

- Tier 1: These requirements are applicable to all surface waters. They protect existing uses and water quality conditions necessary to support such uses. These uses can be established if they can be demonstrated to have actually occurred since November 28, 1975, or if water quality can be demonstrated to be suitable for such uses. If an existing use is established, it must be protected even if it is not listed in the WQS as a designated use.
- Tier 2: These requirements maintain and protect "high quality" water bodies where existing conditions are better than those necessary to support CWA § 101 (a)(2) "fishable/swimmable" uses. Although the water quality in these water bodies can be lowered, States and Tribes must identify procedures that must be followed and questions that must be answered before a reduction in water quality can be allowed. The water quality of these water bodies cannot be lowered to a level that would interfere with existing or designated uses.
- Tier 3: These requirements maintain and protect water quality in Outstanding Natural Resource Waters and generally include the highest quality waters of the United States. Classification also offers special protection for waters of exceptional ecological significance. Except for certain temporary changes, water quality cannot be lowered in these waters. States and Tribes decide which water bodies qualify as Outstanding Natural Resource Waters.

In a January 27, 2005, memorandum to its Regional Offices, EPA concluded that ESA Section 7 consultation does not apply to EPA's approvals of State antidegradation policies because EPA's approval action does not meet the "Applicability" standard defined in the regulations implementing Section 7 of the ESA (50 CFR 402.03). Section 402.03 of the consultation regulations (50 CFR Part 402) states that Section 7 and the requirements of 50 CFR parts 402 apply to all actions in which there is discretionary Federal involvement or control.

EPA concluded that they are compelled to approve State antidegradation policies if State submissions me*et al*l applicable requirements of the *Water Quality Standards Regulation* (40 CFR part 131) and lack discretion to implement measures that would benefit listed species. As a result, EPA determined that consultation is not warranted on antidegradation policies because the Agency does not possess the regulatory authority to require more than the minimum required elements of the regulations. For these reasons, EPA's approvals of State antidegradation policies are not part of this consultation.

APPENDIX B: FLORIDA'S ESTUARY NNC

National Estuary Program Reference Period-Based NNC Not to be Exceeded More than Once in Three Years

Estuary/segments	TP	TN	Chl-a
Charlotte Harbor/Estero Bay	mg/L annual arithmetic mean	mg/L annual arithmetic mean	µg/L annual arithmetic mean
Estero Bay (including Tidal Imperial River)	0.07	0.63	5.9
Charlotte Harbor Proper	0.19	0.67	6.1
Dona and Roberts Bay	0.18	0.42	4.9
Lower Lemon Bay	0.17	0.62	6.1
Matlacha Pass	0.08	0.58	6.1
Pine Island Sound	0.06	0.57	6.5
Tidal Myakka River	0.31	1.02	11.7
Tidal Peace River	0.5	1.08	12.6
Upper Lemon Bay	0.26	0.56	8.9
Clearwater Harbor/St. Joseph Sound	mg/L annual geometric mean	mg/L annual geometric mean	µg/L annual geometric mean
Clearwater North	0.05	0.61	5.4
Clearwater South	0.06	0.58	7.6
St. Joseph Sound	0.05	0.66	3.1
Sarasota Bay	mg/L annual geometric mean	mg/L annual geometric mean	µg/L annual arithmetic mean
Blackburn Bay	0.21	0.43	8.2
Little Sarasota Bay	0.21	0.6	10.4
Palma Sola Bay	0.26	0.93	11.8
Roberts Bay	0.23	0.54	11
Sarasota Bay	0.19	calculated	6.1
Tampa Bay[b]	tons/million m^3	tons/million m^3	µg/L annual arithmetic mean
Boca Ciega North	0.18	1.54	8.3
Boca Ciega South	0.06	0.97	6.3
Hillsborough Bay	1.28	1.62	15
Lower Tampa Bay	0.14	0.97	5.1
Manatee River Estuary	0.37	1.8	8.8
Middle Tampa Bay	0.24	1.24	8.5
Old Tampa Bay	0.23	1.08	9.3
Terra Ceia Bay	0.14	1.1	8.7

[a] The annual geometric mean target for TN in Sarasota Bay is calculated from the monthly arithmetic mean color by region and season.
[b] TMDL

South Florida Marine Systems NNC Based on the "Maintain Healthy Conditions Approach"

Estuary and Segment[a]		TP mg/L	TN mg/L	Chl-a µg/L
Clam Bay - Collier County				
	Clam Bay	Upper Limit[b]	Upper Limit[c]	no standard
Biscayne Bay				
	Card Sound	0.008	0.33	0.5
	Manatee Bay – Barnes Sound	0.007	0.58	0.4
	North Central Inshore	0.007	0.31	0.5
	North Central Outer-Bay	0.008	0.28	0.7
	Northern North Bay	0.012	0.3	1.7
	South Central Inshore	0.007	0.48	0.4
	South Central Mid-Bay	0.007	0.35	0.2
	South Central Outer-Bay	0.006	0.24	0.2
	Southern North Bay	0.010	0.29	1.1
Florida Bay				
	Central Florida Bay	0.019	0.99	2.2
	Coastal Lakes	0.045	1.29	9.3
	East Central Florida Bay	0.007	0.65	0.4
	Northern Florida Bay	0.010	0.68	0.8
	Southern Florida Bay	0.009	0.64	0.8
	Western Florida Bay	0.015	0.37	1.4
Florida Keys				
	Back Bay	0.009	0.25	0.3
	Backshelf	0.011	0.23	0.7
	Lower Keys	0.008	0.21	0.3
	Marquesas	0.008	0.21	0.6
	Middle Keys	0.007	0.22	0.3
	Oceanside	0.007	0.17	0.3
	Upper Keys	0.007	0.18	0.2
Tidal Cocohatchee River/Ten Thousand Islands				
	Blackwater River	0.053	0.41	4.1
	Coastal Transition Zone	0.034	0.61	3.9
	Collier Inshore	0.032	0.25	3.1
	Gulf Islands	0.038	0.44	3.4
	Inner Gulf Shelf	0.018	0.29	1.6
	Inner Waterway	0.033	0.69	5.2
	Mangrove Rivers	0.021	0.71	3.7
	Middle Gulf Shelf	0.016	0.26	1.4
	Naples Bay	0.045	0.57	4.3
	Outer Gulf Shelf	0.013	0.22	1.0
	Ponce de Leon	0.024	0.52	3.0
	Rookery Bay/Marco Island	0.046	0.30	4.9
	Shark River Mouth	0.022	0.75	2.2

Estuary and Segment[a]	TP mg/L	TN mg/L	Chl-a µg/L
Tidal Cocohatchee River	0.057	0.47	5.8
Whitewater Bay	0.026	0.82	4.1

[a] Unless otherwise noted (i.e., Clam Bay) standards are annual geometric means not to be exceeded more than once in a three year period
[b] Upper TP limit is calculated as: e (-1.06256- 0.0000328465*Conductivity (µS), not to be exceeded in more than 10 percent percent of samples
[c]Upper TN limit is calculated as: 2.3601 – 0.0000268325*Conductivity (µS) , not to be exceeded in more than 10 percent percent of samples

Estuary NNC Based On Reference Conditions

Unless Otherwise Indicated, Values Are Annual Geometric Means Not To Be Exceeded More Than Once In A Three-Year Period.

Estuary	Segment	TP mg/L	TN mg/L	Chl-a µg/L
Apalachicola Bay and Alligator Harbor				
	Apalachicola Bay	0.063	0.84	8.4
	East Bay	0.101	1.12	9.7
	St. George Sound	0.083	0.92	6.1
	St. Vincent Sound	0.116[a]	1.1[a]	17.4[a]
Charlotte Harbor/Estero Bay				
	Little Hickory Bay	0.07	0.63	5.9
	Moorings Bay	0.04[a]	0.85[a]	8.1
	Water Turkey Bay	0.057	0.47	5.8
Choctawhatchee Bay				
	Alaqua Bayou	0.027	0.41	4
	Basin Bayou	0.019	0.31	4.7[a]
	Boggy Bayou	0.015	0.33	3
	East Bay	0.027	0.46	4.4
	Garnier Bayou	0.017	0.91	4
	LaGrange Bayou	0.029	0.58	5.1
	Middle Bay	0.02	0.36	3.1
	Rocky Bayou	0.016	0.33	3.1
	West Bay	0.049	0.54	4.1
Guana River/Tolomato River/Matanzas River (GTM) Estuary				
	North Matanzas	0.11	0.55	4
	Pellicer Creek Estuary	0.123	1.1	4.3
	South Matanzas	0.111	0.53	5.5
	Tolomato	0.105	0.65	6.6
Halifax River Estuary and Tomoka River Estuary				
	Lower Halifax River Estuary	0.142	0.72	6.2
	Tomoka Basin	0.105	1.2	7.1
Indian River Lagoon[d], Banana River Lagoond, and Mosquito Lagoon				

Estuary	Segment	TP mg/L	TN mg/L	Chl-a µg/L
	Indian River Lagoon between Loxahatchee River up to and including Hobe Sound	0.021	0.49	2
Intracoastal Waterway –ICWW				
	Central Broward County ICWW	0.045	0.8	2.7
	Gulf ICWW between Choctawhatchee Bay and St. Andrew Bay	0.108[a]	1.13[a]	6.6[a]
	Gulf ICWW between St. Andrew Bay and St. Joseph Bay	0.108[a]	1.13[a]	6.6[a]
	ICWW between North Lake Worth Lagoon and Lower Loxahatchee River	0.035	0.66	4.7
	ICWW between Roberts Bay and Lemon Bay	0.253	0.59	4
	ICWW from North Tolomato River to St. Johns River	0.191	1.27[a]	10.2[a]
	North Broward County ICWW	0.059	0.79	3
	North Central Broward County ICWW	0.048	0.88	3.3
	South Broward County ICWW	0.043	0.7	2
Lake Worth Lagoon				
	Central Lake Worth Lagoon	0.049	0.66	10.2[a]
	Northern Lake Worth Lagoon	0.044	0.54	2.9
	Southern Lake Worth Lagoon	0.05	0.59	5.7
Loxahatchee River Estuary				
	Lower Loxahatchee	0.032	0.63	1.8
	Loxahatchee River Estuary (Southwest Fork)	0.075	1.26	5.5
	Middle Loxahatchee	0.03	0.8	4
	Upper Loxahatchee	0.075	1.26	5.5
Nassau River Estuary				
	Ft. George River Estuary	0.107	0.6	5.9
	Lower Nassau	0.107	0.8	17.5[a]
	Middle Nassau	0.137	0.83	17.1[a]
	Upper Nassau	0.191	1.29	4.7
Pensacola Bay				
	Blackwater Bay	0.082[a]	0.61[a]	11.3[a]
	East Bay	0.084[a]	0.83[a]	4
	Lower Escambia Bay	0.076[a]	0.56	6.8
	Lower Pensacola Bay	0.024	0.48	3.9
	Santa Rosa Sound	0.022	0.41	3.4
	Upper Pensacola Bay	0.084[a]	0.77[a]	6
Perdido Bay				
	Big Lagoon	0.036	0.61	6.4[a]
	Central Perdido Bay	0.103[a]	0.97[a]	7.5[a]
	Lower Perdido Bay	0.11[a]	0.78[a]	6.9[a]
	Upper Perdido Bay	0.102[a]	1.27[a]	11.5[a]
Springs Coast - Crystal River to Anclote River				

Estuary	Segment	TP mg/L	TN mg/L	Chl-a µg/L
	Anclote Bayou	0.063	0.65	3.8
	Anclote Offshore	0.014	0.42	1.7
	Anclote River Estuary	0.063	0.65	3.8
	Aripeka and Hudson Offshore	0.008	0.45	0.8
	Chassahowitzka NWR	0.015	0.55	2
	Chassahowitzka Offshore	0.011	0.46	1.5
	Chassahowitzka River Estuary	0.021	0.44	3.9
	Crystal Offshore	0.034	0.4	2.4
	Crystal River Estuary	0.047	0.37	4.4
	Homosassa Offshore	0.012	0.46	1.3
	Homosassa River Estuary	0.028	0.51	7.7
	Kings Bay[d]	0.033[c]	0.29[c]	5.7
	Pithlachascotee Offshore	0.01	0.47	1
	Pithlachascotee River Estuary	0.034	0.65	4
	St. Martins Marsh	0.031	0.51	3.2
	Weeki Wachee Offshore	0.017	0.54	1.2
	Weeki Wachee River Estuary[d]	0.019	0.6	1.9
St. Andrew Bay				
	Crooked Island Sound	0.019	0.34	3.7
	East Bay	0.016	0.33	3.9
	North Bay	0.014	0.28	3.1
	St. Andrew Bay	0.019	0.34	3.7
	West Bay	0.017	0.35	3.8
St. Joseph Bay				
	St. Joseph Bay	0.021	0.34	3.8
Suwannee, Waccasassa, and Withlacoochee River Estuaries				
	Suwannee Offshore	Empirical[b]	Empirical[b]	5.7
	Waccasassa Offshore	0.063	0.69	5.6
	Withlacoochee Offshore	Empirical[b]	Empirical[b]	4.9
Tampa Bay				
	Alafia River Estuaryd	0.86[c]	0.65[c]	15[c]

[a] "Single-sample standard" not to be exceeded in more than 10 percent of samples.
[b] The Chl-a standards was arrived at using the reference condition approach. NNCs for TP and TN are salinity-dependent, annual geometric means applied to individual monitoring stations within the segment. See Empirical Approach to account for the fluctuating influence of freshwater inflows below.
[c] Long term average of annual mean not to be exceeded.
[d] Includes one or more TMDL-based NNC.

Empirical Approach for the Fluctuating Influence of Freshwater Inflows

Linear regression describing the relationship between salinity and TP and TN concentrations (r2 ≥ 0.5 and p < 0.05) provided the salinity-dependent equations used to establish these criteria. Using the annual arithmetic average salinity (AASal) in practical salinity units (PSU) for each station made in conjunction with the collection of the nutrient samples, the salinity-based equations are:

Suwannee Offshore

TP = -0.0035*AASal + 0.1402
TN = -0.0328*AASal + 1.4177

Withlacoochee Offshore

TP = -0.0021*AASal + 0.0942
TN = -0.0183*AASal + 0.9720

Estuary NNC Based on Mechanistic Modeling.

Unless otherwise indicated, values are annual geometric means not to be exceeded more than once over a three-year period

Estuary	Segment	TP mg/L	TN mg/L	Chl-a µg/L
Big Bend and Apalachee Bay				
	Cedar Key	0.06	0.79	10.9
	Econfina Offshore	0.042	0.65	3.7
	Fenholloway Offshore	0.059	0.68	4.1
	Horseshoe Beach Offshore	0.021	0.45	3.3
	Spring Warrior Offshore	0.047[a]	0.67[a]	8.3[a]
	Steinhatchee Offshore	0.021	0.45	3.3
Charlotte Harbor/Estero Bay				
	Lower Caloosahatchee River Estuary	0.04[b]	9,086,094 lbs/y[c]	5.6[b]
	Middle Caloosahatchee River Estuary	0.055[b]	9,086,094 lbs/y[c]	6.5[b]
	San Carlos Bay	0.045[b]	0.44[b]	3.7[b]
	Upper Caloosahatchee River Estuary	0.086[b]	9,086,094 lbs/y[c]	4.2[b]
Halifax River Estuary and Tomoka River Estuary				
	Upper Halifax River Estuary	0.185[c,d]	1.13[c,d]	9[b]
Pensacola Bay				
	Upper Escambia Bay and Judges Bayou	60l,345 lbs/yr[c]	16,795,853 lbs/yr[c]	7.4[b]

[a] not to be exceeded in more than 10 percent of the measurements and shall be assessed over the most recent seven year period.
[b] long term annual means based on data from the most recent seven-year period and shall not be exceeded
[c] TMDL loads or, for Upper Hallifax River Estuary, concentration calculated from loading.
[d] Annual mean not to be exceeded in any year