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

05/04/2020 F/SER 31:SF/AH
SERO-2019-01935

Elizabeth Williams
Charleston District Corps of Engineers
Department of the Army
69A Hagood Avenue
Charleston, SC 29403

Ref.: SAC-2019-00767, Brian Boan, Dredging, Rip-rap Installation, and Wharf Construction, Goose Creek, Berkeley County, South Carolina

Dear Elizabeth:

The enclosed Biological Opinion (Opinion) was prepared by the National Marine Fisheries Service (NMFS) pursuant to Section 7(a)(2) of the Endangered Species Act (ESA). The Opinion considers the effects of a proposal by the Charleston District of the United States Army Corps of Engineers (USACE) to authorize dredging, rip-rap installation, and wharf construction under the authorities of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act on ESA-listed species and/or critical habitat. NMFS concludes that the proposed action is likely to adversely affect Atlantic sturgeon (Carolina Distinct Population Segment [DPS]), shortnose sturgeon, and will adversely affect but not destroy or adversely modify Atlantic sturgeon critical habitat.

This consultation has been assigned the tracking number SERO-2019-01935 in our new NMFS Environmental Consultation Organizer (ECO). Please refer to the ECO number in all future inquiries regarding this consultation. Please direct questions regarding this Opinion to Andy Herndon, Consultation Biologist, by phone at (727) 824-5367, or by email at Andrew.Herndon@noaa.gov.

Sincerely,

CRABTREE.ROY.E.DR.1365849559 Digitally signed by CRABTREE.ROY.E.DR.1365849559 Date: 2020.05.04 14:42:09 -04'00'

Roy E. Crabtree, Ph.D.
Regional Administrator

Enclosures: Biological Opinion
File: 1514-22.F.2

Endangered Species Act - Section 7 Consultation
Biological Opinion

Action Agency:	United States Army Corps of Engineers, Jacksonville District
Applicant:	Brian Boan Permit Number SAC-2019-00767
Activity:	Nexan Plant dredging, rip-rap installation, and wharf construction, Goose Creek, Berkeley County, South Carolina
Consulting Agency:	National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida Tracking Number SERO-2019-01935
Approved by:	CRABTREE.ROY.E.DR.1365849559 Digitally signed by CRABTREE.ROY.E.DR.1365849559 Date: 2020.05.04 14:47:11 -04'00' ______________________________ Roy E. Crabtree, Ph.D., Regional Administrator NMFS, Southeast Regional Office St. Petersburg, Florida
Date Issued:	05/04/2020

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Acronyms and Abbreviations

BA	Biological Assessment
CFR	Code of Federal Regulations
cSEL	cumulative sound exposure level
DO	Dissolved Oxygen
DPS	Distinct Population Segment
E	endangered
ECO	NMFS Environmental Consultation Organizer
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FR	Federal Register
IPCC	Intergovernmental Panel on Climate Change
LAA	may affect, likely to adversely affect
MHW	Mean High Water
MLLW	Mean Lower Low Water
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NLAA	may affect, not likely to adversely affect
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
Opinion	Biological Opinion
PBF	Physical and Biological Feature
SCDNR	South Carolina Department of Natural Resources
SCECAP	South Carolina Estuarine and Coastal Assessment Program
T	threatened
TNAP	temporary noise attenuation pile
U.S.	United States
USACE	United States Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
YOY	Young-of-the-year

Units of Measurement

°C	degrees Celsius
cm	centimeter(s)
°F	degrees Fahrenheit
ft.	foot/feet
ft^2	square foot/feet
km	kilometer(s)
lin ft.	linear foot/feet
m	meter(s)
mi	mile(s)
yd^3	cubic yard
RKM	river kilometer
RM	river mile

Introduction

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. § 1531 et seq.), requires that each federal agency ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. Section 7(a)(2) requires federal agencies to consult with the appropriate Secretary in carrying out these responsibilities. The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service share responsibilities for administering the ESA.

Consultation is required when a federal action agency determines that a proposed action "may affect" listed species or designated critical habitat. Informal consultation is concluded after NMFS determines that the action is not likely to adversely affect listed species or critical habitat. Formal consultation is concluded after NMFS issues a Biological Opinion (Opinion) that identifies whether a proposed action is likely to jeopardize the continued existence of a listed species, or destroy or adversely modify critical habitat, in which case reasonable and prudent alternatives to the action as proposed must be identified to avoid these outcomes. The Opinion states the amount or extent of incidental take of the listed species that may occur, develops measures (i.e., reasonable and prudent measures) to reduce the effect of take, and recommends conservation measures to further the recovery of the species.

This document represents NMFS's Opinion based on our review of impacts associated with the proposed action to issue a permit within Berkeley County, South Carolina. This Opinion analyzes the proposed action's effects on threatened and endangered species and designated critical habitat in accordance with Section 7 of the ESA. We based our Opinion on project information provided by the United States Army Corps of Engineers (USACE) and other sources of information, including the published literature cited herein.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on October 28, 2019 [84 FR 44976]. This consultation was pending at that time, and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, "[t]his final rule does not lower or raise the bar on Section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." We have reviewed the information and analyses relied upon to complete this Opinion in light of the updated regulations and conclude the Opinion is fully consistent with the updated regulations.

1 CONSULTATION HISTORY

The following is the consultation history for NMFS Environmental Consultation Organizer (ECO) tracking number SERO-2019-01935, Nexan Marine Terminal. On July 8, 2019, NMFS received a request for informal consultation under Section 7 of the ESA from the USACE for construction permit application SAC-2019-00767. NMFS requested additional information on July 26, 2019. NMFS received a response on August 5, 2019 and additional information on October 3, November 21, and December 12. NMFS explained in an email dated November 22, 2019, this consultation would likely require a biological opinion (i.e., formal consultation). NMFS initiated consultation on December 12, 2019. USACE provided additional information on January 2, 2020. NMFS requested additional information on January 24, 2020, and received a response on January 28, 2020. Additional correspondence occurred between February 4 and February 11. NMFS requested additional information on February 12, 2020, and received a response on February 13, 2020. Correspondence continued after February 13 with a phone call between the applicant, action agency, and NMFS held on February 21, 2020. On February 24, 2020, the applicant provided NMFS with additional information about the vessels likely to be using the proposed facility along with revisions to a draft of the proposed action section.

2 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

2.1 Proposed Action

The applicant plans to expand an existing cable land factory to include submarine cable production. The proposed marine terminal design and construction will provide adequate dockage and anchoring for a vessel that will call upon the plant up to 4 times per year (i.e., 8 round trips).

US Army Corps of Engineers (USACE) proposes to permit the applicant to do the following:

Construct a 500-foot (ft.)-long by 100-ft-wide pile-supported concrete wharf, a 50-ft-long by 75-ft-wide loading platform at the northern end of the wharf, and install 581 accompanying 24-inch (in)-diameter concrete piles via impact hammer (100 piles above mean high water [MHW], and 481 below MHW) (see Figures 1 and 2);

- Install 1.95 acres of rip-rap (2:1 slope) at the wharf (see Figure 3)[1]; and
- Mechanically dredge approximately 121,067 cubic yards (yd^3) of material from the Cooper River in the vicinity of the pile-supported concrete wharf and turning basin to depths of -35.9 ft. mean lower low water (MLLW). Dredging will be conducted from land with long-range excavators and from barge-mounted clamshell dredges, and it will remove between roughly 5 and 45 ft. of material, depending on location. According to the revised plans dated March 2, 2020, the total footprint of the proposed dredge area includes approximately 7.62 acres to a depth of -35.9 ft. MLLW and includes isolated

[1] Only 1.34 acres (0.005 km^2) of riprap will be placed on aquatic habitat potentially used by sturgeon. The remaining riprap will be placed on areas previously unusable (i.e., forested wetlands) by sturgeon.

dredge areas on the east and west of the river channel; the channel itself will remain undredged, as will a 100-foot-wide corridor along the eastern shore of the Cooper River.

- According to the December 31, 2019 biological assessment, dredging will deepen some parts of the river that are already over 10 ft. deep by an additional 10 to 15 ft. (see Figures 4 and 5).

To the extent possible, dredged material will be placed directly in the temporary stockpile area. This will most likely be possible from shore-based long-reach excavators. When dredged material cannot be placed directly into the temporary stockpile area, as in the case of barge-based clam shell excavators, dredged material will be staged on a spud-barge. The material will then be offloaded to the temporary stockpile using shore-based long-reach excavators. In some instances, dredged material staged on a spud-barge may have to be transported by truck to the temporary stockpile. The material in temporary stockpile will be allowed to dry before being hauled offsite for final disposal (see "Dredge Note" Figure 6).

The vessel that will use the terminal when finished has an overall length of 491.80 ft., a beam of 101.71 ft., and a draft of 29.53 ft. It also has an azimuth thruster propulsion system, which allows the ship to travel and navigate at speeds (0.5 to 1.5 kts) much slower than standard, propeller/rudder vessels. The vessel has multiple, smaller propellers, enclosed by nozzles with no exposed propeller blade tips that do not draft lower than the keel of the hull.

In-water construction is expected to take 75 days to complete during daylight hours only. The applicant has also agreed to the following conservation measures:

1. NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions.*[2]
2. The contractor will employ a soft-start impact hammer method during construction.
3. Noise attenuation using temporary noise attenuation piles (TNAPs) and/or similar noise reducing strategies will be implemented to avoid adverse impacts to sturgeon.
4. The permittee shall instruct all personnel associated with the project of the potential presence of, and the need to avoid collisions with, protected species, which may include, but not be limited to, Atlantic sturgeon and shortnose sturgeon.
5. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing protected species, which are protected under the ESA of 1973.
6. Any siltation barriers used during the project shall be made of material in which protected species cannot become entangled and must be properly secured, and regularly monitored to avoid protected species entrapment.
7. If protected species are seen within 100 yards of the active construction area the specific precautions described below in #8 shall be implemented to ensure protection of protected species.

[2] NMFS. 2006. Sea Turtle and Smalltooth Sawfish Construction Conditions revised March 23, 2006. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Protected Resources Division (PRD), Saint Petersburg, Florida. https://www.fisheries.noaa.gov/webdam/download/92937961

8. If protected species are seen within 50 ft. of equipment, operations will cease including the immediate shutdown of any moving equipment. Activities will not resume until the protected species has departed the project area of its own volition.

9. Incidents where any individual Atlantic sturgeon and/or shortnose sturgeon appear to be injured or killed as a result of discharges of dredged or fill material into waters of the United States or structures or work in navigable waters of the United States authorized by the Department of the Army permit shall be immediately reported to NOAA Fisheries, Office of Protected Species at (727) 824-5312 the South Carolina Department of Natural Resources (SCDNR) Hotline at 1-800-922-5431, and the Regulatory Office of the Charleston District of the USACE at (843) 329-8044. The observer should leave the animal alone, make note of any circumstances likely causing death or injury, note the location and number of individuals involved and, if possible, take photographs. Adult animals should not be disturbed unless circumstances arise where they are obviously injured or killed by discharge exposure, or some unnatural cause. The finder may be asked to carry out instructions provided by NOAA Fisheries, Office of Protected Resources, to collect specimens or take other measures to ensure the evidence intrinsic to the specimen is preserved.

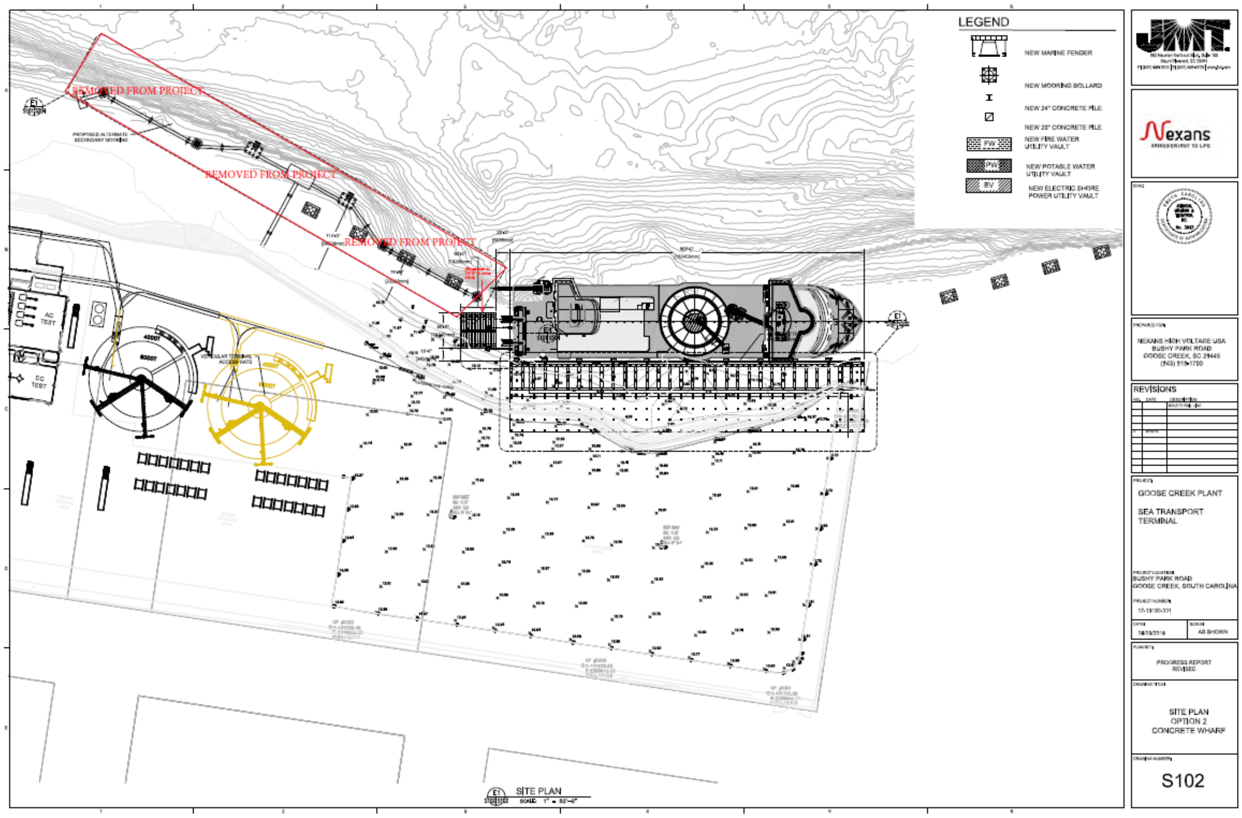


Figure 1. Image showing proposed wharf and loading platform from "Biological Assessment SAC-2019-00767: Nexans Marine Terminal, Goose Creek, Berkeley County, SC (revised December 31, 2019), JMT. Image is p. 58 of 139 (Appendix A-3).

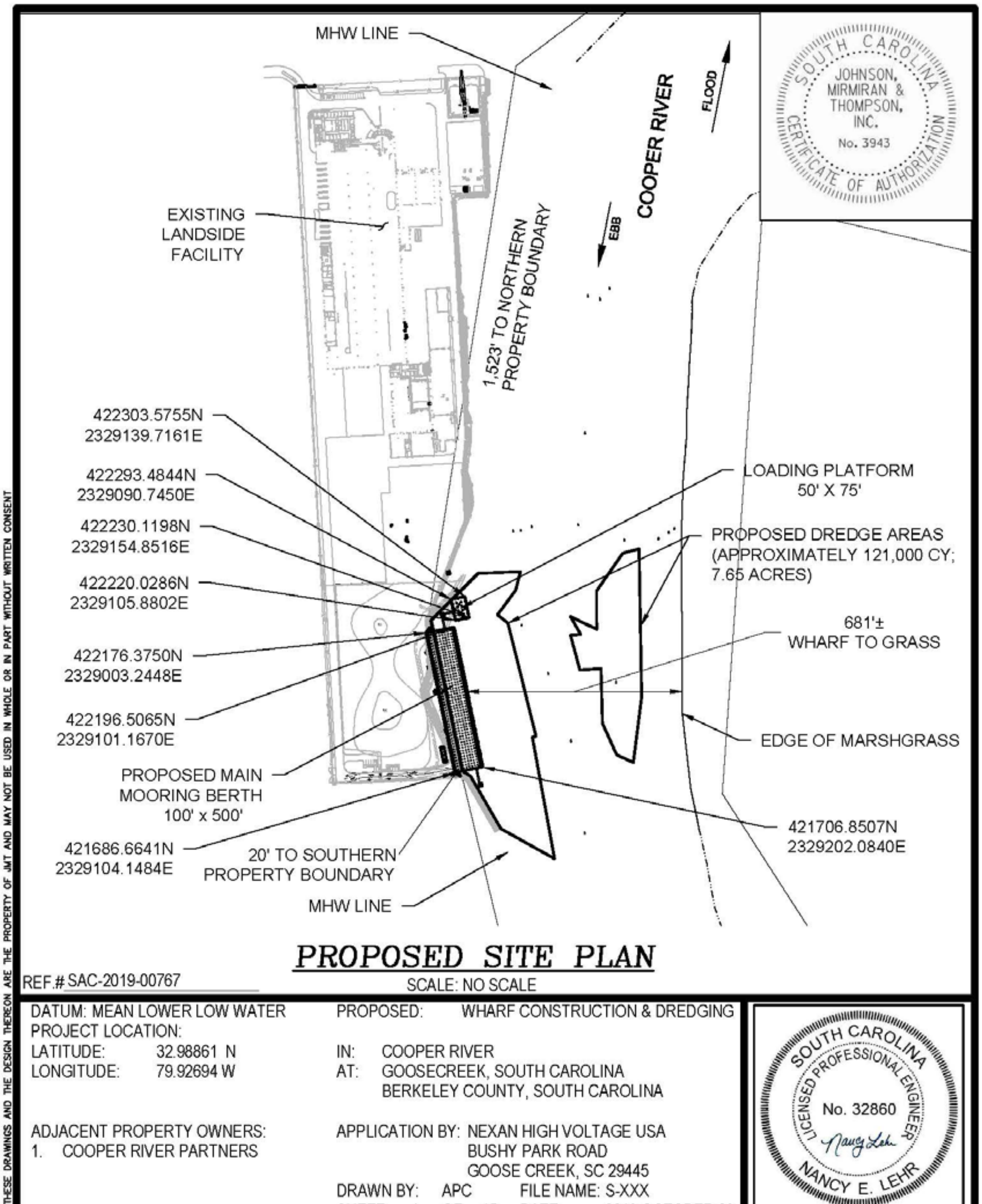


Figure 2. Image showing proposed wharf, loading platform, and dredge area from permit application figures (revised March 3, 2020), JMT. Image is Sheet 4 of 15.

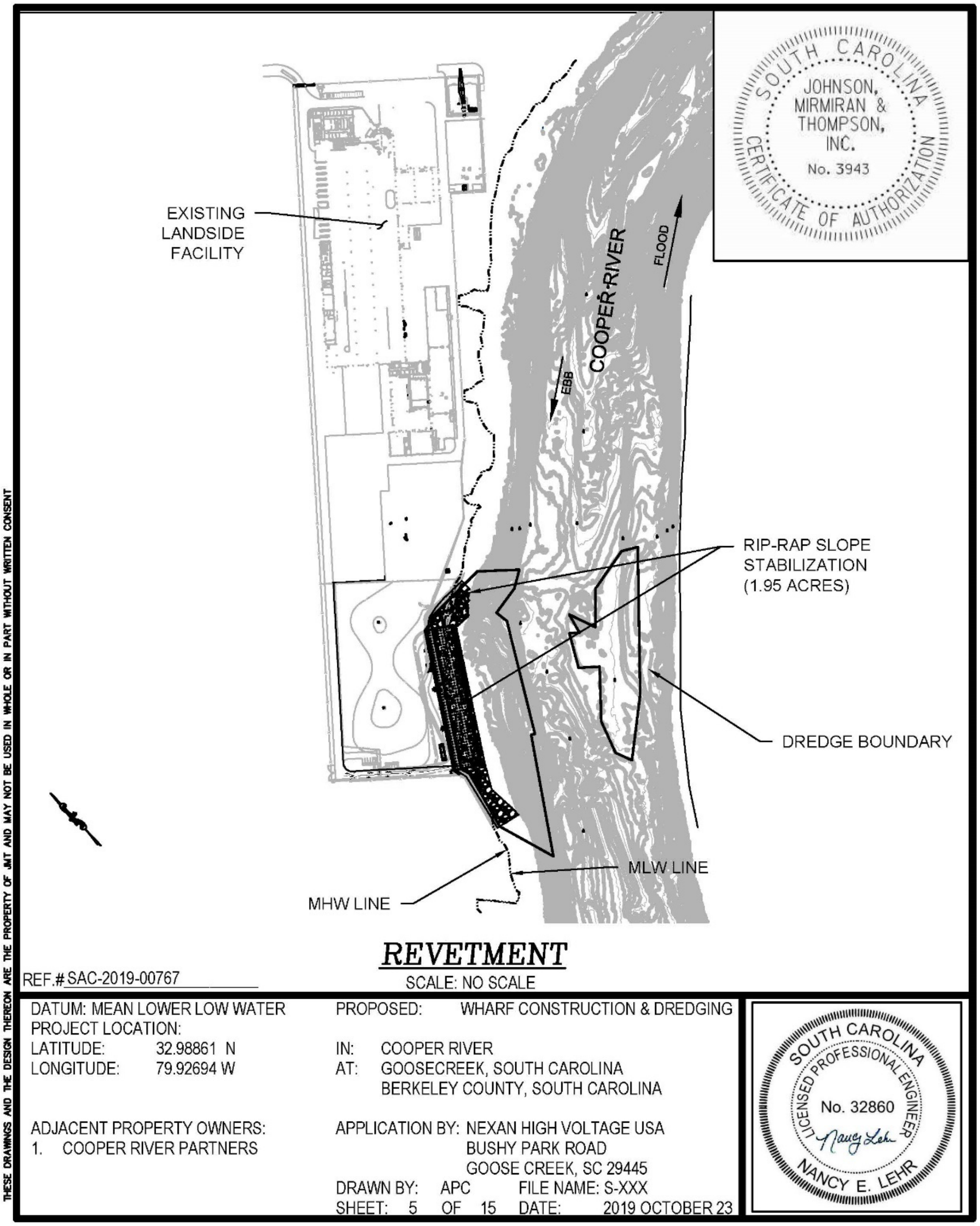


Figure 3. Image showing proposed rip-rap revetment from permit application figures (revised March 3, 2020), JMT. Image is Sheet 5 of 15.

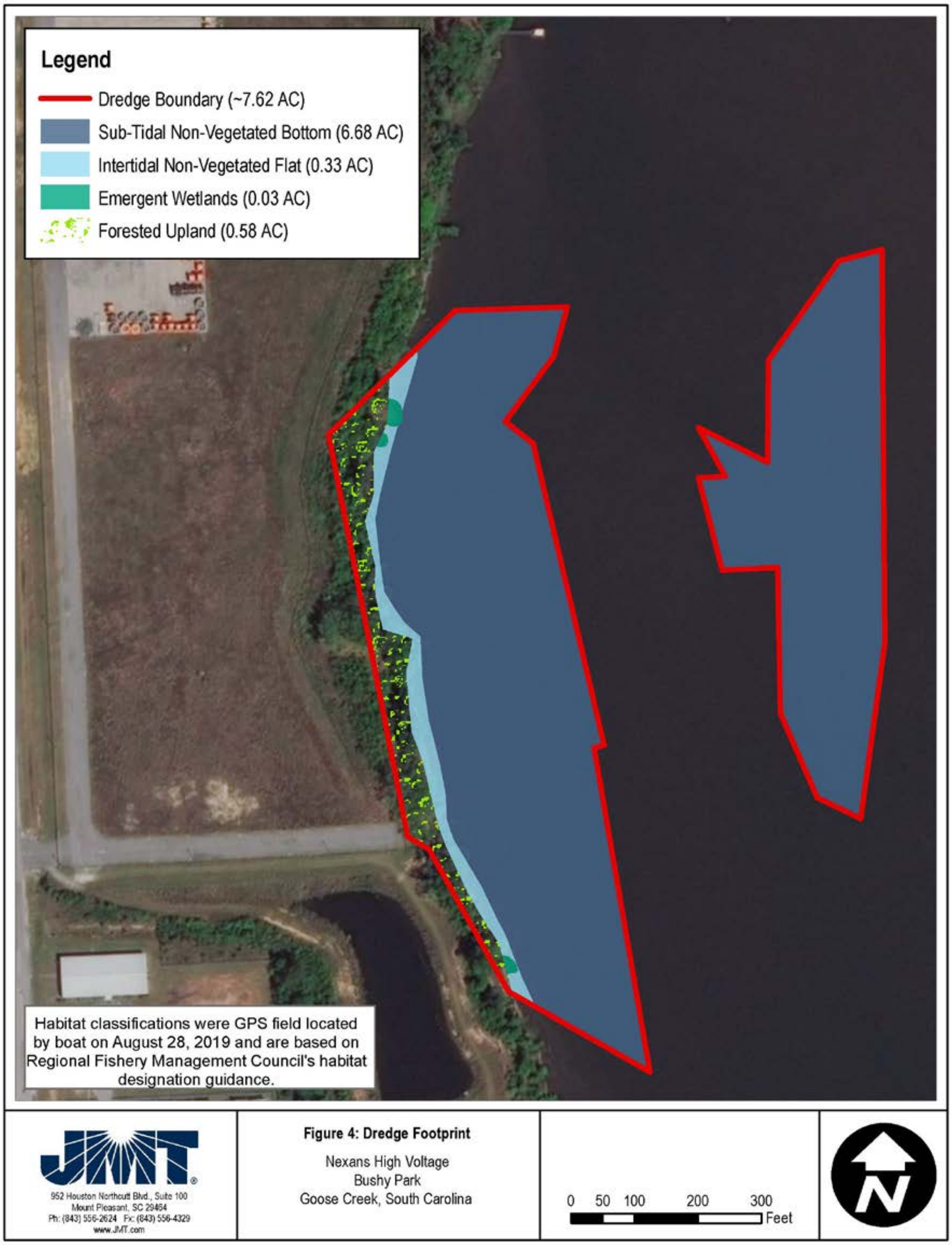


Figure 4. Image showing proposed dredging footprint from USACE file SAC-2019-00767 revised plans for Nexans Marine Terminal, Cooper River, Berkeley County, SC JMT Job No. 17-13130-001 (March 3, 2020), JMT.

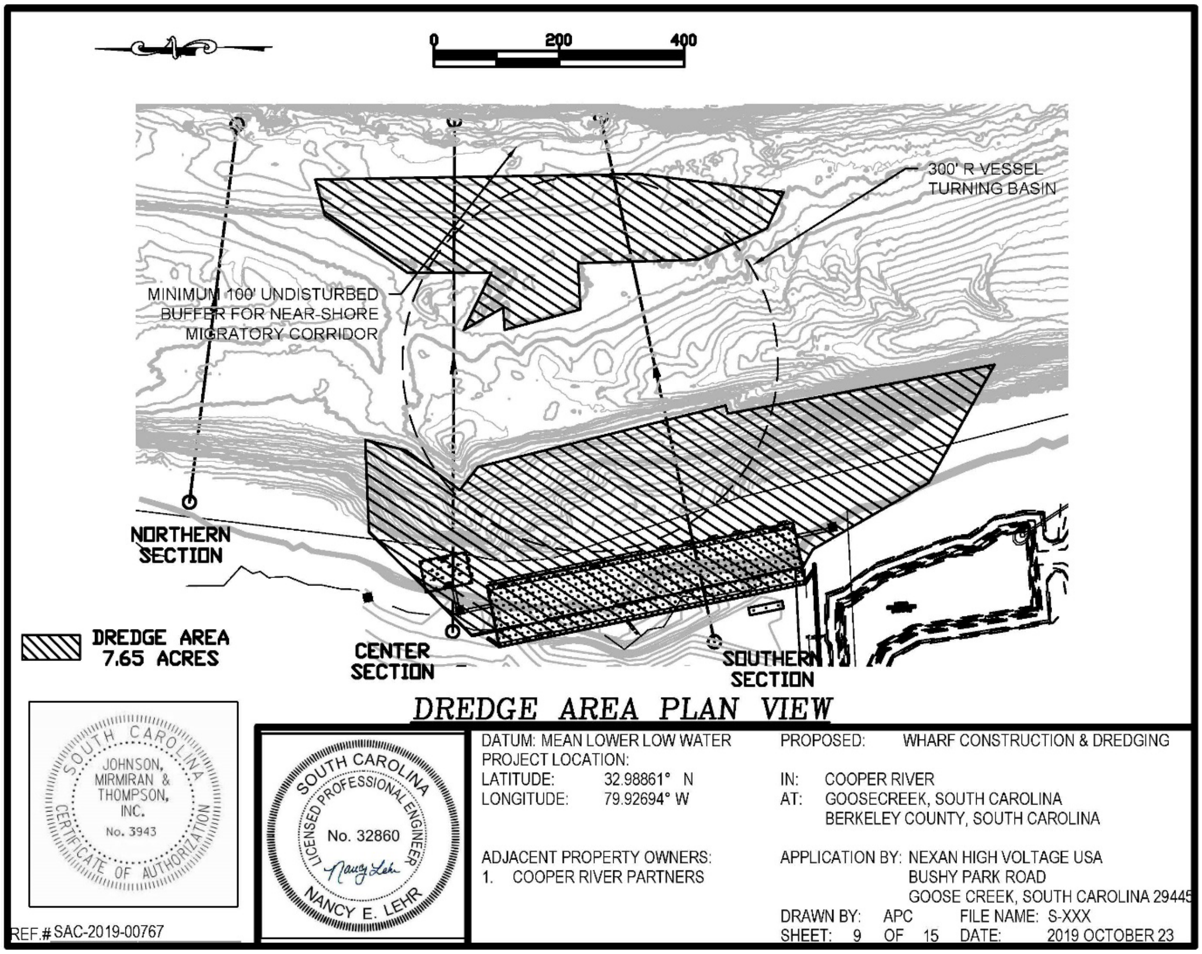


Figure 5. Image showing proposed dredge area plan from permit application figures (revised March 3, 2020), JMT. Image is Sheet 9 of 15.

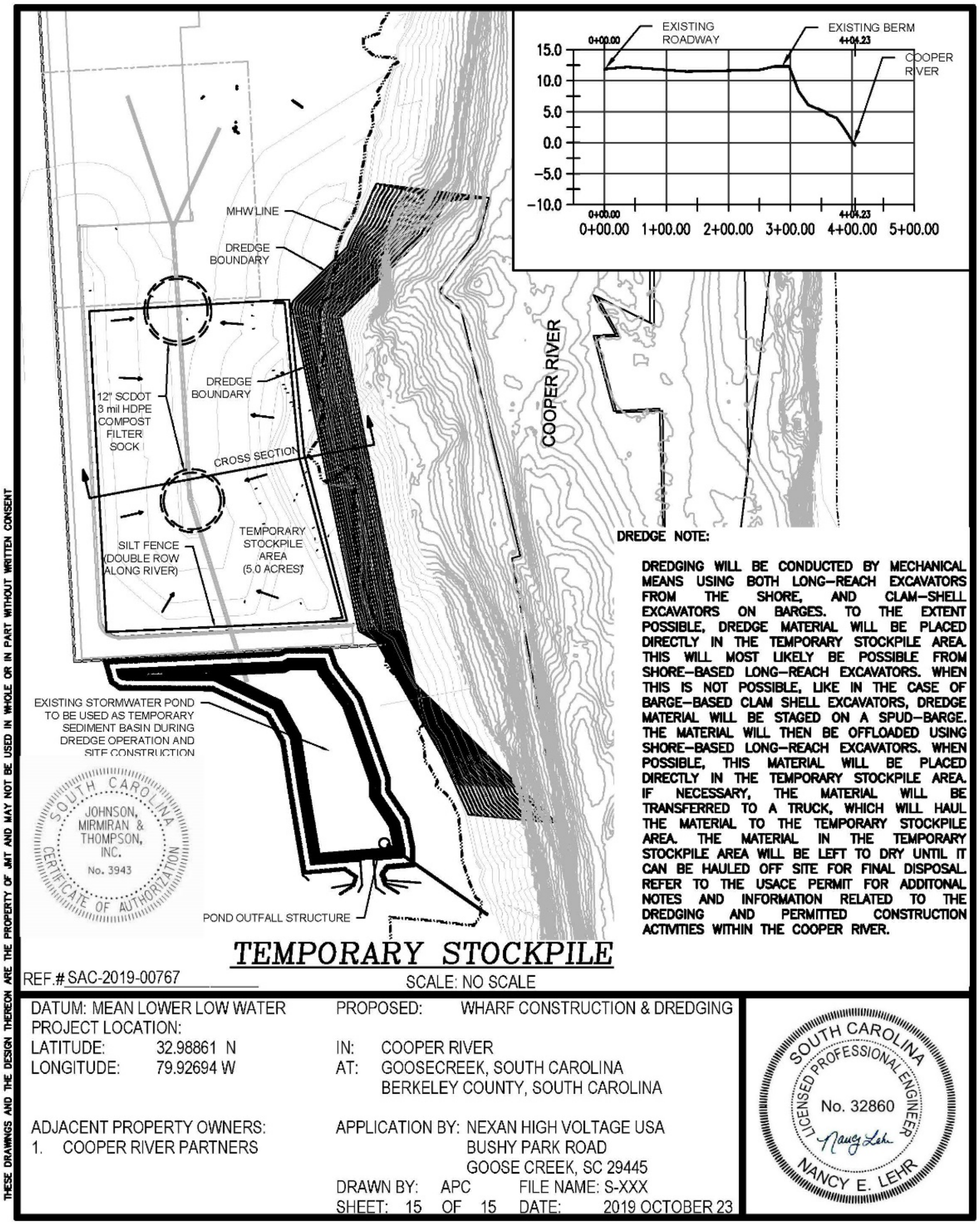


Figure 6. Image showing proposed dredge material temporary stockpile area from permit application figures (revised March 3, 2020), JMT. Image is Sheet 17 of 15.

2.2 Action Area

The project site is located at 1716 Bushy Park Road in Goose Creek, Berkeley County, South Carolina (32.988898°N, 82.12947°W [North American Datum 1983]). The project site is on the Cooper River, adjacent to the Bushy Creek Industrial Complex, about 22 river miles (RM) from the Atlantic Ocean. According to the December 31, 2019 BA, the project area consists of tidal waters; therefore, water depth varies greatly depending on the tide. Industrial communities border the project area to the north, west, and south.

Figure 7. The project site at 1716 Bushy Park Road, Goose Creek, Berkeley County, South Carolina, on the Cooper River (©2020 Google); approximate location of action area outlined in yellow.

The action area is defined by regulation as all areas to be affected by the federal action and not merely the immediate area involved in the action (50 Code of Federal Regulations [CFR] 402.02). The action area includes waters upstream and downstream of the anticipated 7.65-acres proposed dredge area (outlined in yellow in Figure 7). Substrate in the action area consists of silt and fine sands over hardpan clay. According to information provided by the USACE, water depth ranges from less than 10 ft. to about 35 ft., and no mangroves or corals occur within the action area.

3 STATUS OF LISTED SPECIES AND CRITICAL HABITAT

Table 1 provides the effect determinations for species the USACE and/or NMFS believe may be affected by the proposed action.

Table 1. Effects Determination(s) for Species the Action Agency and/or NMFS Believe May Be Affected by the Proposed Action

Species	ESA Listing Status[3]	USACE Effect Determination	NMFS Effect Determination
Shortnose sturgeon	E	NLAA	LAA
Atlantic sturgeon (Carolina DPS)	E	NLAA	LAA

Table 2 provides the effects determinations for designated critical habitat occurring within the action area that the USACE and/or NMFS believe may be affected by the proposed action.

Table 2. Effects Determinations for Designated Critical Habitat the Action Agency and/or NMFS Believe May Be Affected by the Proposed Action

Species	Unit	USACE Effect Determination	NMFS Effect Determination
Atlantic sturgeon (Carolina DPS)	Carolina Unit 7: Santee-Cooper Unit	LAA	LAA

3.1 Potential Routes of Effect Not Likely to Adversely Affect Listed Species or Critical Habitat

Carolina DPS of Atlantic Sturgeon and Shortnose Sturgeon
We have identified potential effects of the proposed action on Atlantic sturgeon and shortnose sturgeon. We believe that these species are not likely to be adversely affected by the aspects of the proposed action described below.

Effects to ESA-listed fishes (i.e., Atlantic sturgeon and shortnose sturgeon) include the risk of injury or death from construction equipment. Due to their expected avoidance of the disturbance and noise during project construction, we believe it is extremely unlikely that Atlantic or shortnose sturgeon would remain within the action area while the pile driving is occurring. Compliance with NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* will provide an additional measure of protection as operation of any mechanical construction equipment will cease immediately if a sturgeon is observed within a 50-ft radius of the equipment. Therefore, we believe this route of effect will be discountable.

The process of installing the pilings into the substrate via impact hammer will increase turbidity during that aspect of the construction process. However, we would anticipate those effects to be temporary, minimal, and therefore insignificant for ESA-listed fishes, because suspended particles will settle out or disperse quickly due to the river current.

[3] E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; LAA = may affect, likely to adversely affect

ESA-listed fishes may be affected by being struck by the additional vessel utilizing the proposed wharf. An increase in vessel traffic in the area may result from the construction of 1 new slip to accommodate a vessel that may call 4 times per year (i.e., 8 round trips). ESA-listed fishes could be adversely affected by increased vessel traffic in the area, as it may increase the risk of collisions with these species. Nexan vessels are equipped with an azimuth thruster propulsion system, which allows the ship to travel and navigate at speeds (0.5 to 1.5 kts) much slower than standard, propeller/rudder vessels. The propeller blades used for this system are housed within the hull of the ships. This design prevents the thrusters from injuring or killing sturgeon. The vessels also have external propellers at the aft of the ship. Yet, these smaller propellers are enclosed by nozzles with no exposed propeller blade tips, and they do not draft lower than the keel of the hull (Figure 8). We anticipate physical injury caused to sturgeon from jetted water expelled from the nozzle-enclosed propellers will be extremely unlikely to occur. The relatively unique nature of these vessels trips (e.g., relatively few port calls, internal thrusters, enclosed external props, and lower transit speeds) means the likelihood of sturgeon being struck or injured by vessels is highly unlikely and, therefore, discountable.

Figure 8. View of vessel types making calls at the proposed site.

Finally, we consider the potential injurious and behavioral effects of pile driving for the project. Noise created by pile driving activities can physically injure animals or change animal behavior in the affected areas. Injurious effects can occur in 2 ways. First, immediate adverse effects can occur to listed species if a single noise event exceeds the threshold for direct physical injury. Second, effects can result from prolonged exposure to noise levels that exceed the daily cumulative exposure threshold for the animals, and these can constitute adverse effects if animals are exposed to the noise levels for sufficient periods. Behavioral effects can be adverse if such effects interfere with animals migrating, feeding, resting, or reproducing, for example. Our evaluation of effects to listed species as a result of noise created by construction activities is based on the analysis prepared in support of the Opinion for SAJ-82.[4] The noise analysis in this consultation evaluates effects to ESA-listed fish identified by NMFS in Table 1.

Based on our noise calculations, installation of four hundred eighty-one 24-in by 24-in concrete piles by impact hammer (up to 12 piles per day) will not cause single-strike or peak-pressure injury to sea turtles or ESA-listed fish. However, the cumulative sound exposure level (cSEL) of

[4] NMFS. Biological Opinion on Regional General Permit SAJ-82 (SAJ-2007-01590), Florida Keys, Monroe County, Florida. June 10, 2014.

multiple pile strikes over the course of a day may cause injury to ESA-listed fish. The installation of 12 concrete piles using an impact hammer will result in a daily cumulative sound injury zone ranging up to 1,658 ft. (505 meters) per day for ESA-listed fishes. To minimize potential noise impacts to species, the applicant has agreed to use noise abatement measures (i.e., TNAPs) to reduce noise levels. Using noise abatement will reduce the daily cumulative noise injury impact zone to a maximum of 31 ft. (9 meters) for ESA-listed fishes. Due to their expected avoidance of the disturbance and noise during project construction, we believe it is extremely unlikely that Atlantic or shortnose sturgeon would remain within the action area while the pile driving is occurring and the noise is being produced. Compliance with NMFS's *Sea Turtle and Smalltooth Sawfish Construction Conditions* will provide an additional measure of protection as operation of any mechanical construction equipment will cease immediately if a sturgeon is observed within a 50-ft radius of the equipment. Given these conditions, we believe any injurious cSEL effects are extremely unlikely to occur and this route of effect is therefore discountable.

The installation of piles using an impact hammer could also result in behavioral responses at radii 383 ft. (117 m) for ESA-listed fish. Yet, noise abatement measures reduce the behavioral impact zone radius to 7 ft. (2 m) for ESA-listed fishes. While the project occurs within a confined space, the river at the project site is wide enough (600-900 ft.) that we expect sturgeon will be able to move 8 or more ft. to escape the behavioral impact zone. Since installation will occur only during the day, these species will be able to resume normal activities during quiet periods between pile installations and at night. Individuals will be able to transit from the behavioral impact zone or resume normal activities during quiet periods between pile installations. Thus, we believe any behavioral response during pile driving will be insignificant.

Atlantic Sturgeon Critical Habitat – Carolina Unit 7 (Santee-Cooper Unit)
We have identified potential effects of the proposed action on Atlantic sturgeon critical habitat – Carolina Unit 7. Of the 4 physical and biological features (PBFs) identified for Atlantic sturgeon critical habitat (Table 6), only the salinity gradient and soft substrate PBF and unobstructed water of appropriate depth PBF may be affected by the proposed action. We anticipate only the former would be adversely affected by the proposed action. The likely impacts to that PBF are discussed in more detail in Section 5. Below is our determination as to why the proposed action is not likely to be adversely affected the unobstructed water of appropriate depth PBF.

This unobstructed water of appropriate depth PBF refers to water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites. This PBF could be affected by the sound generated by pile driving, but this effect is insignificant. The "unobstructed water of appropriate depth" PBF refers to adequate water depth that is free from obstruction, and is necessary to ensure all life stages of Atlantic sturgeon have enough physical space (i.e., enough water to allow them to swim) to maneuver through the river. The mainstem of the river needs to be free of obstruction to ensure that all life stages of fish can migrate between the river mouth and spawning sites. Under these circumstances, the noise produced during pile driving that occurs for about 40 days (of in-water pile driving) is not likely to create a physical barrier to passage. Any physical barrier to passage created by pile-driving noise will be temporary as we expect pile driving will only occur during the day and the sound-created barrier will not exist when pile driving ceases at night. Because the proposed action is deepening the river, it will have no adverse effect on the depth portion of this PBF.

3.2 Species Likely to be Adversely Affected

ESA-listed shortnose sturgeon and the Atlantic Sturgeon Carolina DPS may be adversely affected by the proposed action. The following subsections are synopses of the best available information on the status of the species and DPS, including information on the distribution, population structure, life history, abundance, and population trends of each species/DPS and threats to each. The biology and ecology of these species/DPS as well as their status and trends inform the effects analysis for this Opinion.

Additional information on the status and trends of these listed resources and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on these NMFS websites:

https://www.fisheries.noaa.gov/species/shortnose-sturgeon
https://www.fisheries.noaa.gov/species/atlantic-sturgeon

3.2.1 Shortnose Sturgeon

Shortnose sturgeon were initially listed as an endangered species by the U.S. Fish and Wildlife Service (USFWS) on March 11, 1967, under the Endangered Species Preservation Act (32 FR 4001). Shortnose sturgeon continued to meet the listing criteria as "endangered" under subsequent definitions specified in the 1969 Endangered Species Conservation Act and remained on the list with the inauguration of the ESA in 1973. NMFS assumed jurisdiction for shortnose sturgeon from USFWS in 1974 (39 FR 41370). The shortnose sturgeon currently remains listed as an endangered species throughout all of its range along the east coast of the United States and Canada. A recovery plan for shortnose sturgeon was published by NMFS in 1998 (NMFS 1998).

Species Description and Distribution
The shortnose sturgeon (*Acipenser brevirostrum)* is the smallest of the 3 sturgeon species that occur in eastern North America. They attain a maximum length of about 6 ft., and a weight of about 55 pounds. Shortnose sturgeon inhabit large coastal rivers of eastern North America. Although considered an amphidromous species,[5] shortnose sturgeon are more properly characterized as "freshwater amphidromous," meaning that they move between fresh and salt water during some part of their life cycle, but not necessarily for spawning. Shortnose sturgeon rarely leave the rivers where they were born ("natal rivers"). Shortnose sturgeon feed opportunistically on benthic insects, crustaceans, mollusks, and polychaetes (Dadswell et al. 1984).

Historically, shortnose sturgeon were found in the coastal rivers along the east coast of North America from the Saint John River, New Brunswick, Canada, to the St. Johns River, Florida, and perhaps as far south as the Indian River in Florida (Evermann and Bean 1898; Gilbert 1989b). Currently, the distribution of shortnose sturgeon across their range is disconnected, with northern

[5] Meaning they are born in freshwater, then live primarily in their natal river, making short feeding or migratory trips into salt water, and then return to freshwater.

populations separated from southern populations by a distance of about 250 miles (400 km) near their geographic center in Virginia (see Figure 9). In the southern portion of the range, they are currently found in the Edisto, Cooper, Altamaha, Ogeechee, and Savannah Rivers in Georgia. Sampling has also found shortnose in the Roanoke River, Albemarle Sound, and Cape Fear Rivers, while fishers have reported the species in Neuse River and Pamlico Sound (NMFS 2010). Females bearing eggs have been collected in the Cape Fear River (Moser and Ross 1995). Spawning is known to be occurring in the Cooper River (NMFS 2010; Ruddle 2018)), the Congaree River (Collins et al. 2003; Post et al. 2017), and the Pee Dee River (NMFS 2010). While it had been concluded that shortnose sturgeon are extinct from the Satilla River in Georgia and the St. Marys River along the Florida and Georgia border, targeted surveys in both the Satilla (Fritts and Peterson 2010) and St. Marys (Fox and Peterson 2017; Fritts and Peterson 2010) have captured shortnose sturgeon. A single specimen was found in the St. Johns River by the Florida Fish and Wildlife Conservation Commission during extensive sampling of the river in 2002 and 2003 (NMFS 2010).

Life History Information

Shortnose sturgeon populations show clinal variation[6], with a general trend of faster growth and earlier age at maturity in more southern systems. Fish in the southern portion of the range grow the fastest, but growth appears to plateau over time. Conversely, fish in the northern part of the range tend to grow more slowly, but reach a larger size because they continue to grow throughout their lives. Male shortnose sturgeon mature at 2-3 years of age in Georgia, 3-5 years of age in South Carolina, and 10-11 years of age in the Saint John River, Canada. Females mature at 4-5 years of age in Georgia, 7-10 years of age in the Hudson River, New York, and 12-18 years of age in the Saint John River, Canada. Because animals are considered mature at the onset of developing mature gonads, spawning is usually delayed relative to reaching maturity. Males begin to spawn 1-2 years after reaching sexual maturity and spawn every 1-2 years (Dadswell 1979; Kieffer and Kynard 1996; NMFS 1998). Age at first spawning for females is about 5 years post-maturation with spawning occurring every 3-5 years (Dadswell 1979). Fecundity of shortnose sturgeon ranges between approximately 30,000-200,000 eggs per female (Gilbert 1989b).

Adult shortnose sturgeon spawn in the rivers where they were born. Initiation of the upstream movement of shortnose sturgeon to spawn is likely triggered partially by water temperatures. Shortnose sturgeon captured in 5 coastal river systems of South Carolina all spawned during temperatures of 5–18°C (Post et al. 2014), which is similar to what has been documented throughout the range (Duncan et al. 2004; Hall et al. 1991; Kieffer and Kynard 1996; NMFS 1998; Taubert 1980). In the Altamaha River, Georgia, adults began their upstream migrations during likely spawning runs during the late-winter months when water temperatures declined to 11.6–16.9 °C (Post et al. 2014). Water depth and flow are also important at spawning sites (Kieffer and Kynard 1996). Spawning sites are characterized by moderate river flows with average bottom velocities between 1-2.5 ft. (0.4-0.8 meters) per second (Hall et al. 1991; Kieffer and Kynard 1996; NMFS 1998). Shortnose sturgeon tend to spawn on rubble, cobble, or large rocks (Buckley and Kynard 1985; Dadswell 1979; Kynard 1997; Taubert 1980), timber, scoured clay, or gravel (Hall et al. 1991). Southern populations of shortnose sturgeon usually spawn at

[6] A gradual change in a character or feature across the distributional range of a species or population, usually correlated with an environmental or geographic transition.

least 125 miles (200 km) upriver (Kynard 1997) or throughout the fall line[7] zone if they are able to reach it. Adults typically spawn in the late winter to early spring (December-March) in southern rivers (i.e., North Carolina and south) and the mid to late spring in northern rivers. They spend the rest of the year in the vicinity of the saltwater/freshwater interface (Collins and Smith 1993).

Little is known about young-of-the-year (YOY) behavior and movements in the wild, but shortnose sturgeon at this age are believed to remain in freshwater channels upstream of the saltwater/freshwater interface for about 1 year, potentially due to their low tolerance for salinity (Dadswell et al. 1984; Kynard 1997). Residence of YOY in freshwater is supported by several studies on cultured shortnose sturgeon (Jarvis et al. 2001; Jenkins et al. 1993; Ziegeweid et al. 2008). In most rivers, juveniles aged 1 and older join adults and show similar patterns of habitat use (Kynard 1997). In the Southeast, juveniles aged 1 year and older make seasonal migrations like adults, moving upriver during warmer months where they shelter in deep holes, before returning to the fresh/saltwater interface when temperatures cool (Collins et al. 2002; Flournoy et al. 1992). Due to their low tolerance for high temperatures, warm summer temperatures (above 82°F) may severely limit available juvenile rearing habitat in some rivers in the southeastern United States. Juveniles in the Saint John, Hudson, and Savannah Rivers use deep channels over sand and mud substrate for foraging and resting (Dovel et al. 1992; Hall et al. 1991; Pottle and Dadswell 1979).

Status and Population Dynamics

The 1998 shortnose sturgeon recovery plan identified 19 distinct shortnose sturgeon populations based on natal rivers (NMFS 1998). Since 1998, significantly more tagging/tracking data on straying rates to adjacent rivers has been collected, and several genetic studies have determined where coastal migrations and effective movement (i.e., movement with spawning) are occurring. Genetic analyses aided in identifying population structure across the range of shortnose sturgeon. Several studies indicate that most, if not all, shortnose sturgeon riverine populations are statistically different ($p < 0.05$) (King et al. 2001; Waldman et al. 2002; Wirgin et al. 2005; Wirgin et al. 2010; Wirgin et al. 2000). Gene flow is low between riverine populations indicating that while shortnose sturgeon tagged in one river may later be recaptured in another, it is unlikely the individuals are spawning in those non-natal rivers. This is consistent with our knowledge that adult shortnose sturgeon are known to return to their natal rivers to spawn (NMFS 1998). However, (Fritts et al. 2016) provide evidence that greater mixing of riverine populations occurs in areas where the distance between adjacent river mouths is relatively close, such as in the Southeast.

In addition to genetic differences associated with shortnose sturgeon only spawning in their natal rivers, researchers have also identified levels of genetic differentiation that indicate high degrees of reproductive isolation in at least 3 groupings (i.e., metapopulations) (Figure 9). Shortnose sturgeon in the Southeast comprise a single metapopulation, the “Carolinian Province” (Figure 9) (Wirgin et al. 2010) note that genetic differentiation among populations within the Carolinian Province was considerably less pronounced than among those in the other 2 metapopulations (i.e., Virginian Province and Acadian Province) and contemporary genetic data suggest that

[7] The fall line is the boundary between an upland region of continental bedrock and an alluvial coastal plain, sometimes characterized by waterfalls or rapids.

reproductive isolation among these populations is lower than elsewhere. In other words, the shortnose sturgeon populations within the Carolinian Province are more closely related to each other than the populations that make up either the Virginian or Acadian Provinces.

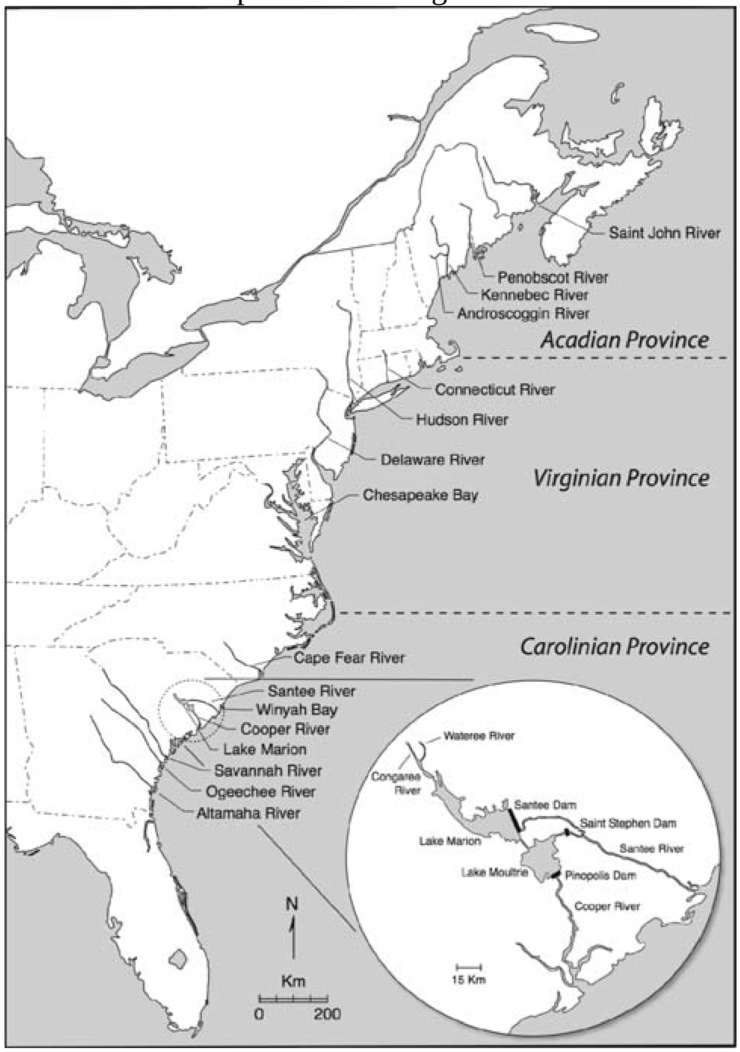


Figure 9. The North American Atlantic coast depicting 3 shortnose sturgeon metapopulations based on mitochondrial DNA control region sequence analysis (Wirgin et al. 2010).

The 3 shortnose sturgeon metapopulations should not be considered collectively but as individual units of management because each is reproductively isolated from the other and constitutes an evolutionarily (and likely an adaptively) significant lineage. Loss of the Carolinian Province ("southern") metapopulation of shortnose sturgeon would result in the loss of the southern half of the species' range (i.e., there is no known reproduction occurring between the Delaware River and Winyah Bay, SC). Loss of the Virginian Province ("mid-Atlantic") metapopulation would create a conspicuous discontinuity in the range of the species from the Hudson River to the northern extent of the southern metapopulation. The Acadian Province ("northern") metapopulation constitutes the northernmost portion of the U.S. range. Loss of the mid-Atlantic metapopulation (Virginian Province) would create a conspicuous discontinuity in the range of the species from the Hudson River to the northern extent of the southern metapopulation. The northern metapopulation constitutes the northernmost portion of the U.S. range. Loss of this metapopulation would result in a significant gap in the range that would serve to isolate the shortnose sturgeon that reside in Canada from the remainder of the species' range in the United States. The loss of any metapopulation would result in a decrease in spatial range, biodiversity, unique haplotypes, adaptations to climate change, and gene plasticity. Loss of unique haplotypes that may carry geographic specific adaptations would lead to a loss of genetic plasticity and, in turn, decrease adaptability. The loss of any metapopulation would increase species' vulnerability to random events.

The current status of the shortnose sturgeon in the Southeast is variable. Populations within the southern metapopulation are relatively small compared to their northern counterparts. Table 3 shows available abundance estimates for rivers in the Southeast. The Altamaha River supports the largest known shortnose sturgeon population in the Southeast with successful self-sustaining recruitment. Total population estimates in the Altamaha show large interannual variation is occurring; estimates have ranged from as low as 468 fish in 1993 to over 5,550 fish in 2006 (NMFS 1998; Peterson and Bednarski 2013). Abundance estimates for the Ogeechee River indicate the shortnose sturgeon population in this river is considerably smaller than in the Altamaha River. The highest point estimate since 1993 occurred in 2007 and resulted in a total Ogeechee River population estimate of 404 shortnose sturgeon (95% confidence interval [CI]: 175-633) (Peterson and Farrae 2011). However, subsequent sampling in 2008 and 2009 resulted in point estimates of 264 (95% CI: 126-402) and 203 (95% CI: 32-446), respectively (Peterson and Farrae 2011). Spawning is also occurring in the Savannah, Cooper, Congaree, and Yadkin-Pee Dee Rivers. The Savannah River shortnose sturgeon population is possibly the second largest in the Southeast with highest point estimate of the total population occurring in 2013 at 2,432 (95% CI: 1,025-6,102). Mean population estimates were lower in 2014 and 2015, reaching an estimated 1,390 (95% CI: 890-2,257) total individuals in 2015 (Bahr and Peterson 2017). Animals in the Savannah River face many environmental stressors and spawning is likely occurring in only a very small area. While active spawning is occurring in South Carolina's Winyah Bay complex (Black, Sampit, Yadkin-Pee Dee, and Waccamaw Rivers) the population status there is unknown. The most recent estimate for the Cooper River suggests a population of approximately 220 spawning adults (Cooke et al. 2004). Status of the other riverine populations supporting the southern metapopulation is unknown due to limited survey effort, with capture in some rivers limited to fewer than 5 specimens.

Table 3. Shortnose Sturgeon Populations and Their Estimated Abundances

Population (Location)	Data Series	Abundance Estimate (CI)[a]	Population Segment	Reference
Cape Fear River (NC)		>50	Total	
Winyah Bay (NC, SC)		unknown		
Santee River (SC)		unknown		
Cooper River (SC)	1996-1998	220 (87-301)	Adults	(Cooke et al. 2004)
ACE Basin (Ashepoo, Combahee, and Edisto Rivers) (SC)		unknown		
Savannah River (SC, GA)		1,000 - 3,000	Adults	B. Post, SCDNR 2003; NMFS unpublished
	2013	2,432 (1,025-6,102)	Total	(Bahr and Peterson 2017)
	2014	1,957 (1,261-3,133)	Total	
	2015	1,390 (890-2,257)	Total	
Ogeechee River (GA)	1993	361 (326-400)	Total	(Rogers and Weber 1994)
	1999-2000	147 (104-249)	Total	(Fleming et al. 2003)
	2007	404 (175-633)	Total	(Peterson and Farrae 2011)
	2008	264 (126-402)	Total	
	2009	203 (32-446)	Total	
Altamaha River (GA)	1988	2,862 (1,069-4,226)	Total	(NMFS 1998)
	1990	798 (645-1,045)	Total	(NMFS 1998)
	1993	468 (316-903)	Total	(NMFS 1998)
	2006	5,551 (2,804–11,304)	Total	(Peterson and Bednarski 2013)
	2009	1,206 (566–2,759)	Total	
Satilla River (GA)		N/A		
Saint Marys River (FL)		N/A		
St. Johns River (FL)		unknown	Total	(Fox et al. 2017)

[a] Population estimates (with confidence intervals [CIs]) are established using different techniques and should be viewed with caution. In some cases, sampling biases may have violated the assumptions of the procedures used or resulted in inadequate representation of a population segment. Some estimates (e.g., those without CIs or those that are depicted by ranges only) are the "best professional judgment" of researchers based on their sampling effort and success.

Annual variation in population estimates in many basins is due to changes in yearly capture rates that are strongly correlated with weather conditions (e.g., river flow, water temperatures). In "dry years," fish move into deep holes upriver of the saltwater/freshwater interface, which can make them more susceptible to gillnet sampling. Consequently, rivers with limited data sets among years and limited sampling periods within a year may not offer a realistic representation of the size or trend of the shortnose sturgeon population in the basin. As a whole, the data on shortnose sturgeon populations is rather limited and some of the differences observed between years may be an artifact of the sampling methods, models and assumptions used.

Threats

The shortnose sturgeon was listed as endangered under the ESA as a result of a combination of habitat degradation or loss (resulting from dams, bridge construction, channel dredging, and pollutant discharges), mortality (from impingement on cooling water intake screens, turbines, climate change, dredging, and incidental capture in other fisheries), and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats. The primary threats to the species today are described below.

Dams

Dams for hydropower generation, flood control, and navigation adversely affect shortnose sturgeon habitat by impeding access to spawning, developmental, and foraging habitat, modifying free-flowing rivers to reservoirs, physically damaging fish on upstream and downstream migrations, and altering water quality in the remaining downstream portions of spawning and nursery habitat.

Historically, sturgeon ascended to the farthest freshwater reaches and river heads to reach natal spawning grounds (Hightower 1998; Lawson 1711; McDonald 1887). An inability to move above dams and use potentially beneficial habitats may restrict population growth (NMFS 1998). Dams blocking migration could force sturgeon to spawn at locations that were not historically used (Kynard et al. 1999). If sturgeon have to deposit eggs in habitat further downstream because of an upstream dam, this may make survival of their progeny less likely. Sturgeon embryos and larvae have limited salt tolerance, so their habitat must be well upstream of the salt front (Van Eenennaam et al. 1996a). Also, if sturgeon must utilize habitat that is not suitable or less suitable than the original blocked spawning sites for successful adherence, fertilization, and development, then those eggs may not become viable progeny. This will affect the survival and recruitment of individuals of that particular year class and, over time, reduce the reproductive success and recruitment of new individuals to the population.

Fish passage devices have shown limited benefit to shortnose sturgeon as a means of minimizing impacts of dams because these devices have been historically designed for salmon and other water-column fish rather than large, bottom-dwelling species like sturgeon. However, NMFS continues to evaluate ways to effectively pass sturgeon above and below man-made barriers. For example, large nature-like fishways (e.g., rock ramps) hold promise as a mechanism for successful passage. Dams have separated the shortnose sturgeon population in the Cooper River, trapping some above the structure while blocking access upstream to sturgeon below the dam. Telemetry studies indicate that some shortnose sturgeon do pass upriver through the vessel lock in the Pinopolis Dam on the Cooper River in the Santee Cooper Lakes (Post et al. 2014). In 2011, 2 tagged shortnose sturgeon used the vessel lock in the Pinopolis Dam to pass upstream of the dam. One of the sturgeon was still inhabiting the lakes as of 2013, while the other sturgeon entered Lake Moultrie in March and returned to the Cooper River in April, either through the Pinopolis Lock or through the turbines at Jefferies Power Station (Post et al. 2014). Shortnose sturgeon inhabit only Lake Marion, the upper of the 2 reservoirs.

Additional impacts from dams include the Kirkpatrick Dam (aka Rodman Dam) located about ~12.9 km upstream from the St. Johns River, Florida on the Ocklawaha River (the largest tributary) as part of the Cross Florida Barge Canal. The Ocklawaha River has been speculated as the spawning area for shortnose sturgeon (NMFS 2010). The New Savannah Bluff Lock and Dam located on the Savannah River on the South Carolina and Georgia border also impedes shortnose sturgeon from accessing upstream shoal areas (NMFS 2010).

The presence of the dams on the Savannah River also harms sturgeon by restricting life functions other than spawning, particularly in the case of shortnose sturgeon. Sturgeon migrate to optimize feeding, avoid unfavorable conditions, and to optimize reproductive success (McKeown 1984; Northcote 1978; Tsyplakov 1978). Shortnose sturgeon are considered freshwater amphidromous species and are relatively constrained in their migratory patterns, as they typically migrate between freshwater and mesohaline river reaches but do not migrate extensively to marine habitats for feeding (Kynard 1997).

Dredging

Riverine, nearshore, and offshore areas are often dredged to support commercial shipping and recreational boating, construction of infrastructure, and marine mining. Environmental impacts of dredging include the direct removal/burial of prey species; turbidity/siltation effects; contaminant resuspension; noise/disturbance; alterations to hydrodynamic regime and physical habitat; and actual loss of riparian habitat (Chytalo 1996; Winger et al. 2000). Dredging in spawning and nursery grounds modifies the quality of the habitat and further restricts the extent of available habitat in the Cooper and Savannah Rivers, where shortnose sturgeon habitat has already been modified and restricted by the presence of dams.

Dredging directly effects sturgeon by entraining them in dredge drag arms and impeller pumps. Mechanical dredges have also been documented to kill sturgeon. (Dickerson 2013) summarized observed takes of 38 sturgeon from dredging activities conducted by USACE and observed from 1990-2013: 3 Gulf, 11 shortnose, and 23 Atlantic, and 1 unidentified due to decomposition. Of the three types of dredges included (hopper, clamshell, and pipeline) in the report, most sturgeon were captured by hopper dredge, though some takes were also noted in clamshell and pipeline dredges. Notably, reports include only those trips when an observer was on board to document capture. To offset the adverse effects associated dredging relocation trawling is used at times. The USACE has successfully used this technique to relocated Atlantic sturgeon, but only 2 shortnose sturgeon (1992 and 2004) have been captured in the Southeast.

Seasonal restrictions on dredging operations have been imposed in some rivers for some species; from example, a March 16–May 31 prohibition to protect striped bass in the Savannah River. This spring closure likely benefits sturgeon as well. Seasonal restrictions are also placed on hopper dredging conducted offshore of Savannah Harbor in the shipping channel to protect sea turtles. To reduce the impacts of dredging on anadromous fish species, most of the Atlantic states impose work restrictions during sensitive time periods (spawning, migration, feeding) when anadromous fish are present.

Water Quality

Shortnose sturgeon rely on a variety of water quality parameters to successfully carry out their life functions. Low dissolved oxygen (DO) and the presence of contaminants modify the quality of sturgeon habitat and, in some cases, restrict the extent of suitable habitat for life functions. (Secor 1995b) noted a correlation between low abundances of sturgeon during this century and decreasing water quality caused by increased nutrient loading and increased spatial and temporal frequency of hypoxic (low oxygen) conditions.

Shortnose sturgeon appear to become more resilient to low levels of DO as they age. (Jenkins et al. 1993) exposed 11-330 day old shortnose sturgeon to a range of DO levels at a static temperature of 22.5°C (72.5°F) for 6 hours. DO concentrations of 2.5 mg/L killed 100% of 25-day-old fish, 96% of fish 32 days old, and 86% of fish 64 days old but only 12% of the fish older than 104 days (Jenkins et al. 1993). (Jenkins et al. 1993) also reported young fish died at significantly higher rates for DO concentrations of 3.0 mg/L, while this concentration did not appear to adversely affect fish >77 days old. They also concluded that regardless of age, groups exposed to 2.0 mg/L died at significantly higher rates than the control groups (Jenkins et al. 1993).

Campbell and Goodman (2004) investigated the environmental impacts of water quality on shortnose sturgeon. They conducted tests with hatchery-produced fish exposed to ranges of DO, salinity, and temperature similar to what might be expected in the southeastern United States coastal river–estuary interfaces during spring and summer. For 77-day-old fish, they determined 50% mortality in 24 hours was likely when exposed to a combination of 2 parts per thousand (ppt) salinity, a temperature of 25°C (77°F), and a DO level of 2.7 mg/L. In older fish (104-days-old), a 50% mortality rate in 24 hours occurred with DO concentrations of 2.2 mg/L at 22°C (71.6°F) and salinities of 4 ppt (Campbell and Goodman 2004). However, even with relatively higher DO concentrations (3.1 mg/L), (Campbell and Goodman 2004) reported a 50% mortality rate in 24 hours for 100-day-old fish when temperature increased to of 30°C (86°F), even if the salinity decreased to 2 ppt.

These studies highlight concerns regarding the frequent occurrence of low DO conditions coupled with high temperatures in the river systems throughout the range of the shortnose sturgeon in the Southeast. For example, shallow waters in many of the estuaries and rivers in North Carolina and South Carolina will reach temperatures nearing 30^{o}C in the summer months. Both low flow and high water temperatures can cause DO levels to drop to less than 3.0 mg/L. Sturgeon are more sensitive to low DO than other fish species (Niklitschek and Secor 2009a; Niklitschek and Secor 2009b), and low DO in combination with high temperature is particularly problematic.

Elevated levels of environmental contaminants, including chlorinated hydrocarbons, in several fish species are associated with reproductive impairment (Cameron et al. 1992; Longwell et al. 1992), reduced egg viability (Hansen 1985; Mac and Edsall 1991; Von Westernhagen et al. 1981b), and reduced survival of larval fish (Berlin et al. 1981; Giesy et al. 1986). Several characteristics of shortnose sturgeon (i.e., long life span, extended residence in estuarine habitats, benthic predator) predispose the species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979). Chemicals and metals such as chlordane, dichlorodiphenyldichloroethylene (DDE*)*, dichlorodiphenyltrichloroethane (DDT), dieldrin, polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium settle to the river bottom and are later consumed by benthic feeders such as sturgeon or macroinvertebrates, and then work their way into the food web. Some of these compounds may affect physiological processes and impede a fish's ability to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing DO, altering pH, and altering other physical properties of the waterbody. Exposure to sufficient concentrations of these chemicals can cause lethal and sub-lethal effects such as: behavioral alterations, deformities, reduced growth, reduced fecundity, and reduced egg viability (Ruelle and Keenlyne 1993; USFWS 1993).

Waterborne contaminants may also affect the aquatic environment. Issues such as raised fecal coliform and estradiol concentrations affect all wildlife that utilize riverine habitat. The impact of many of these waterborne contaminants on sturgeon is unknown, but they are known to affect other species of fish in rivers and streams. These compounds may enter the aquatic environment via wastewater treatment plants, agricultural facilities, as well as runoff from farms (Culp et al. 2000; Folmar et al. 1996; Wallin et al. 2002; Wildhaber et al. 2000) and settle to the bottom, therefore affecting benthic foragers to a greater extent than pelagic (Geldreich and Clarke 1966). For example, estrogenic compounds are known to affect the male to female sex ratio of fish in streams and rivers via decreased gonadal development, physical feminization, and sex reversal (Folmar et al. 1996). Although the effects of these contaminants are unknown in shortnose and Atlantic sturgeon, Omoto et al. (2002) found that varying the oral doses of estradiol-17β or 17α methyltestosterone given to captive hybrid "bester" sturgeon (*Huso huso* female × *Acipenser ruthenus* male) could induce abnormal ovarian development or a lack of masculinization. These compounds, along with high or low DO concentrations, can result in sub-lethal effects that may have negative consequences on small populations.

More specifically to action area, Wilhelm and Maluk (1998) identified the following water-quality issues as high priority, regional-scale issues of concern in the Santee River Basin: (1) enrichment by nitrogen and phosphorus that has caused algal populations to increase; (2) sediment erosion due to agricultural practices of the 19^{th} and 20^{th} centuries; (3) runoff from urban areas that transport trace elements and synthetic organic compounds; (4) pesticides and nutrients that can contaminate surface and ground water; and (5) mercury presence in elevated concentrations in fish that inhabit the basin. Feaster and Conrads (2000) also identified point and non-point sources of bacterial contamination in the Santee River Basin.

Water Quantity

Water allocation issues are a growing threat in the Southeast and exacerbate existing water quality problems. Taking water from one basin and transferring it to another fundamentally and irreversibly alters natural water flows in both the originating and receiving basins. This transfer can affect DO levels, temperature, and the ability of the basin of origin to assimilate pollutants (GWC 2006). Large water withdrawals negatively affected water quality within the river systems in the range of the shortnose sturgeon. Known water withdrawals of over 240 million gallons per day are permitted from the Savannah River for power generation and municipal uses. However, permits for users withdrawing fewer than 100,000 gallons per day are not required, so actual water withdrawals from the Savannah River and other rivers within the range of the shortnose sturgeon are likely much higher. As of March 2020, no direct water withdrawals from the Cooper River had been permitted or registered with the South Carolina Department of Health and Environmental Control (L. Monroe, SCDHEC to A. Herndon, NMFS March 2020). The removal of large amounts of water from a river system alters flows, temperature, and DO. Water shortages and "water wars" are already occurring in the rivers occupied by the shortnose sturgeon and will likely be compounded in the future by human population growth and potentially by climate change.

Climate Change

Large-scale factors impacting riverine water quality and quantity that likely exacerbate habitat threats to shortnose sturgeon include drought, and intra- and inter-state water allocation. Changes in the climate are very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. For example, while annual precipitation in the Southeast has increased by 0.19 inches per decade since 1950 (NCDC 2019), the southeastern United States has experienced several years of drought since 2007. During this time, South Carolina experienced drought conditions that ranged from moderate to extreme. Between March 2007 and December 2008, 50-100% of the State of South Carolina experienced some level of drought ranging in intensity from "abnormally dry" to "exceptional," based on the drought intensity categories used by the U.S. Drought Monitor (NDMC 2018). That drought was surpassed just a few years later. South Carolina again experienced "abnormally dry" to "exceptional" drought conditions across 50-100% of those states again from September 2010-March 2013, experienced "abnormally dry" to "exceptional" drought conditions https://droughtmonitor.unl.edu/Data/Timeseries.aspx (NDMC 2018). Abnormally low stream flows can restrict sturgeon access to important habitats and exacerbate water quality issues such as reduced DO, and increased water temperature, nutrient levels, and contaminants.

Long-term observations also confirm changes in temperature are occurring at a rapid rate. From 1895-2018, the average annual temperature in the Southeast rose 0.1°F per decade. From 1950-2018, the increase tripled to 0.3°F per decade (NCDC 2019). Aside from observation, climate modeling also projects future increases in temperatures in the Southeast. Table 4 summarizes the increases projected for the Southeast by the mid-century (2036–2065) and late-century (2071–2100). These are projections from the Representative Concentration Pathway (RCP) model scenarios RCP8.5 and RCP4.5, used by the Intergovernmental Panel on Climate Change (IPCC), relative to average from 1976–2005 (Hayhoe et al. 2017).[8]

Table 4. Projected Temperature Increase in the Southeast Under Two Model Projections and Time Series (Hayhoe et al. 2017)

National Climate Assessment Region	RCP4.5 Mid-Century (2036–2065)	RCP8.5 Mid-Century (2036–2065)	RCP4.5 Late-Century (2071–2100)	RCP8.5 Late-Century (2071–2100)
Southeast	3.40°F (1.89°C)	4.30°F (2.39°C)	4.43°F (2.46°C)	7.72°F (4.29°C)

Shortnose sturgeon are already susceptible to reduced water quality resulting from dams, inputs of nutrients, contaminants from industrial activities and nonpoint sources, and interbasin transfers of water. The IPCC projects with high confidence that higher water temperatures and changes in extremes in the Southeast region, including floods and droughts, will affect water quality and exacerbate many forms of water pollution from sediments, nutrients, dissolved organic carbon, pathogens, pesticides, and salt, as well as thermal pollution, with possible negative impacts on ecosystems (IPCC 2007).

[8] RCPs make predictions based on changes, if any, in future greenhouse gas emissions. Specifically, they evaluate radiative forcing, or the amount of energy stored at the Earth's surface in watts/m^2. As the amount of greenhouse gases increases in the atmosphere more energy is trapped, and the number of watts/m^2 increases. RCP2.6 and RCP8.5 represent the lowest and highest radiative scenarios, of 2.6 watts/m^2 and 8.5 watts/m^2, respectively. RCP4.5 and RCP6.0 assume intermediate levels of radiative forcing.

Sea-level rise is another consequence of climate change; it has already had significant impacts on coastal areas and these impacts are likely to increase. Since 1852, when the first topographic maps of the Southeastern United States were prepared, high tidal flood elevations have increased approximately 12 inches. During the 20th century, global sea level has increased 15 to 20 cm (NAST 2000). Sea level rise is also projected to extend areas of salinization of groundwater and estuaries. Some of the most populated areas of this region are low-lying; the threat of saltwater entering into this region's aquifers with projected sea level rise is a concern (USGRG 2004). Saltwater intrusion will likely exacerbate existing water allocation issues, leading to an increase in reliance on interbasin water transfers to meet municipal water needs, further stressing water quality. Similarly, saltwater intrusion is likely to affect local ecosystems. Analysts attribute the forest decline in the Southeast to saltwater intrusion associated with sea level rise. Coastal forest losses will be even more severe if sea level rise accelerates as is expected as a result of global warming.

The effects of future climate change will vary greatly in diverse coastal regions for the United States. Warming is very likely to continue in the United States during the next 25 to 50 years, regardless of reduction in greenhouse gases, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that they will accelerate. A warmer and drier climate would reduce stream flows and increase water temperatures. Expected consequences would be a decrease in the amount of DO in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch et al. 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer, wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch et al. 2000).

Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the Southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer et al. 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development, like the Savannah or Cooper River, will experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer et al. 2008).

Dams, dredging, and poor water quality have already modified and restricted the extent of suitable habitat for shortnose sturgeon spawning and nursery habitat. Changes in water availability (depth and velocities) and water quality (temperature, salinity, DO, contaminants, etc.) in rivers and coastal waters inhabited by shortnose sturgeon resulting from climate change will further modify and restrict the extent of suitable habitat. Effects could be especially harmful since these populations have already been reduced to low numbers, potentially limiting their capacity for adaptation to changing environmental conditions (Belovsky 1987; Salwasser et al. 1984; Soulé 1987; Thomas 1990).

Bycatch

Overutilization of shortnose sturgeon from directed fishing caused initial severe declines in shortnose sturgeon populations in the Southeast, from which they have never rebounded. Further, continued collection of shortnose sturgeon as bycatch in commercial fisheries is an ongoing impact. Shortnose sturgeon are incidentally caught in state shad gillnet fisheries is occurring in the Ogeechee (NMFS 2010) and Altamaha (Bahn et al. 2012) rivers. Shortnose sturgeon are sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum reproductive rates, and a large percentage of egg production occurs later in life. In addition, stress or injury to shortnose sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

As a wide-ranging anadromous species, shortnose sturgeon are subject to numerous federal (United States and Canadian), state, provincial, and interjurisdictional laws, regulations, and agencies' activities. While these mechanisms have addressed impacts to shortnose sturgeon through directed fisheries, there are currently no mechanisms in place to address the significant risk posed to shortnose sturgeon from commercial bycatch. Though statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species, such as shortnose sturgeon, and their habitat, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the historical spawning rivers along the Atlantic coast, even with existing controls on some pollution sources. Current regulatory authorities are not necessarily effective in controlling water allocation issues (e.g., no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution).

Stochastic Events

Stochastic events, such as hurricanes, are common throughout the range of shortnose sturgeon. These events are unpredictable and their effect on the survival and recovery of the species in unknown; however, they have the potential to impede the survival and recovery directly if animals die as a result of them, or indirectly if habitat, is damaged as a result of these disturbances. For example, in 2018, flooding from Hurricane Florence flushed significant amounts of organic matter into rivers supporting sturgeon. The DO levels in those rivers dropped so low (i.e., 0.2 mg/L) that thousands of fish suffocated, including multiple sturgeon.

3.2.2 Carolina Distinct Population Segment of Atlantic Sturgeon

Five separate DPSs of Atlantic sturgeon were listed under the ESA by NMFS effective April 6, 2012 (77 FR 5880 and 5914, February 6, 2012). The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered. The Gulf of Maine DPS was listed as threatened.

Species Description and Distribution

Atlantic sturgeon are long-lived, late-maturing, estuarine-dependent, anadromous fish distributed along the eastern coast of North America (Waldman and Wirgin 1998). Historically, sightings have been reported from Hamilton Inlet, Labrador, Canada, south to the St. Johns River, Florida (Murawski et al. 1977; Smith and Clugston 1997). Atlantic sturgeon may live up to 60 years, reach lengths up to 14 ft., and weigh over 800 lbs (ASSRT 2007; Collette and Klein-MacPhee 2002). They are distinguished by armor-like plates (called scutes) and a long protruding snout that has four barbels (slender, whisker-like feelers extending from the lower jaw used for touch and taste). Adult Atlantic sturgeon spend the majority of their lives in nearshore marine waters, returning to the rivers where they were born (natal rivers) to spawn (Wirgin et al. 2002). Young sturgeon may spend the first few years of life in their natal river estuary before moving out to sea (Wirgin et al. 2002). Atlantic sturgeon are omnivorous benthic (bottom) feeders and incidentally ingest mud along with their prey. Diets of adult and subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (ASSRT 2007; Bigelow and Schroeder 1953; Guilbard et al. 2007; Savoy 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (ASSRT 2007; Bigelow and Schroeder 1953; Guilbard et al. 2007).

The Carolina DPS includes all Atlantic sturgeon that are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida.

The action area includes the Cooper River. The location of the action means eggs, larvae, juveniles, subadult, and adults could be affected by the action. While adult Atlantic sturgeon from all DPSs mix extensively in marine waters, generally adults return to their natal rivers to spawn. Genetic studies show that fewer than two adults per generation spawn in rivers other than their natal river (King et al. 2001; Waldman et al. 2002; Wirgin et al. 2000). Young sturgeon spend the first few years of life in their natal river estuary before moving out to sea.

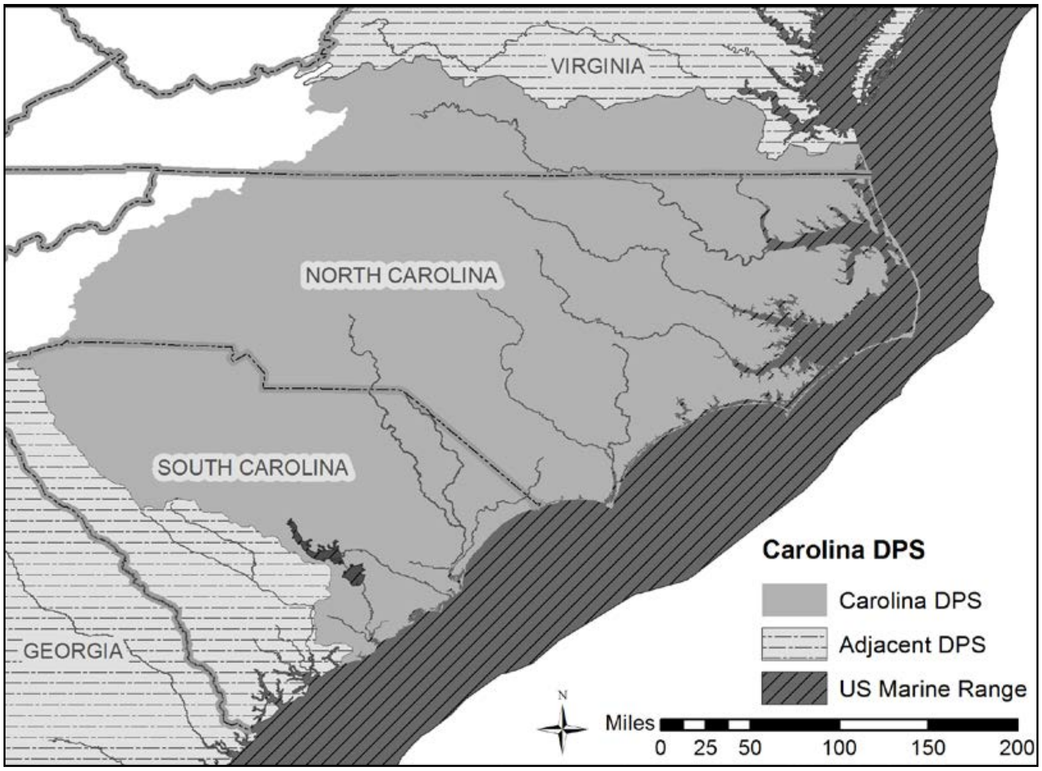


Figure 10. The Carolina DPS, including the adjacent portion of the marine range.

Life History Information

Atlantic sturgeon are generally referred to as having four size/developmental categories: larvae; young-of-year (YOY); juveniles and subadults; and adults. Hatching occurs approximately 94-140 hours after egg deposition. Immediately after hatching larvae enter the yolk sac larval stage and assume a demersal existence (Smith et al. 1980b). The yolk sac provides nutrients to the animals until it is completely absorbed 8-12 days after hatching (Kynard and Horgan 2002). Animals in this stage are fewer than 4 weeks old, with total lengths (TL) less than 30 millimeters (mm) (Van Eenennaam et al. 1996a). Animals in this phase are in freshwater and are located far upstream very near the spawning beds. As the larvae develop they commence downstream migration towards the estuaries. During the first half of their downstream migration, movement is limited to night. During the day, larvae use gravel, rocks, sticks, and other three-dimensional cover as refugia (Kynard and Horgan 2002). During the latter half of migration when larvae are more fully developed, movement occurs both day and night. Salinities of 5-10 ppt are known to cause mortality at this young stage (Bain 1997; Cech and Doroshov 2005; Kynard and Horgan 2002).

As larvae grow and absorb the yolk sac, they enter the YOY phase. YOY are greater than 4 weeks old but less than 1 year, and generally occur in the natal river. These animals are generally located in freshwater downstream of the spawning beds, though they can be found in the estuaries.

Following the YOY life phase, sturgeon develop into juveniles and subadults. There is little morphometric difference, aside from overall size, between juveniles and subadults; they are primarily distinguished by their occurrence within estuarine or marine waters. Juveniles are generally only found in estuarine habitats, while subadults may be found in estuarine and marine waters. As a group, juveniles and subadults range in size from approximately 300-1500 mm TL. The term “juveniles” refers to animals 1 year of age or older that reside in the natal estuary. Estuarine habitats are important for juveniles, serving as nursery areas by providing abundant foraging opportunities, as well as thermal and salinity refuges, for facilitating rapid growth. During their first 2 years, juvenile Atlantic sturgeon remain in the estuaries of their natal rivers, which may include both fresh and brackish channel habitats below the head of tide (Hatin et al. 2007). Upon reaching age 2, juveniles become increasingly salt tolerant and some individuals will begin their outmigration to nearshore marine waters (Bain 1997; Dovel and Berggren 1983; Hatin et al. 2007). Some juveniles will take up residency in non-natal rivers that lack active spawning sites (Bain 1997). By age 5, most juveniles have completed their transition to saltwater becoming “subadults,” “late-stage juveniles,” or “marine migratory juveniles”; however, these animals are frequently encountered in estuaries of non-natal rivers (Bahr and Peterson 2016).

Out migration of larger juveniles may be influenced by the density of younger, less-developed juveniles. Because early juveniles are intolerant of salinity, they are likely unable to use foraging habitats in coastal waters if riverine food resources become limited. However, older, more-developed juveniles are able to use these coastal habitat, though they may prefer the relatively predator-free environments of brackish water estuaries as long as food resources are not limited (Schueller and Peterson 2010).

Adults are sexually mature individuals of 1500+ mm TL and 5 years of age or older. They may be found in freshwater riverine habitats on the spawning grounds or making migrations to and from the spawning grounds. They also use estuarine waters seasonally, principally in the spring through fall and will range widely in marine waters during the winter. After emigration from the natal estuary, subadults and adults travel within the marine environment, typically in waters shallower than 50 m in depth, using coastal bays, sounds, and ocean waters often occurring over sand and gravel substrate (Collins and Smith 1997; Dovel and Berggren 1983; Dunton et al. 2010; Erickson et al. 2011; Greene et al. 2009; Laney et al. 2007; Murawski et al. 1977; Savoy and Pacileo 2003; Smith 1985; Stein et al. 2004; Vladykov and Greely 1963a; Welsh et al. 2002; Wirgin and King 2011).

Atlantic sturgeon populations show clinal variation, with a general trend of faster growth and earlier age at maturity in more southern systems. Atlantic sturgeon mature between the ages of 5 and 19 years in South Carolina (Smith et al. 1982), between 11 and 21 years in the Hudson River (Young et al. 1988), and between 22 and 34 years in the St. Lawrence River (Scott and Crossman 1973b). Atlantic sturgeon likely do not spawn every year. Multiple studies have shown that spawning intervals range from 1 to 5 years for males (Caron et al. 2002; Collins et al. 2000b; Smith 1985) and 2 to 5 years for females (Stevenson and Secor 1999; Van Eenennaam et al. 1996b; Vladykov and Greely 1963b). Fecundity (number of eggs) of Atlantic sturgeon has been correlated with age and body size, with egg production ranging from 400,000 to 8,000,000 eggs per female per year (Dadswell 2006; Smith et al. 1982; Van Eenennaam and Doroshov 1998). The average age at which 50 percent of maximum lifetime egg production is achieved is estimated to be 29 years, approximately 3 to 10 times longer than for other bony fish species examined (Boreman 1997b).

Spawning adult Atlantic sturgeon generally migrate upriver in spring to early summer, which occurs in February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Bain 1997; Caron et al. 2002; Murawski et al. 1977; Smith 1985; Smith and Clugston 1997). (Smith et al. 2015) confirmed a fall spawning run in the Roanoke River, North Carolina; however, they report a spring spawning run is also likely occurring. Fall spawning runs have also been confirmed in the Edisto and Altamaha rivers, in the South Atlantic DPS. Telemetry data collected in 2013 and 2015 show acoustically tagged fish making spawning runs in late summer (August – September) in the Savannah River (SCDNR, Unpublished data). This suggests that a fall spawn is occurring in a number of southern rivers (Collins et al. 2000b; Ingram and Peterson 2016; McCord et al. 2007; Moser et al. 1998; Rogers and Weber 1995; Weber and Jennings 1996). Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 centimeters (cm) per second and depths are 3-27 meters (m) (Bain et al. 2000a; Borodin 1925; Crance 1987b; Leland 1968b; Scott and Crossman 1973b). Males commence upstream migration to the spawning sites when waters reach around 6°C (Dovel and Berggren 1983; Smith 1985; Smith et al. 1982) with females following a few weeks later when water temperatures are closer to 12° or 13°C (Collins et al. 2000a; Dovel and Berggren 1983; Smith 1985). Atlantic sturgeon have highly adhesive eggs that must be laid on hard bottom in order to stick. Thus, spawning occurs over hard substrate, such as cobble, gravel, or boulders (Gilbert 1989a; Smith and Clugston 1997).

Status and Population Dynamics

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002; Secor 2002). Secor (2002) estimates that 8,000 adult females were present in South Carolina during that same time-frame. At the time of listing, each river population within the DPS was estimated at 3% of historical abundance, with fewer than 300 spawning adults (ASSRT 2007).

NMFS identified 7 rivers/river systems within the Carolina DPS where spawning is likely occurring (Roanoke; Tar- Pamlico; Neuse; Cape Fear and Northeast Cape Fear; Pee Dee, Waccamaw, Bull Creek; Black; Santee [although none confirmed as of 2020], and Cooper). We determined spawning was occurring if YOY were observed, or mature adults were present, in freshwater portions of a system. However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth due to lack of suitable habitat and the presence of other stressors on juvenile survival and development. Historically, both the Sampit and Ashley Rivers in South Carolina may have had spawning populations at one time. Yet, the spawning population (if it existed) in the Sampit River is believed to be extirpated and the current status of the spawning population in the Ashley River is unknown. Both rivers may be used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. This represents our current knowledge of the river systems likely being used by individuals from the Carolina DPS for spawning. Fish from the Carolina DPS likely use these and other river systems to fulfill other specific life functions (e.g., nursery habitat, foraging).

In 2017, the Atlantic States Marine Fisheries Commission (ASMFC) completed an Atlantic Sturgeon Benchmark Stock Assessment (ASMFC 2017). The purpose of the assessment was to evaluate the status of Atlantic sturgeon along the U.S. Atlantic coast (ASMFC 2017). The assessment considered the status of each DPS individually, as well as all 5 DPSs collectively as a single unit. The assessment determined the Carolina DPS abundance is "depleted" relative to historical levels. It also determined there is a relatively high probability (67%) that the Carolina DPS abundance has increased since the implementation of the 1998 fishing moratorium, and a relatively high probability (75%) the Carolina DPS is still subjected to mortality levels higher than determined acceptable in the 2017 assessment.

The assessment also estimated effective population sizes (N_e) when possible. Effective population size is generally considered to be the number of individuals that contribute offspring to the next generation. More specifically, based on genetic differences between animals in a given year, or over a given period of time, researchers can estimate the number of adults needed to produce that level of genetic diversity. For the Carolina DPS, N_e has only been reported for the Albemarle Sound, in the assessment and also by (Waldman et al. 2018) (Table 5).

Table 5. Estimates of Effective Population Size for the Albemarle Sound

River	Effective Population Size (N_e) (95% CI)	Sample Size	Collection Years	Reference
Albemarle Sound	14.2 (11.8-17.1)	37	1998-2008	(ASMFC 2017)
	19.0 (16.5–20.6)	88	1998, 2006-2011, 2013-2014	(Waldman et al. 2018)

Generally, a minimum N_e of 100 individuals is considered the threshold required to limit the loss in total fitness from in-breeding depression to <10%; while an N_e greater than 1,000 is the recommended minimum to maintain evolutionary potential (ASMFC 2017; Frankham et al. 2014). N_e is useful for defining abundance levels where populations are at risk of loss of genetic fitness (ASMFC 2017). Based on estimates presented in Table 5, the N_e for Albemarle Sound ranges from14.2 (ASMFC 2017) to 19.0 individuals (Waldman et al. 2018). While not inclusive of all the spawning rivers in the Carolina DPS, these estimates at least hint that there is a risk for both inbreeding depression ($N_e < 100$) and loss of evolutionary potential ($N_e < 1000$) in the DPS.

The concept of a viable population able to adapt to changing environmental conditions is critical to Atlantic sturgeon. Low population numbers of every river population in the Carolina DPS relative to historical abundance, as well as low N_e estimates, indicates the DPS is in danger of extinction; none of the river populations are large or stable enough to provide with any level of certainty for continued existence of the Carolina DPS. Although the largest impact that caused the precipitous decline of the species has been restricted (directed fishing), the population sizes within the Carolina DPS have remained relatively constant at very reduced levels (approximately 3% of historical population sizes) for 100 years. Small numbers of individuals resulting from drastic reductions in populations, such as occurred with Atlantic sturgeon due to the commercial fishery, can remove the buffer against natural demographic and environmental variability provided by large populations (Berry 1971; Shaffer 1981; Soulé 1980). Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon, and they continue to face a variety of other threats that contribute to their risk of extinction. Their late age at maturity provides more opportunities for individual Atlantic sturgeon to be removed from the population before reproducing. While a long life span also allows multiple opportunities to contribute to future generations, it also increases the timeframe over which exposure to the multitude of threats facing the Carolina DPS can occur.

The viability of the Carolina DPS depends on having multiple self-sustaining riverine spawning populations and maintaining suitable habitat to support the various life functions (spawning, feeding, growth) of Atlantic sturgeon populations. Because a DPS is a group of populations, the stability, viability, and persistence of individual populations affects the persistence and viability of the larger DPS. The loss of any population within a DPS will result in (1) a long-term gap in the range of the DPS that is unlikely to be recolonized, (2) loss of reproducing individuals, (3) loss of genetic biodiversity, (4) potential loss of unique haplotypes, (5) potential loss of adaptive traits, (6) reduction in total number, and (7) potential for loss of population source of recruits. The loss of a population will negatively impact the persistence and viability of the DPS as a whole, as fewer than two individuals per generation spawn outside their natal rivers (King et al. 2001; Waldman et al. 2002; Wirgin et al. 2000). The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, the immigration into marine habitats to grow, and then the return of adults to natal rivers to spawn.

Threats

Atlantic sturgeon were once numerous along the East Coast until fisheries for their meat and caviar reduced the populations by over 90 percent in the late 1800s. Fishing for Atlantic sturgeon became illegal in state waters in 1998 and in waters under federal jurisdiction in 1999. Dams, dredging, poor water quality, and accidental catch (bycatch) by fisherman continue to threaten Atlantic sturgeon. The Carolina DPS was listed as endangered under the ESA because of a combination of habitat restriction and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

<u>Dams</u>

Dams for hydropower generation, flood control, and navigation adversely affect Atlantic sturgeon habitat by impeding access to spawning, developmental, and foraging habitat, modifying (diverting) free-flowing rivers to reservoirs, physically damaging fish on upstream and downstream migrations, and altering water quality in the remaining downstream portions of spawning and nursery habitat.

Fish passage devices have shown limited benefit to Atlantic sturgeon as a means of minimizing impacts of dams because these devices have been historically designed for salmon and other water-column fish rather than large, bottom-dwelling species like sturgeon. However, NMFS continues to evaluate ways to effectively pass sturgeon above and below man-made barriers. For example, large nature-like fishways (e.g., rock ramps) hold promise as a mechanism for successful passage. Dams have restricted Atlantic sturgeon spawning and juvenile developmental habitat by blocking over 60% of the historical sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. Water quality (velocity, temperature, and DO) downstream of these dams, as well as on the Roanoke River, have been reduced, which modifies and restricts the extent of spawning and nursery habitat for the Carolina DPS.

<u>Dredging</u>

Riverine, nearshore, and offshore areas are often dredged to support commercial shipping and recreational boating, construction of infrastructure, and marine mining. Environmental impacts of dredging include the direct removal/burial of prey species, turbidity/siltation effects, contaminant resuspension, noise/disturbance, alterations to hydrodynamic regime and physical habitat, and actual loss of riparian habitat (Chytalo 1996; Winger et al. 2000). According to (Smith and Clugston 1997), dredging and filling impact important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates. Dredging in spawning and nursery grounds modifies the quality of the habitat and is further restricting the extent of available habitat in the Cape Fear and Cooper Rivers, where Atlantic sturgeon habitat has already been modified and restricted by the presence of dams.

Dredging directly affects sturgeon by entraining them in dredge drag arms and impeller pumps. The potential impacts to Atlantic sturgeon from mechanical dredging and potential benefits from seasonal dredging restrictions are similar to those described for shortnose sturgeon in Section 3.2.1 *Threats – Dredging*.

<u>Water Quality</u>

Atlantic sturgeon rely on a variety of water quality parameters to successfully carry out their life functions. Low DO and the presence of contaminants modify the quality of Atlantic sturgeon habitat and in some cases, restrict the extent of suitable habitat for life functions. (Secor 1995a) noted a correlation between low abundances of sturgeon during this century and decreasing water quality caused by increased nutrient loading and increased spatial and temporal frequency of hypoxic (low oxygen) conditions. Of particular concern is the frequent occurrence of low DO coupled with high temperatures in the river systems throughout the range of the Carolina DPS in the Southeast. Sturgeon are more sensitive to low DO than other fish species (Niklitschek and Secor 2009b; Niklitschek and Secor 2009c) and low DO in combination with high temperature is particularly problematic for Atlantic sturgeon. Studies have shown that juvenile Atlantic sturgeon experience lethal and sublethal (metabolic, growth, feeding) effects as DO drops and temperatures rise (Niklitschek and Secor 2005; Niklitschek and Secor 2009b; Niklitschek and Secor 2009c; Secor and Gunderson 1998). Reductions in water quality from terrestrial activities have modified habitat utilized by the Carolina DPS. In the Pamlico and Neuse systems, nutrient loading and seasonal anoxia are occurring, associated in part with concentrated animal feeding operations (CAFOs). Heavy industrial development and CAFOs have degraded water quality in the Cape Fear River. Water quality in the Waccamaw and Yadkin-Pee Dee Rivers has been affected by industrialization and riverine sediment samples contain high levels of various toxins, including dioxins.

Atlantic sturgeon may be particularly susceptible to impacts from environmental contamination because they are long-lived, benthic feeders. Sturgeon feeding in estuarine habitats near urbanized areas may be exposed to numerous suites of contaminants within the substrate. Contaminants, including toxic metals, polychlorinated aromatic hydrocarbons (PAHs), organophosphate and organochlorine pesticides, polychlorinated biphenyls (PCBs), and other chlorinated hydrocarbon compounds can have substantial deleterious effects on aquatic life. These elements and compounds can cause acute lesions, growth retardation, and reproductive impairment in fishes (ASSRT 2007; Cooper 1989; Sindermann 1994).

Water Quantity

Water allocation threats facing Atlantic sturgeon are similar to those described for shortnose sturgeon in Section 3.2.1 *Threats – Water Quantity*. However, additional impacts affecting Carolina DPS Atlantic sturgeon include 20 interbasin water transfers that existed prior to 1993, averaging 66.5 million gallons per day. These withdrawals were authorized at their maximum levels without being subjected to an evaluation for certification by the North Carolina Department of the Environment and Natural Resources or other resource agencies. Since the 1993 legislation requiring certificates for transfers, almost 170 million gallons per day of interbasin water withdrawals have been authorized, with an additional 60 million gallons per day pending certification. The removal of large amounts of water from the system will alter flows, temperature, and DO. Existing water allocation issues will likely be compounded by human population growth and potentially climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient loading, pollution inputs, and lower DO, all of which are current stressors to the Carolina DPS.

Climate Change

Large-scale factors impacting riverine water quality and quantity that likely exacerbate habitat threats to Atlantic sturgeon of the Carolina DPS include drought, and intra- and inter-state water allocation. Changes in the climate are very likely to be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. The Carolina DPS is already susceptible to reduced water quality resulting from inputs of nutrients; contaminants from industrial activities, CAFOs, and non-point sources; and inter-basin transfers of water. Many of same stressors and projections described previously for shortnose sturgeon in Section 3.2.1 *Threats – Climate Change* apply to Atlantic sturgeon as well.

Bycatch Mortality

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast, from which they have never rebounded. Further, continued overutilization of Atlantic sturgeon as bycatch in commercial fisheries is an ongoing impact to the Carolina DPS. Atlantic sturgeon are more sensitive to bycatch mortality because they are a long-lived species, have an older age at maturity, have lower maximum reproductive rates, and a large percentage of egg production occurs later in life. Based on these life history traits, Boreman (1997a) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5 percent of their population to bycatch mortality without suffering population declines. Mortality rates of Atlantic sturgeon taken as bycatch in various types of fishing gear range between 0 and 51 percent, with the greatest mortality occurring in sturgeon caught by sink gillnets. Atlantic sturgeon are particularly vulnerable to being caught in sink gillnets; therefore, fisheries using this type of gear account for a high percentage of Atlantic sturgeon bycatch. Little data exists on bycatch in the Southeast and high levels of bycatch underreporting are suspected. Further, a total population abundance for the DPS is not available, and it is therefore not possible to calculate the percentage of the DPS subject to bycatch mortality based on the available bycatch mortality rates for individual fisheries. However, fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to capture in multiple fisheries throughout their range. In addition, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins and low DO). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality.

Stochastic Events

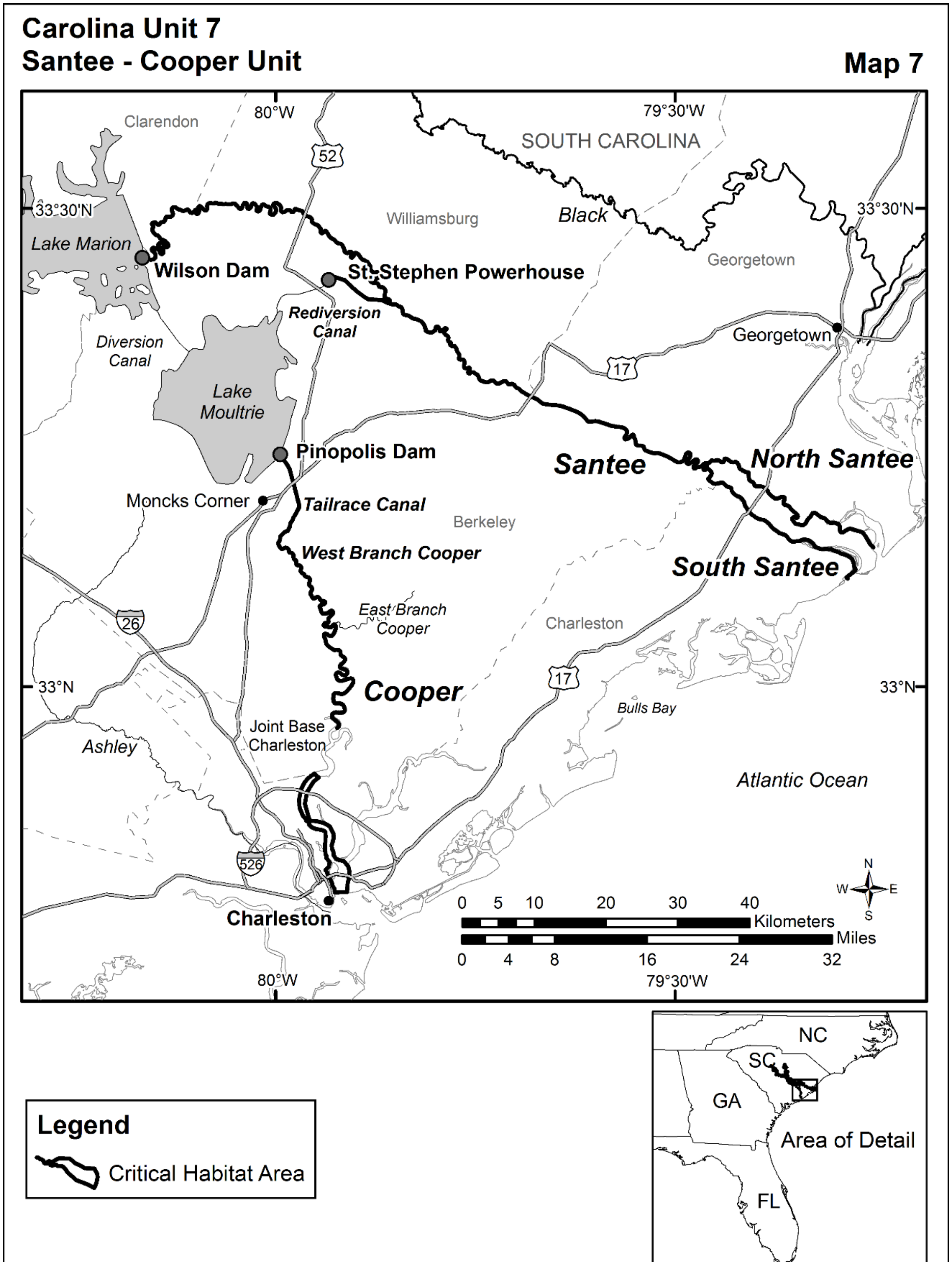
Stochastic events, just like those described for shortnose sturgeon in Section 3.2.1. *Threats – Stochastic Events*, can affect Atlantic sturgeon from the Carolina DPS.

3.3 Critical Habitat Likely to be Adversely Affected

In 2012, NMFS listed five DPSs of Atlantic sturgeon under the ESA: Four were listed as endangered (New York Bight DPS and Chesapeake Bay DPS; 77 FR 5880; February 6, 2012; Carolina DPS and South Atlantic DPS; 77 FR 5914; February 6, 2012) and one as threatened (Gulf of Maine DPS; 77 FR 5880; February 6, 2012). At the time, NMFS was unable to determine critical habitat for any of the DPSs. On August 17, 2017, NMFS designated a total of 28 critical habitat units for all five DPSs (82 FR 39160). Fourteen units were designated in Southeast; 7 in Carolina DPS and 7 in the South Atlantic DPS.

Critical Habitat Unit Affected by this Action

This consultation focuses on an activity occurring in Carolina Unit 7-Santee and Cooper Rivers. Carolina Unit 7 includes the mainstem Santee River (below the Wilson Dam), the Rediversion Canal (below the St. Stephens Dam), the North Santee River, the South Santee River, and Trailrace Canal – West Branch Cooper River (below the Pinopolis Dam) and the mainstem Cooper River (Figure 11). The lateral extent for the unit is the ordinary high water mark on each bank of the river and shorelines.



This map illustrates Atlantic sturgeon critical habitat. Critical habitat is all of the river within the illustrated Critical Habitat Area from the ordinary high water mark on one riverbank to the ordinary high water mark of the opposing riverbank, with the exception of U.S. Department of Defense sites determine to be ineligible for designation. For clarification of the critical habitat definition, please refer to the narrative description.

Figure 11. Atlantic Sturgeon Critical Habitat Carolina Unit 7

Essential Features of Critical Habitat

The final rule designating critical habitat for Atlantic sturgeon identified the key conservation objectives for the Carolina and South Atlantic DPSs are to increase their abundance by facilitating increased survival of all life stages and facilitating adult reproduction and juvenile and subadult recruitment into the adult population (82 FR 39160; August 17, 2017). The physical features determined to essential to conservation of the species that may require special management considerations or protection, which support the identified conservation objectives, are in the Table 6.

Table 6. Physical and Biological Features (PBF) of Atlantic Sturgeon Critical Habitat

PBF		Purpose/Role of PBF
“Hard Substrate”	Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand [ppt] range)	Necessary for the settlement of fertilized eggs and refuge, growth, and development of early life stages
“Salinity Gradient and Soft Substrate”	Aquatic habitat inclusive of waters with a gradual downstream gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites	Necessary for juvenile foraging and physiological development
“Unobstructed Water of Appropriate Depth”	Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites	Necessary to support: • Unimpeded movement of adults to and from spawning sites; • Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and • Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (at least 1.2 meters) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river
“Water Quality”	Water quality conditions, especially in the bottom meter of the water column, with suitable temperature and oxygen values	Necessary to support: • Spawning; • Annual and inter-annual adult, subadult, larval, and juvenile survival; and • Larval, juvenile, and subadult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L dissolved oxygen or greater likely supports juvenile rearing habitat, whereas dissolved oxygen less than 5.0 mg/L for longer than 30 days is less likely to support rearing when water temperature is greater than 25°C. In temperatures greater than 26°C, dissolved oxygen greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 to 26 °C are likely to support spawning.

Habitat Use and Biological and Physical Feature (PBF) Function

Hard Substrate

Atlantic sturgeon spawn well upstream, at or near the fall line of rivers, over hard substrate consisting of rock, pebbles, gravel, cobble, limestone, or boulders (Gilbert 1989b; Smith and Clugston 1997). Spawning sites are well-oxygenated areas with flowing freshwater (Bain et al. 2000b; Balazik et al. 2012; Bigelow et al. 1963; Collins et al. 2000a; Dees 1961; Hager et al. 2014; Ryder 1890; Scott and Crossman 1973a; Vladykov and Greely 1963a). Hard bottom substrates are required for successful spawning because within minutes of being fertilized, the eggs become sticky and adhere to the substrate for the relatively short and temperature-dependent period of larval development (Mohler 2003; Murawski et al. 1977; Ryder 1890; Smith et al. 1980a; Van Den Avyle 1984; Vladykov and Greely 1963a). After hatching the larvae begin to move downstream. The interstitial spacing in these complex hard bottom habitats also provide refuge for newly hatched larvae (Gilbert 1989b; Smith and Clugston 1997).

Very low salinity (i.e., 0.0 – 0.5 ppt) water is required because exposure to even low levels of salinity can kill Atlantic sturgeon during their first few weeks of life. This susceptibility to salt water limits their downstream movement until they can endure brackish waters (Bain et al. 2000b). Atlantic sturgeon tend to spawn 200-300 km upriver, buffering the youngest life stages from salt exposure too early in their development. (Parker and Kynard 2005) also noted that long larval/early juvenile downstream movement is common in shortnose sturgeon from the Savannah River, and that this may be a widespread adaptation of sturgeon inhabiting river systems in the southern United States. Due to the similarities between shortnose and Atlantic sturgeon, they likely both adapted a similar spawning strategy. Therefore, successful recruitment requires that hard bottom spawning substrate is located far enough upstream to allow Atlantic sturgeon larvae to develop and mature during their downstream movement before encountering saline water.

Salinity Gradient and Soft Substrate

Developing Atlantic sturgeon also need to forage in areas of soft substrate and to encounter transitional salinity zones as they move downstream to allow physiological adaptations to higher salinity waters to occur. These early life stages are susceptible to exposure to salinity and will die if exposed to salinities of 5-10 ppt prior to undergoing the proper physiological development. As the juveniles grow and move back toward the estuaries/ocean, they become more salt tolerant and spend the majority of their time over soft substrate feeding on things like isopods, aquatic insects, and other invertebrates.

Unobstructed Water of Appropriate Depth

Minimum water depths for Atlantic sturgeon spawning are necessary to: (1) allow adult fish to access spawning substrate, (2) adequately hydrate and aerate newly deposited eggs, and (3) facilitate successful development and downstream movement of newly spawned Atlantic sturgeon. The scientific literature indicates that Atlantic sturgeon spawn in water depths from 3-27 meters (9.8 – 88.6 ft.) (Bain et al. 2000b; Borodin 1925; Crance 1987a; Leland 1968a; Scott and Crossman 1973a). However, much of this information is derived from studies of Atlantic sturgeon in northern United States and Canadian river systems. Atlantic sturgeon in the Southeast are likely spawning in much shallower water depths based on repeated observations by biologists of sturgeon with lacerations on their undersides from moving into extremely shallow water to spawn on hard substrate. Based on the available information, and the body depth and spawning behavior of Atlantic sturgeon, water depths of at least 1.2 meters (4 ft.) are necessary to accommodate Atlantic sturgeon spawning. However, water depth at spawning areas in the Southeast can be dynamic and portions of rivers may be dry or have little water at times due to natural seasonal river fluctuations, temporary drought conditions, and/or regulation by manmade structures such as dams. Because Atlantic sturgeon must travel such far distances upriver to reach their spawning grounds, water depth and river barriers play an important role in determining whether or not they reach suitable spawning habitat (82 FR 39160; August 17, 2017).

Adult Atlantic sturgeon need to be able to safely and efficiently move from downstream areas into upstream spawning habitats to successfully spawn. Similarly, larvae, juvenile, and post-spawning adult Atlantic sturgeon must be able to safely and efficiently travel from the upstream spawning areas downstream to nursery and foraging habitat. Therefore, unobstructed migratory pathways are as important as water depth (82 FR 39160; August 17, 2017). Barriers to migration (e.g., dams, fishing gear, sound) or water too shallow to swim through can prevent adults from reaching the spawning grounds, while also preventing juveniles from being able to move back down toward the estuaries and ocean.

Water Quality

Water quality (particularly temperature and DO) can be a critically limiting factor to Atlantic sturgeon in the shallow, warm, poorly oxygenated rivers of the southeast United States. Conditions in these river systems can change rapidly, particularly in rivers managed for hydropower production, and conditions can quickly become suboptimal or lethal for sturgeon. The distribution of Atlantic sturgeon juveniles in the natal estuary is a function of physiological development and habitat selection based on water quality factors of temperature, salinity, and DO, which are inter-related environmental variables. In laboratory studies with salinities of 8 to 15 ppt and temperatures of 12 and 20 °C, juveniles less than a year old had reduced growth at 40 percent DO saturation, grew best at 70 percent DO saturation, and selected conditions that supported growth (Niklitschek and Secor 2009a; Niklitschek and Secor 2009c). Results obtained for age-1 juveniles (i.e., greater than 1 year old and less than 2 years old) indicated that they can tolerate salinities of 33 ppt (i.e., a salinity level associated with seawater), but grow faster in lower salinity waters (Allen et al. 2014; Niklitschek and Secor 2009a). The best growth for both age groups occurred at DO concentrations greater than 6.5 mg/L. While specific DO concentrations at temperatures considered stressful for Atlantic sturgeon are not available, instantaneous minimum concentrations of 4.3 mg/L protect survival of shortnose sturgeon at temperatures greater than 29°C (EPA 2003). (Secor and Niklitschek 2001) report shortnose sturgeon are more tolerant of higher temperatures than Atlantic sturgeon. This is why (Campbell and Goodman 2004) considered 29°C a stressful temperature for shortnose sturgeon, while (Secor and Gunderson 1998) report Atlantic sturgeon becoming stressed at a lower threshold of 26°C.

Status and Threats to Critical Habitat

The close relationship between a species and its habitat means threats posed to a species, often pose similar threats to their habitat. Many of the threats to the Santee-Cooper Unit of Atlantic Sturgeon Critical Habitat are very similar to those posed to Atlantic sturgeon occupying the unit.

Modification and loss of Atlantic sturgeon critical habitat is an ongoing threat contributing to the current status of the species. Habitat alterations potentially affecting Atlantic sturgeon critical habitat are very similar to those affecting the species. These include dam construction and operation, dredging and disposal, and water quality modifications such as changes in levels of DO, water temperature, and contaminants. Loss of habitat and poor water quality have contributed to the decline of Atlantic sturgeon since European settlement; however, the importance of this threat has varied over time and by location. Some important aspects of habitat quality, especially water quality, have improved during the last thirty years (ASSRT 2007).

Dams

Dams for hydropower generation, flood control, and navigation adversely affect all 4 PBFs of Atlantic sturgeon critical habitat. Dams are one of the clearest examples of an obstruction to movement of all life stages of sturgeon. Dams often completely block access to the hard substrate feature. Even in cases where sturgeon can pass above a dam, the impoundments dams create slow river flows which causes sedimentation. Sedimentation reduces the efficiency of egg adhesion and eventually will completely bury hard substrate. The same sedimentation effects can occur on downstream hard substrate during flow releases from dams. Sedimentation also fills interstitial spaces between hard substrate, removing/reducing refugia for larval sturgeon.

Dams' influence over downstream flows also has significant effects on Atlantic sturgeon critical habitat. Dams can change the salinity gradient by withholding water, reducing downstream flows. Those reduced flows allow saltwater to move further upriver. Reduced flows can also alter the depth within a river. Reduced river depths can affect the ability of sturgeon to move between upstream spawning habitat and downstream foraging, staging, resting, and holding habitat. The quality of water released, specifically temperature and DO, by dams is also often poor. Because the water released from dams is often from near the bottom of the impoundment, it is usually very low in DO and very cold.

The Santee-Cooper rivers is dominated by the 3 dams: the Pinopolis Dam at the upper end of the Cooper River (after construction of the Tailrace Canal, it is at mile 48); the Santee Dam at mile 87 on the Santee River; and the St. Stephens Dam also on the Santee River. These dams were constructed in the coastal plain and block access to over 60% of the historical sturgeon habitat upstream of the dams (77 FR 5914; February 6, 2012).

The amount of water flowing through Carolina Unit 3 is largely dictated by the releases from these 3 dams. Flow from the Pinopolis Dam (via the Jefferies Powerhouse) into the Cooper River maintained at a weekly average of 4,500 cubic feet per second (cfs). The operations constraints at the Jefferies Powerhouse are due to the re-diversion of flow through the USACE St. Stephen Project and to help manage the intrusion of the saltwater wedge in the Cooper River to protect industrial and potable water intakes. Flows into the Santee River from the Wilson Dam are currently a minimum instantaneous flow of 500 cfs. However, following NMFS' completion of an Opinion of the hydropower facilities, flows into the Santee River will increase to 1,200 cfs May through November and 2,400 cfs December through April. Flows may be increased to as high as 5,000 cfs if needed to support sturgeon spawning.

Dredging
Dredging can affect all 4 PBFs. Environmental impacts of dredging include the direct removal/burial of organisms (PBF 2); turbidity/siltation effects (PBF 1-4); contaminant resuspension (PBF 2-4); noise/disturbance (PBF 3); alterations to hydrodynamic regime and physical habitat (Chytalo 1996; Winger et al. 2000). According to (Smith and Clugston 1997), dredging and filling impact important habitat features of Atlantic sturgeon as they disturb benthic fauna, eliminate deep holes, and alter rock substrates. Dredging in nursery grounds modifies the quality of the habitat and is further curtailing the extent of available habitat in the Cooper River, where sturgeon habitat has already been modified and curtailed by the presence of dams. Maintenance dredging is currently modifying Atlantic sturgeon nursery habitat in the Cooper River and modeling indicates that the deepening of the navigation channel will result in reduced DO and upriver movement of the salt wedge, restricting spawning habitat. For example, the dredging associated with the Port of Charleston deepening were estimated to change the location of the saltwater/freshwater interface; increase salinity in the Cooper River by 0.4 ppt on average; and reduce the Cooper River DO reductions by 0.02 mg/L to 0.1256 mg/L (NMFS 2015).

Water Quality
Atlantic sturgeon rely on a variety of water quality parameters to successfully carry out their life functions. Low DO (PBF 4) and the presence of contaminants (PBF 3) modify the quality of Atlantic sturgeon habitat and in some cases, restrict the extent of suitable habitat for life functions. Of particular concern is the high occurrence of low DO coupled with high temperatures in the river systems throughout the range of the South Atlantic DPS in the Southeast. Unlike many rivers in the Southeast, DO concentrations in the Santee and Cooper rivers are generally not stressful for sturgeon and likely do not affect any PBF's ability to fulfill its conservation objective

Wilhelm et al. (1998) identified the following water-quality issues as high priority, regional-scale issues of concern in the Santee River Basin: (1) enrichment by nitrogen and phosphorus that has caused algal populations to increase; (2) sediment erosion due to agricultural practices of the 19th and 20th centuries; (3) runoff from urban areas that transport trace elements and synthetic organic compounds; (4) pesticides and nutrients that can contaminate surface and ground water; and (5) mercury presence in elevated concentrations in fish that inhabit the basin. Feaster and Conrads (2000) also identified point and non-point sources of bacterial contamination in the Santee River Basin.

Environmental contamination can affect PBF 3 because Atlantic sturgeon are long-lived, benthic feeders. Sturgeon feeding in estuarine habitats near urbanized areas may be exposed to numerous suites of contaminants within the substrate. While contamination may not directly affect the availability of prey on soft substrate, it may affect the quality. If those prey species ultimately absorb contaminants and pass them along to sturgeon. For example, heavy metals and organochlorine compounds accumulate in sturgeon tissue, but their long-term effects are not known (Ruelle and Henry 1992; Ruelle and Keenlyne 1993). Elevated levels of contaminants, including chlorinated hydrocarbons, in several other fish species are associated with reproductive impairment (Cameron et al. 1992; Drevnick and Sandheinrich 2003; Hammerschmidt et al. 2002; Longwell et al. 1992), reduced egg viability (Billsson et al. 1998; Giesy et al. 1986; Mac and Edsall 1991; Matta et al. 1997; Von Westernhagen et al. 1981a), reduced survival of larval fish

(Berlin et al. 1981; Giesy et al. 1986), delayed maturity (Jorgensen (Jorgensen et al. 2004) and posterior malformations (Billsson et al. 1998). Pesticide exposure in fish may affect antipredator and homing behavior, reproductive function, physiological development, and swimming speed and distance (Beauvais et al. 2000; Moore and Waring 2001; Scholz et al. 2000; Waring and Moore 2004). It should be noted that the effect of multiple contaminants or mixtures of compounds at sub-lethal levels on fish has not been adequately studied.

Water Quantity

Water allocation issues are a growing threat in the Southeast and exacerbate existing water quality problems. Removals of water from a river can affect all 4 PBFs, but the primary direct impacts are to PBF 3 and PBF 4. Water withdrawals can directly affect the water depth in rivers creating obstructions if the water depths fall so low the river channel becomes impassible. Similarly, shallower water can warm more quickly causing decreases in DO concentrations. Significant warming can lead to stressful water temperatures and DO concentrations. Water shortages and "water wars" are already occurring and will likely be compounded in the future by population growth and potentially by climate change.

Climate Change

Large-scale factors impacting riverine water quality and quantity that likely exacerbate habitat threats to Atlantic sturgeon of the Carolina DPS include drought, and intra- and inter-state water allocation. Because the adverse effects from climate change to Atlantic sturgeon are most likely to manifest themselves via habitat impacts, the potential impacts of climate change on Atlantic sturgeon critical habitat will be very similar to those discussed previously under Section 3.2.1 *Threats – Climate Change*.

Stochastic Events

Stochastic events such as hurricanes, are relatively common in and around the Santee-Cooper Unit. These events are unpredictable and their effect on the ability of the PBFs to function properly is variable but can be significant. For example, in 2018, flooding from Hurricane Florence flushed significant amounts of organic matter into rivers supporting sturgeon in North Carolina. During that event, the DO concentrations dropped so low (i.e., 0.2 mg/L) that water quality PBF ceased to function, resulting in the death of thousands of fish including multiple sturgeon. While not specific to the Santee-Cooper Unit, stochastic events such as this one are certainly possible within the range of the unit.

4 ENVIRONMENTAL BASELINE

This section describes the effects of past and ongoing human and natural factors contributing to the current status of the shortnose sturgeon, the Carolina DPS of Atlantic sturgeon, and the Atlantic sturgeon critical habitat unit affected within the action area. The environmental baseline describes the species' and critical habitat's health based on information available at the time of this consultation.

By regulation, the environmental baseline for an Opinion refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to the listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

Focusing on the current state of critical habitat is important because in some areas critical habitat features will commonly exhibit, or be more susceptible to, adverse responses to stressors than they would be in other areas, or may have been exposed to unique or disproportionate stresses. These localized stress responses or stressed baseline conditions may increase the severity of the adverse effects expected from the proposed action.

4.1 Status and Distribution of Shortnose Sturgeon and the Carolina DPS of Atlantic sturgeon in the Action Area

4.1.2 Status and Distribution of Atlantic Sturgeon from Carolina DPS in the Action Area

Historically Atlantic sturgeon were abundant enough in South Carolina to support a commercial fishery with an average catch of 78,864 kg between 1880-1901 (Secor 2002). Landings of Atlantic sturgeon in South Carolina were greatest just north of the action area in Winyah Bay; harvesting also occurred in both the Cooper and Santee Rivers (Secor 2002).

Unlike shortnose sturgeon (discussed below) tagged Atlantic sturgeon within the Cooper River do not show a discernible pattern in habitat use. The telemetry data clearly shows animals making spawning runs upriver to approximately RKM 77 (the base of the Pinopolis Dam) during late summer-early fall (Figure 12). The remainder of the year they are found generally throughout the river RKM 0-45.

Based on unpublished telemetry data of Atlantic sturgeon movements in the Cooper River provided by SCDNR, we were able to look more closely at the likelihood individuals would be around the action area. Using the available information, we determined any Atlantic sturgeon detected above the I-526 Bridge (32°53'26.46"N, 79°57'44.85"W) in Charleston, South Carolina, could be considered potentially within the action area. Table 7 reports the number of Atlantic sturgeon detected anywhere in the Cooper River, as well as the number detected closer to the action area from 2016-2018. With this information we were able to determine what percentage of individuals might be near the action area by month and over the entire time series. The percentage of tagged Atlantic sturgeon potentially in the action area varied by month and year, ranging from a low of 19% (March) to a high of 90% (August) (Table 7). On average, approximately 56% of tagged Atlantic sturgeon in the Cooper River could be found near the action area at any time.

Table 7. Atlantic Sturgeon Detected in the Cooper River, Near the Action Area, and the Probability of Foraging Near the Action Area, by Month, 2016-2018 (Source: SCDNR)

Year(s)	ATS Detection Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan-Dec
2016	ATS Detected Anywhere in the River	7	8	8	8	11	7	8	4	10	11	12	5	99
	ATS Detected Near Action Area	4	5	3	4	9	5	7	4	9	4	4	1	59
2017	ATS Detected Anywhere in the River	2	4	4	6	8	8	8	6	10	15	14	9	94
	ATS Detected Near Action Area	1	2	1	3	6	6	6	4	8	10	4	3	54
2018	ATS Detected Anywhere in the River	3	2	9	8	13	8	7	10	10	9	8	1	88
	ATS Detected Near Action Area	1	0	0	3	7	5	5	10	9	5	0	0	45
2016-2018	ATS Detected Anywhere in the River	12	14	21	22	32	23	23	20	30	35	34	15	281
	ATS Detected Near Action Area	6	7	4	10	22	16	18	18	26	19	8	4	158
	% Detected Near Action Area	50.0%	50.0%	19.0%	45.5%	68.8%	69.6%	78.3%	90.0%	86.7%	54.3%	23.5%	26.7%	56.2%

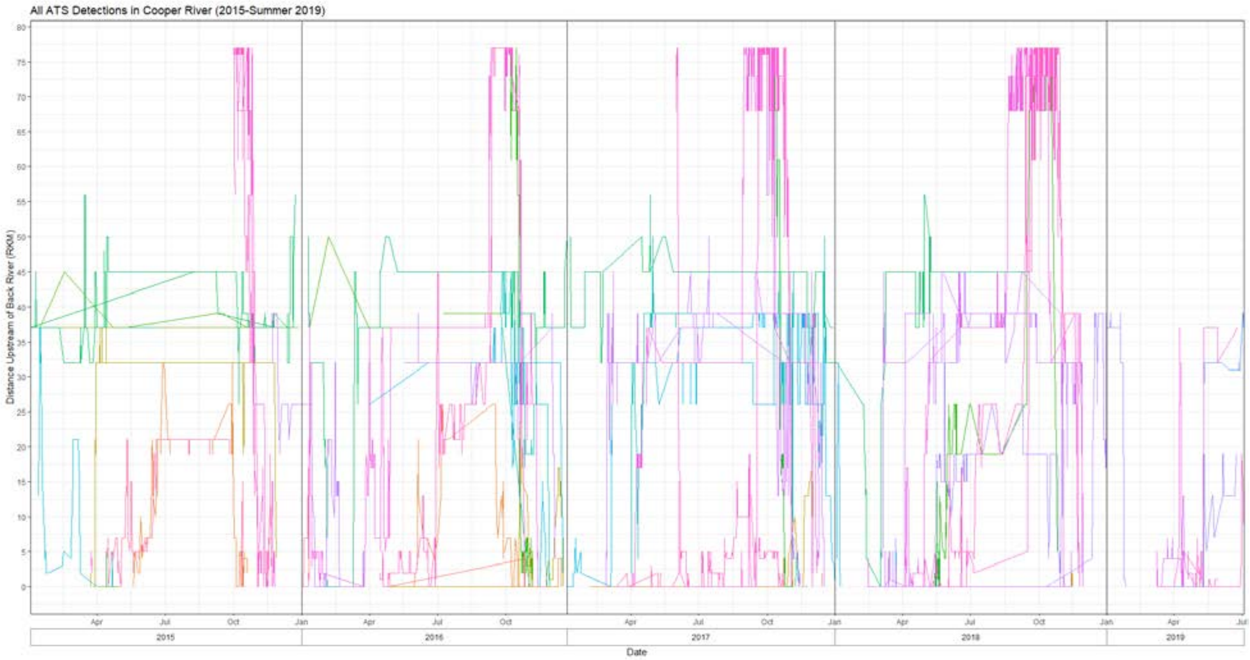


Figure 12. Atlantic Sturgeon Movement in the Cooper River, 2015-2019 (Source SCDNR, Unpublished Data)

Based on mean annual harvest levels (1880-1901), abundance of spawning females was estimated at 8,000 for the State of South Carolina (Secor 2002). South Carolina closed the Atlantic sturgeon fishery in state waters in 1985. Current abundance estimates for Atlantic sturgeon are limited. While there is no record of Atlantic Sturgeon Carolina DPS spawning in the Cooper River below the Pinopolis Dam, spawning size fish have been captured. Efforts to assess spawning Atlantic sturgeon did not begin until 2015, and only 3 partial seasons of data are available (due to weather issues). Eight were documented using spawning habitat below the Pinopolis dam during the fall, all males. No genetic information is available at this point to assess from which DPS the animals came (E. Waldrop, SCDNR, pers. comm. to P. Opay, NMFS SERO, August 17, 2018); however, given they were in spawning habitat, NMFS believes they were from the Carolina DPS. Unlike shortnose sturgeon, Atlantic sturgeon using the Cooper River do not show the high site fidelity. Though quantitative abundance estimates obtained through sampling surveys are not available, NMFS conservatively estimated that at the time of listing, the Cooper River population contained fewer than 300 spawning adults (77 FR 5914; February 6, 2012). However, if any spawning is occurring, we do not anticipate recruitment (i.e., survival of eggs/larvae) will be successful in the Santee River or Cooper rivers, likely as a result of insufficient conditions (e.g., insufficient water flows in the Santee River, and excessive water flows/salt wedge issues in the Cooper River) to support successful reproduction.

4.1.1 Status and Distribution of Shortnose Sturgeon in the Action Area

Relative to historical abundance, the populations of sturgeon within the Santee/Cooper River System have significantly decreased in number, mostly attributed to overfishing and habitat modification due to construction of dams. The major rivers along the East Coast historically supported the largest commercial sturgeon fishery in the South, though no differentiation between shortnose and Atlantic sturgeon was noted in landings records (NMFS 1998). The accessibility to, and condition of, habitat throughout the river system continues to be negatively impacted by dams and is a major negative factor in the species' current status.

Written accounts document diadromous fish ascending through the entire Santee Basin, clearly indicating that sturgeon migrated above the fall line to access extensive bedrock, cobble, and gravel shoal areas in the upper regions that provided high quality spawning habitat (USFWS et al. 2001). With the completion of the Santee Cooper Diversion Dam and Canal Project in 1942, anadromous fish migrations were completely confined to the lower 87 miles of the Santee Basin.

While it is difficult to ascertain the number of sturgeon in the basin prior to 1942 and the construction of the SCPSA Project, there is no doubt the abundance of shortnose sturgeon in the Santee Basin has been significantly reduced. Sturgeon were abundant enough to sustain a fishery within the Santee Basin in the late nineteenth century (Secor 2002). Fisheries for the shortnose sturgeon closed in 1973 concurrent with the ESA listing.

It is likely that the total number of shortnose sturgeon within the action area is greatly decreased from historic accounts. The shortnose sturgeon population within the Cooper River also shows remarkable site fidelity to a relatively small stretch of the river. Based on the information available, it appears environmental conditions may play some role in how the animals use the habitat. It is not immediately clear what driver(s) create the upstream boundary. However, the downstream boundary seems to be driven largely by the presence of the freshwater/saltwater interface; with shortnose sturgeon selecting less saline waters upstream of the interface (B. Post, SCDNR, pers. comm. to A. Herndon, NMFS 2020).

We estimate the Cooper River is approximately 77 RKMs (47.85 RMs) miles long from the mouth of Charleston Harbor to base of the Pinopolis Dam. Tagged shortnose sturgeon in the Cooper River indicate high occupancy year round in the Cooper River RKMs ~26-50 (Figure 13). The telemetry data clearly shows animals making spawning runs upriver to approximately RKM 77 (the base of the Pinopolis Dam) during winter months. The remainder of the year they are largely found in RKM 26-50. Retreat upriver during summer months when the saltwater/freshwater interfaces moves further upstream is also clearly visible.

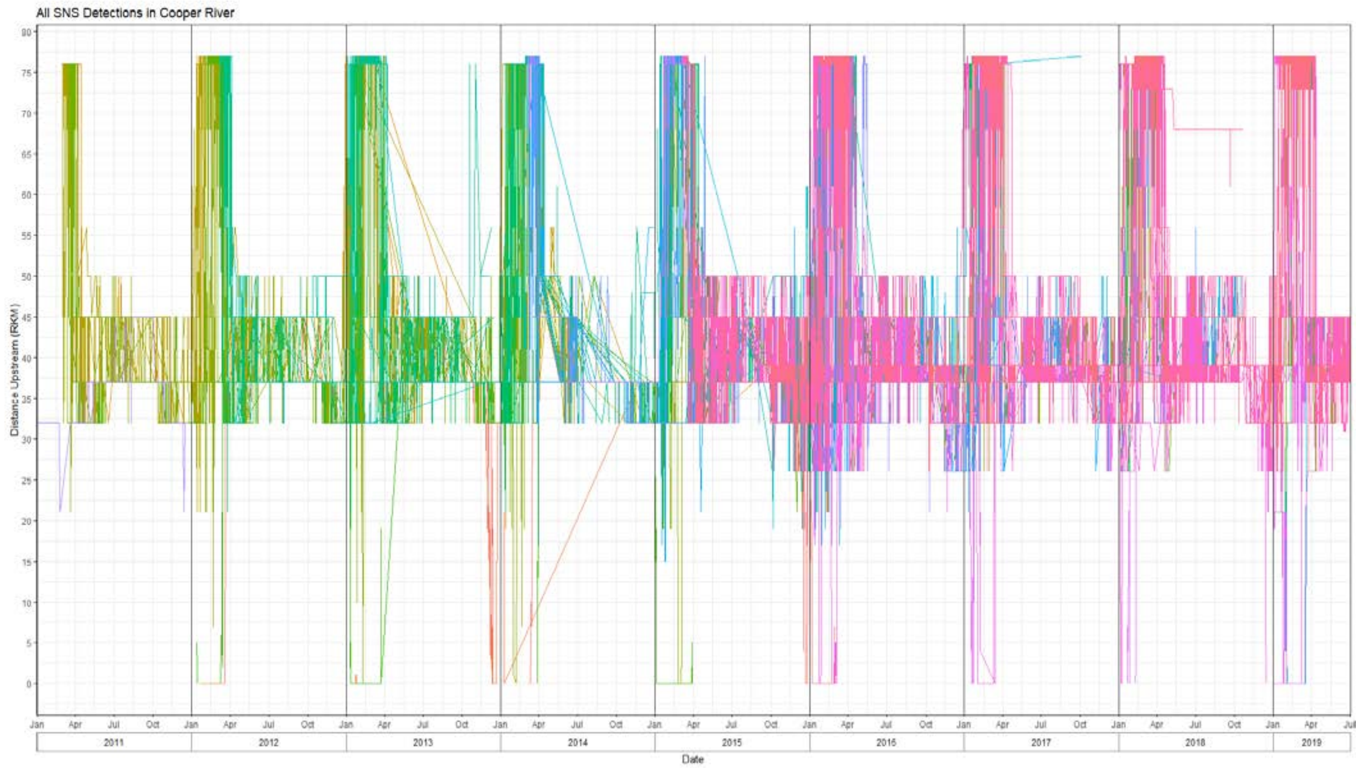


Figure 13. Shortnose Sturgeon Movement in the Cooper River, 2011-2019 (Source SCDNR, Unpublished Data)

The most recent abundance estimate available for adult shortnose sturgeon in the Cooper River below the Pinopolis Dam is 229 adult fish (SCDNR; Unpublished data). While there is evidence that Cooper River shortnose sturgeon spawn in the Pinopolis Dam tailrace (Cooke et al. 2004), there is little indication that larvae successfully hatch and survive into the juvenile stage (Duncan et al. 2004; Ruddle 2018). Over the past 20 years, SCDNR has reached an almost 100% recapture rate of adult shortnose sturgeon in the Cooper River, suggesting that little to no recruitment occurs (Ruddle 2018). Since shortnose sturgeon in other river systems have been documented traveling up to 200 km upstream to spawn (Hall et al. 1991; Murdoch et al. 2007; Rogers and Weber 1994), it is likely the Pinopolis Dam at RKM 77 forces sturgeon to spawning habitats they may not have otherwise chosen (Ruddle 2018). Spawning success in areas immediately downstream of impoundments, such as the Pinopolis Dam, has been unsuccessful in other systems (Cooke et al. 2004; Kynard 1997; Ruddle 2018). Recruitment is also likely hampered by the downstream flow generated by water releases from the Pinopolis Dam) (Ruddle 2018). Very high water flows below the dam result in scouring of eggs (i.e., poor adhesion and thus inability to develop). There is also an insufficient distance between the spawning site and the upstream boundary of the freshwater/saltwater interface. The location of the interface is such that if eggs could survive scouring, the larvae would be exposed to lethal levels of salinity before they mature.

The small size of the Cooper River population and apparent low reproductive success puts it at greater risk of extinction than a larger population, as several processes affect population dynamics differently in small populations compared to large (Brainard et al. 2011). These processes include: 1) deterministic density effects including depensation (Allee effect) and increased predation; 2) inbreeding resulting in loss of diversity and accumulation of deleterious mutations; and 3) increased susceptibility to catastrophic events.

4.2 Status and Distribution of Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit) in the Action Area

The proposed action area is located within the boundaries of Atlantic sturgeon critical habitat Carolina Unit 7 (Santee-Cooper Unit) on the Cooper River at an existing Nexan cable land factory, adjacent to the Bushy Creek Industrial Complex, about 22 river miles from the Atlantic Ocean. The project area ranges in depth from 0 ft. at the shoreline, to approximately 25 ft. in locations near the middle of the river and will be approximately 35 ft. deep following the proposed action. The action area is primarily soft substrate, void of corals or submerged aquatic vegetation and has no hard substrate. USGS gauge 02172053 reports the salinities in the river fluctuate with flows and tides, ranging from fresh (0 ppt) to brackish (approximately 15 ppt). Dissolved oxygen concentrations fluctuate seasonally between approximately 5 mg/L during warmer summer months to over 10 mg/L during cooler winter months (USGS gauge 02172053; https://maps.waterdata.usgs.gov/mapper/index.html). Water temperatures also fluctuate seasonally ranging from average lows of approximately 10°C in January to averages close to 30°C in August. The estimated length of Carolina Unit 7 is approximately 77 RKM (approximately 48 RM).

4.3 Factors Affecting Sturgeon within the Action Area

The following examines the past and ongoing human and natural factors actions that have impacted sturgeon and sturgeon habitat in the action area of this consultation.

4.3.1 Federal Actions

In recent years, NMFS has undertaken several ESA Section 7 consultations to address the effects of federal actions on shortnose and Atlantic sturgeon in the Cooper River. Because Atlantic sturgeon was listed in 2012 there are relatively few consultation records analyzing potential impacts to them. However, within the action area of the Nexan project, only the consultation on Federal Energy Regulatory Commission's (FERC) re-licensing of the Santee-Cooper Hydroelectric project is relevant.

Dams
The Santee-Cooper Hydroelectric Project has significant impacts on the flows in the Cooper River relative to natural conditions. Between 1943 and 1985, most of the natural flow of the Santee River was diverted into Lake Moultrie and discharged into the Cooper River. This diversion resulted in severe silting in the Cooper River and Charleston Harbor during that period. To alleviate this problem, in 1985 the USACE constructed another canal to redivert water from Lake Moultrie back into the Santee River. The normal operation of Lake Moultrie releases a daily average of 4,500 cfs into the Cooper River – enough to keep the salinity of the river low – and returns the remainder of its discharge – on average about 10,000 cfs – to the Santee River.

Prior to diversion, saline conditions extended ~18 miles up the Cooper River from the mouth of Charleston Harbor and a distinct salt wedge extended upstream ~ 9 miles (Mathews and Shealy 1978; Mathews and Shealy 1982). Following rediversion, saline waters extended approximately

31 miles up the Cooper River, with salinities primarily controlled by tidal stage rather than seasonal freshwater flow. Since rediversion, the lower fresh water discharge rate has eliminated much of the seasonal variability previously reported (Davis et al. 1990). Because of these reductions in flow and increases in salinity, the quality of habitat below the Pinopolis is less than ideal and is not believed to support viable sturgeon spawning. Additionally, the Santee Cooper operations covered by the relicensing have negatively affected passage of sturgeon upstream to spawning habitat, and downstream to foraging habitat.

NMFS completed a biological opinion on the Santee-Cooper Hydroelectric Project re-licensing in 2020 (NMFS 2020). Following discussion with NMFS, the South Carolina Public Service Authority (SCPSA), owners of the Santee-Cooper Hydroelectric Project, agree to include several measures to protect sturgeon in their license renewal request. Those actions and the corresponding biological opinion established measures to protect sturgeon in the Cooper River, including: actions to reduce potential mortality at the navigational lock at that Pinopolis Dam; translocating shortnose sturgeon from the Cooper River to the Santee River to increase the potential for successful recruitment; increasing flows to Santee River to support translocated sturgeon; and establishing an adaptive management process to allow resource manager to take additional measures to concern sturgeon, if necessary.

Dredging

Due to the size of the action area, the threats to sturgeon posed from federal dredging projects are anticipated to be same as those describe previously in *Section 3: Status of Species*.

4.3.2 ESA-Permitted Sturgeon Research

The ESA allows the issuance of permits to take ESA-listed species for the purposes of scientific research (Section 10(a)(1)(A)). The ESA also allows for NMFS to enter into cooperative agreements with states developed under Section 6 of the ESA, to assist in recovery actions of listed species. Prior to issuance of these authorizations, the proposal must be reviewed for compliance with Section 7 of the ESA.

Authorization of research and enhancement activities on shortnose and Atlantic sturgeon is established through the issuance of an ESA Section 10(a)(1)(A) permit. The current permits and specific stressors to fish in the action area subject to NMFS-issued ESA permit conditions are listed in Table 8 and Table 9.

Table 8. Shortnose Sturgeon ESA Section 10 (a)(1)(A) Research Permits (ELS = early life stage)

Permit No.	Location	Authorized Take	Objectives and Research Activities
20528 South Carolina DNR Expires: 3/31/2027	Cooper River	70 adult/juv. (2 lethal) 50 ELS	**1) River Survey** and **2) Genetics**: Capture, handling, netting, measure, weigh, PIT and external tag, genetic tissue sample, telemetry acoustic tag, aging, gonadal biopsy, collect ELS

Table 9. Atlantic sturgeon – Carolina DPS ESA Section 10 (a)(1)(A) Research Permits (ELS = early life stage)

Permit No.	Location	Authorized Take	Objectives and Research Activities
20528 South Carolina DNR Expires: 3/31/2027	Cooper River	50 adult/juv. (2 lethal), 50 ELS	**1) River Survey** and **2) Genetics**: Capture, handling, netting, measure, weigh, PIT and external tag, genetic tissue sample, telemetry acoustic tag, aging, gonadal biopsy, collect ELS

4.3.3 State or Private Actions

A number of state or private activities that may directly or indirectly affect shortnose and Atlantic sturgeon in the action area include impacts from fisheries, wastewater systems, stormwater systems, and residential or commercial developments adjacent to waterways. Given the lack of monitoring and reporting of impacts associated with these activities, the direct and indirect impacts are difficult to quantify. However, due to the size of the action area, the threats to sturgeon posed from these activities are anticipated to be same as those describe previously in *Section 3: Status of Species*.

4.3.4 Other Potential Sources of Impacts in the Environmental Baseline

Other potential sources impacting the environmental baseline in the action area include: water quality, water quantity, climate change, drought, sea level rise, and drought. However, due to the size of the action area, the threats to sturgeon from these activities are anticipated to be same as those describe previously in *Section 3: Status of Species*.

4.3.5 Conservation Activities Benefitting Sturgeon in the Action Area

NMFS finalized the Recovery Plan for the shortnose sturgeon in 1998. The Recovery Plan identified 19 discrete populations of shortnose sturgeon: both the Santee and Cooper River populations were determined to be discrete (NMFS 1998). The 1998 Shortnose Sturgeon Recovery Plan also identified four main recovery actions: establish listing criteria for shortnose sturgeon population segments; protect shortnose sturgeon and their habitats; rehabilitate shortnose sturgeon populations and habitats; and implement recovery tasks. To rehabilitate shortnose sturgeon habitats and population segments, the Recovery Plan specifically calls for actions to restore access to habitats, spawning habitat and conditions, and foraging habitat.

Atlantic sturgeon have historically been managed under a Fishery Management Plan implemented by the ASMFC. In 1998, the ASFMC instituted a coast-wide moratorium on the harvest of Atlantic sturgeon, which was to remain in effect until there are were least 20 protected age classes in each spawning stock (anticipated to take up to 40 or more years). NMFS followed the ASMFC moratorium with a similar moratorium for Federal waters. Amendment 1 to ASMFC's Atlantic Sturgeon Fishery Management Plan also includes measures for preservation of existing habitat, habitat restoration and improvement, monitoring of bycatch and stock recovery, and breeding/stocking protocols. Atlantic Sturgeon DPSs were placed on the Endangered Species List in February, 2012 (77 FR 5880 and 5419). The listing was effective April 6, 2012, and provides protections for the Carolina DPS, including prohibitions against take. NMFS has not yet drafted a Recovery Plan. However, a Recovery Outline exists (and is discussed in section 7 of this Opinion). Critical habitat was designated on August 17, 2017 (82

FR 39160), and will ensure Federal agencies carefully assess and ensure that their actions do not destroy or adversely modify the critical habitat.

Through ESA Section 6 cooperative agreements, NMFS has funded shortnose and Atlantic sturgeon research projects within the South Atlantic region to obtain the best available information to investigate life history and effects of existing project operations. Shortnose sturgeon were added to the International Union for Conservation of Nature and Natural Resources (IUCN) Red List in 1986 as vulnerable. Shortnose sturgeon remain listed by the IUCN as vulnerable based in part on an estimated range reduction of greater than 30% over the past 3 generations, irreversible habitat losses, effects of habitat alteration and degradation, degraded water quality, and extreme fluctuations in the number of mature individuals between rivers. Shortnose sturgeon are listed in Appendix I under CITES. Appendix I species are considered threatened by extinction and trade is permitted only in exceptional circumstances. Atlantic sturgeon are listed under Appendix II. Appendix II includes species in which trade must be controlled in order to avoid utilization incompatible with their survival.

4.4 Factors Affecting Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit) within the Action Area

4.4.1 Federal Actions

We have consulted on some USACE dredging projects and FERC hydroelectric relicensing projects within the Cooper River. Because Atlantic sturgeon critical habitat was not designated until 2017 there are relatively few consultation records analyzing potential impacts to the Carolina Unit 7 (Santee-Cooper Unit). Within the action area of the Nexan project, only the consultation on Federal Energy Regulatory Commission's (FERC) re-licensing of the Santee-Cooper Hydroelectric project is relevant.

Dams

NMFS completed a biological opinion on the Santee-Cooper Hydroelectric Project re-licensing in 2020 (NMFS 2020). The biological opinion concluded the impacts of continued operation of the dam on the PBFs for critical habitat would largely remain exactly the same in the Cooper River, as they were on the date critical habitat was designated in 2017 (these exact conditions were present when designated). It also noted that requirements in the biological opinion would improve river conditions leading to beneficial effects to some PBFs. Ultimately, it concluded the reauthorization of the dam and its continued operation would have no adverse effects on the critical habitat, and may have beneficial effects.

4.4.2 State or Private Actions

Due to the size of the action area, we do not have any knowledge of state or private actions occurring there that were not previously discussed.

4.4.3 Other Potential Sources of Impacts in the Environmental Baseline

Other potential sources impacting the environmental baseline in the action area include: water quality, water quantity, climate change, drought, sea level rise, and drought. However, due to the size of the action area, we do not have any knowledge of additional ways these factors may be affecting the Santee-Cooper Unit that were not previously discussed.

5 EFFECTS OF THE ACTION

Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02).

Section 9 of the ESA prohibits activities that "take" any endangered species within the United States or its territorial sea. "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." NMFS has defined "harm" to include "significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering" (50 C.F.R. § 222.102). NMFS has also explained that habitat modification that significantly impairs essential behaviors constitutes injury and, therefore, a prohibited "take" (64 FR 60727; November 8, 1999). We determined only the dredging and riprap installation associated with the proposed action is likely to adversely affect Atlantic and shortnose sturgeon.

In this section of the Opinion, we assess those effects on the shortnose sturgeon and Atlantic sturgeon of the Carolina DPS populations present in the Cooper River. We also consider the action’s effect on Atlantic sturgeon critical habitat Carolina Unit 7. The analyses in this section form the foundation for the jeopardy and destruction and adverse modification analyses in Section 7.

5.1 Effects of Foraging Habitat Loss to Shortnose Sturgeon

As discussed previously, the applicant will mechanically dredge approximately 6.68 acres (0.027 km^2) of river bottom supporting sturgeon foraging resources. Following dredging, the applicant proposes to install 1.34 acres (0.005 km^2) of riprap on aquatic habitat potentially used by sturgeon and 481 in-water piles, causing a total permanent loss of 1.38 acres (0.006 km^2) in foraging resources.[9] We anticipate the remaining 5.3 acres (0.021 km^2) of dredged area is likely to eventually recover and represents only a temporary loss in foraging resources. To evaluate the impacts of the action, we considered the mean density of the primary sturgeon prey items (i.e., amphipods and polychaetes) recorded in and around the action area within the area of high occupancy displayed by shortnose sturgeon (RKM 26-50; Figure 13). We began this analysis by creating a Cooper River polygon for the high occupancy area, with the boundaries set by the waterline in satellite imagery provided by ESRI Basemap (Sources: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community). That effort determined the shortnose sturgeon area of high occupancy is 1,737 acres (7.03 km^2). Based on the anticipated dredge footprint, we estimate the dredging will

[9] 1.34 acres (0.005 km^2) of riprap in following dredging + 0.04 acres of drive pile (Area per pile for 24-in by 24-in pile = 576 square inches = 4 ft^2. Total area = (481 in-water piles)(4 ft^2 per pile) = 1,924 ft^2).

adversely affect 0.38%[10] of the foraging habitat in the shortnose sturgeon area of high occupancy.

Aside from just considering the amount of area dredged, we also considered the likelihood that the area removed would provide high-quality foraging opportunities. To do so, we considered information on foraging resources available in the action area provided by the South Carolina Estuarine and Coastal Assessment Program (SCECAP) (http://dnr.sc.gov/marine/scecap/index.html) and the USACE Charleston Harbor Dredging Project Environmental Assessment (SCDNR 2013). Using those datasets, we were able to estimate the mean density of the primary sturgeon prey items (i.e., amphipods and polychaetes) recorded in and around the action area. Primary sturgeon forage density was defined as the sum of mean amphipod and polychaete density. With that information, we explored several geostatistical methods (e.g., simple kriging, areal interpolation, inverse distance weighting) to interpolate foraging resource availability throughout the shortnose sturgeon area of high occupancy (RKM 26-50); each method generated essentially the same results. Of all the methods explored, we ultimately chose Inverse Distance Weighting due to its minimal data requirements and ability to account for spatial autocorrelation in the data. The Inverse Distance Weighting method provided fits to most of the occupancy area; remaining areas were visually interpolated using nearest neighbor averaging approaches. Given data limitations, and to be conservative when assessing the impacts of the action on the species, the unsampled reach upriver of the northernmost data point available from the SCECAP and USACE Charleston Harbor Dredging Project Environmental Assessment was assumed to have the same (low) value of forage as the northernmost data point (Figure 14). The interpolation method assumes a gradient between the SCECAP sampling site near the Nexan project site (red cross adjacent to green star in Figure 14) and the nearest sampling site to the north (blue cross in Figure 14). Predictive fits could be improved by increasing benthic prey sampling or a more comprehensive understanding of sediment composition throughout the shortnose sturgeon occupancy area, as sediment composition appears to be the major driver of amphipod and polychaete density.

Once prey distribution and likely density of prey were determined, we evaluated the potential impacts of the proposed action on those resources. To estimate impacts of the project, weighted foraging values were computed as the multiple of the estimated prey density and the area of the subsection of river. The weighted foraging value that would be removed, temporarily and possibly permanently, by the dredging activities, was approximately 1% of the total foraging value of the high occupancy area.

The long-term foraging loss caused by dredging activities will depend greatly on how quickly the foraging resources return, if at all, and the quality of those returning resources. Observed rates of benthic community recovery after dredging range from 3-24 months (Culter and Mahadevan 1982; Ray 1997; Saloman et al. 1982; Van Dolah et al. 1984; Wilber et al. 2007). Previous benthic studies in the Savannah Harbor, conducted just prior to annual maintenance dredging, determined areas with soft mud bottoms and oligohaline or mesohaline salinities recovered quickly, likely due to the dominance of opportunistic species assemblages (e.g., *Streblospio benedicti, Capitella capitata, Polydora ligni*) (Ray 1997). Recovery of the dredged areas is

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[10] 6.68 acres (0.027 km^2) of 1,737 acres (7.03 km^2)

likely to occur via one or more of the following mechanisms: undredged materials remaining in the dredge footprint; slumping of benthic material from just outside the dredging footprint; immigration of adult prey species into the newly dredged area; or larval settlement into the newly dredged area. Remnant materials act as sources of "seed" populations to colonize recently defaunated sediments. Adult immigration can occur as organisms burrow laterally throughout the sediments, drift with currents and tides, or actively seek out recently defaunated sediments (Ray 1997). Likewise, materials slumping or falling into the site from channel slopes provide organisms for colonization (Kaplan et al. 1975). Regardless of the potential mechanism, successful recolonization will be contingent on there being suitable water quality conditions and bottom substrates for these organisms to survive. If these conditions are not met, the anticipated impacts from dredging may be permanent.

The loss of foraging resources will reduce the amount of prey available, making successful foraging more difficult. This reduction in prey and foraging success will result in slower growth rates and reduced fitness. Reduced fitness can increase susceptibility to disease and mortality. Changes in foraging resources can effect fecundity, as well as egg size/quality. Adult females with smaller body size, reduced fitness, or acute environmental stress may produce fewer eggs (Van Eenennaam and Doroshov 1998) or reabsorb late-stage oocytes through atresia (Webb et al. 1999; Webb et al. 2001). In general, larger mature females from a broad variety of marine and freshwater species produce far more and often larger eggs that may develop into larvae that grow faster and better withstand starvation (Hixon et al. 2014). Hendry et al. (2001) developed a species specific theoretical model for sockeye salmon. Those results suggest that the overall size and number of eggs they produced would vary based on habitat conditions (Hendry et al. 2001). The model predicted that optimal egg sizes should be larger in better incubation habitats, that larger females should produce more and larger eggs, that increasing female size should result in greater proportional increases in egg number than in egg size, and that females with greater relative egg production (i.e., for a given body size) should produce more but not larger eggs (Hendry et al. 2001). Lost foraging opportunities may also reduce the energy available to make spawning runs, which may reduce reproductive success.

Regardless of the effect, there is no reliable way to quantify the actual numbers of shortnose sturgeon that will experience them. Consequently, we believe the 1% loss in foraging value will result in sublethal effects to the entire population of shortnose sturgeon using this portion of the Cooper River.

We assume reduced fitness will manifest itself as lower fecundity of adult female shortnose sturgeon (e.g., Hixon et al. (2014)). However, the actual number of lost eggs associated with a 1% loss in foraging value is currently unquantifiable. To be conservative to the species, we assumed the reduced fitness associated with a 1% loss in foraging value translated to a 1% loss in overall egg production. Heidt and Gilbert (1978) estimated the egg production for shortnose sturgeon in the Altamaha River as 14,316 eggs per kilogram. Similarly, Marchette and Smiley (1982) estimated egg production for shortnose sturgeon in the Pee Dee River as 16,216 eggs per kilogram. Applying these estimates to the average weight of adult female shortnose sturgeon (10.35 kg) captured in the Cooper River by SCDNR (SCDNR unpublished data), and accounting for a 1% reduction in reproductive output because of foraging loss, we anticipate between 1,482-

1,678 fewer eggs would be produced per sexually mature female per spawning event.[11] Of those lost eggs, only a fraction would have likely to survived to become juveniles. Egg survival rates for shortnose sturgeon are not readily available, but have been estimated for Lake sturgeon (*Acipenser fulvescens*)(Caroffino et al. 2010). Caroffino et al. (2010) reported the mean survival rate of eggs becoming larvae at 0.82%, and mean survival rate of larvae to age-0 (i.e., individuals that are no longer larvae but have no reached 1 year of age) as 5.64%. If these estimates accurately reflect mean survival rates for shortnose sturgeon in the Cooper River, it is possible that the eggs lost due to the reduced fitness would preclude 0.69-0.78 age-0 individuals, per mature female per spawning event, from entering the population.[12]

Survival rates of age-0 shortnose sturgeon are not available, but only a fraction of age-0 individuals are anticipated to survive to adulthood. Survival rates of age-0 pallid sturgeon from the Missouri River range from 5% (Steffensen et al. 2010) to 7% (Steffensen et al. 2019). Though the authors caution that survival estimates might be underestimated as a result of immigration out of the main-stem Missouri River, an indeterminate tagging regime, or tag loss. While not specific to shortnose sturgeon (or Atlantic sturgeon) we anticipate survival rates of age-0 individuals would be similarly low.

Regardless, of species-specific survival rates, the current conditions in the Cooper River are such that very few, if any, individuals younger than 1 year of age survive. Thus, it is possible that any lost reproduction as a result of the proposed action would not actually be manifested in the population because those individuals would not have survived anyway.

[11] Average weight of adult female shortnose sturgeon 10.35 kg x 14,316 eggs per kilogram (Heidt and Gilbert 1978) x 1% lost = 1,481.7; Average weight of adult female shortnose sturgeon 10.35 kg x 16,216 eggs per kilogram (Marchette and Smiley 1982) x 1% eggs lost = 1,678.4.

[12] 1,482 eggs lost x 0.82% mean survival rate of Lake sturgeon eggs to larval stage x 5.64% mean survival rate of Lake sturgeon larvae to age-0 = 0.69 eggs lost that may have survived to age-0; 1,679 eggs lost x 0.82% mean survival rate of Lake sturgeon eggs to larval stage x 5.64% mean survival rate of Lake sturgeon larvae to age-0 = 0.78 eggs lost that may have survived to age-0

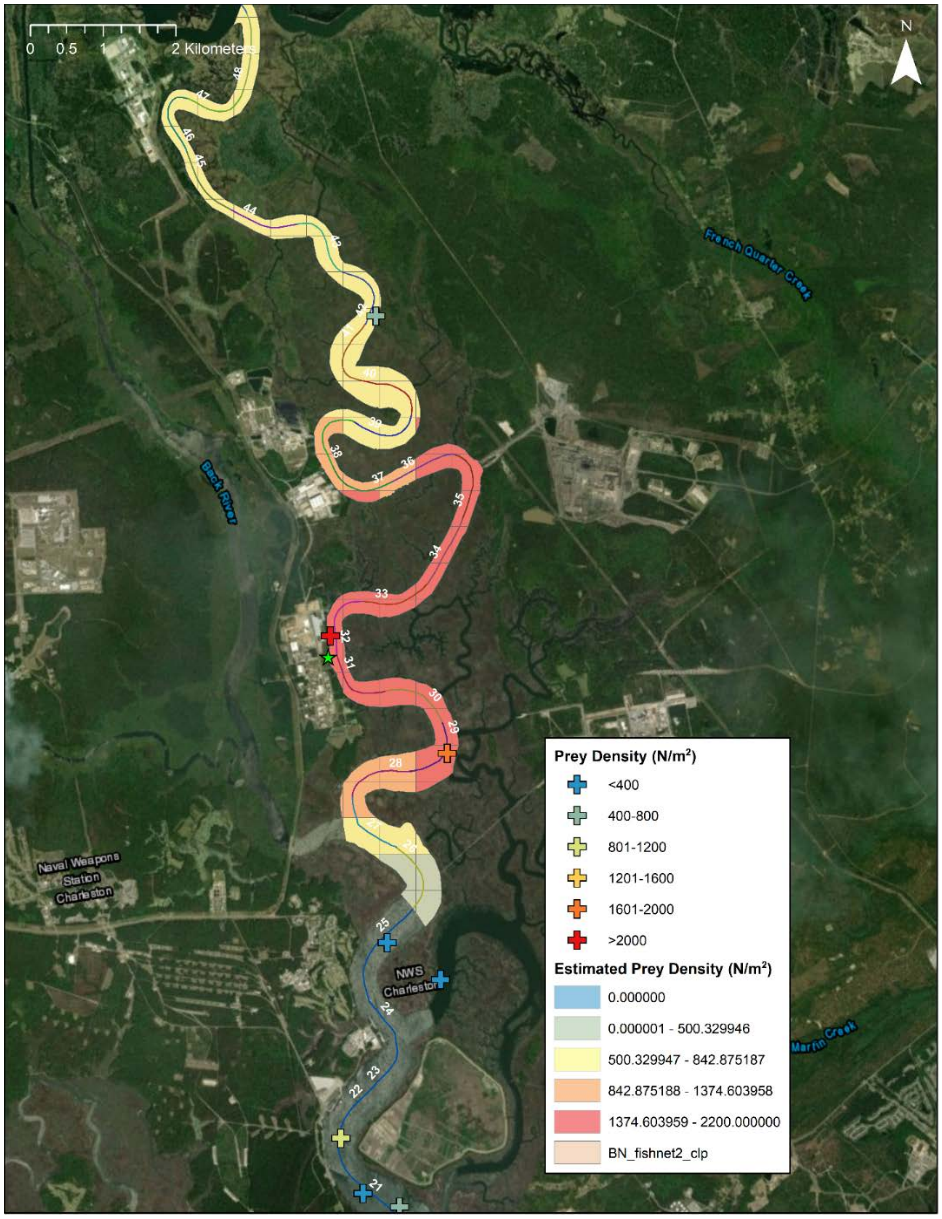

Figure 14. Estimated prey density (N/m^2) from Inverse Distance Weighted interpolation (shaded polygons) derived from field sampling (crosses).

5.2 Effects of Foraging Habitat Loss to Atlantic Sturgeon of the Carolina DPS

The potential impacts of the action on Atlantic sturgeon are less clear. Because of similarities in life history and diet, we anticipate the foraging habitat lost as a result of dredging will also adversely affect Atlantic sturgeon. However, unlike shortnose sturgeon, Atlantic sturgeon range much more widely throughout the Cooper River so the effects of that foraging loss is likely to be less pronounced. Based on the telemetry data available, we believe all individual Atlantic sturgeon in the river could be foraging throughout the river. We estimate, across the entire population of the Atlantic sturgeon in the Cooper River, the probability of an Atlantic sturgeon foraging in the action area at any given time over the course of the year is 56% (Table 7).

The foraging habitat in the Cooper River has not been extensively mapped. We estimate there is a 56% probability that Atlantic sturgeon may use the action area, experiencing the 1% loss in foraging value in the action area, associated with the proposed action. Consequently, we anticipate 0.56% sublethal reduction in fitness to across all Atlantic sturgeon in the Cooper River.[13]

The impacts to Atlantic sturgeon from the reduction in foraging resources are anticipated to be the same as for shortnose sturgeon (e.g., slower growth rates, reduced fitness, higher risk of disease and mortality, reduction in reproductive potential/success). However, unlike the shortnose sturgeon, only adult male Atlantic sturgeon have been detected near the spawning grounds over the last several years (E. Waldrop, SCDNR, pers. comm. to A. Herndon, NMFS, March 2020). Thus, the potential impact to Atlantic sturgeon reproduction from the action, at least in the near term, is anticipated to be less significant since males, can reproduce every year. To date, it appears no females have attempted to spawn in the Cooper River. Without females, no reproduction can take place. If only males make spawning runs without the presence of females, we would expect no functional impact to Atlantic sturgeon reproduction. However, female sturgeon could have attempted to spawn but gone undetected.

Summary of Effects to Sturgeon

We anticipate 1% of high quality foraging value will be lost (some permanently) as a result of the proposed action. How shortnose and Atlantic sturgeon compensate for disrupted foraging in the Cooper River is currently unknown. There is currently no clearly accepted approach for measuring sublethal impacts to fitness and reproduction from loss in foraging value in shortnose and Atlantic sturgeon. As a result, we will monitor habitat change and prey recolonization rates to determine the extent of the effects to these species and to determine the need to reinitiate consultation.

5.3 Effects of the Action on Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit)

The project is located in Atlantic sturgeon critical habitat Carolina Unit 7 (Santee-Cooper River Unit). Of the 4 PBFs identified for Atlantic sturgeon critical habitat, only the following will be affected by the proposed action: salinity gradient and soft substrate and unobstructed water of appropriate depth (Table 10).

Table 10. Atlantic Sturgeon Critical Habitat Physical and Biological Features (PBF) and Associated Function or Purpose

PBF		Purpose/Function of PBF
"Salinity Gradient and Soft Substrate"	Aquatic habitat inclusive of waters with a gradual downstream gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites	Necessary for juvenile foraging and physiological development

[13] 56% probability of an individual Atlantic sturgeon foraging in the action area x 1% loss in foraging value = 0.56% loss in fitness caused to Atlantic sturgeon as a result of lost foraging resources.

The applicant will mechanically dredge approximately 6.68 acres (0.027 km^2) of river bottom supporting sturgeon foraging resources. Following dredging, the applicant proposes to install 1.95 acres (0.007 km^2) of riprap; of which 1.34 acres (0.005 km^2) will be placed on aquatic habitat potentially used by sturgeon. Approximately, 0.61 acres of riprap will be placed on land that was forested uplands or emergent wetlands did not provide habitat for sturgeon or function as critical habitat.

Salinity Gradient and Soft Substrate Physical and Biological Feature (PBF)
This PBF will be permanently affected by the pile driving and riprap, which will remove about 1.38 acres (0.006 km^2) total area of soft substrate habitat. The total area of the Carolina Unit 7 of Atlantic sturgeon critical habitat has not been estimated. It extends from RKM 0 to 77 (excluding the area adjacent to the Joint Base Charleston). We anticipate a vast majority of that area (if not all) would contain PBF 2. We previously estimated the area of Carolina Unit 7 from RKM 26 to ~49 has being 1,737 acres (7.03 km^2). The dredge impacts of 6.68 acres (0.027 km^2) accounted for 0.38% of that 1,737 acres (7.03 km^2) area. Given that the total area of the critical habitat unit is more than 1,737 acres (7.03 km^2), the dredging impacts to the entire critical habitat unit is likely significantly less than 0.38%. Atlantic sturgeon also range widely in the Cooper River giving them access to significantly more foraging opportunities than shortnose sturgeon. However, because the availability and quality of other foraging resources in the Cooper River is not currently known, we will act conservatively toward the habitat and assume the proposed action will adversely affect up to 0.38% of the area, leading to a 1% loss of value of the soft substrate feature of PBF 2. We anticipate no measurable change to the salinity gradient as a result of the proposed action.

6 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, or local 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 (50 CFR 402.02).

Within the action area, major future changes are not anticipated in ongoing human activities described in the environmental baseline. At present, the major human activities of the action area affecting sturgeon, including dredging and projects that affect water quality and quantity such as dams, wastewater systems, stormwater systems, and residential or commercial developments. These activities are expected to continue at current rates. Future cooperation between NMFS, and SCDNR on these issues could help decrease take of sturgeon. NMFS will continue to work with states to implement ESA Section 6 agreements and with researchers with Section 10 permits, to enhance programs to quantify and mitigate these takes.

7 JEOPARDY AND DESTRUCTION AND ADVERSE MODIFICATION ANALYSIS

The analyses conducted in the previous sections of this Opinion provide the basis on which we determine whether the proposed action would be likely to jeopardize the continued existence of shortnose sturgeon, and the Carolina DPS of Atlantic sturgeon or whether it will destroy or adversely modify Atlantic sturgeon critical habitat.

7.1 Shortnose and Atlantic Sturgeon Jeopardy Analysis

It is the responsibility of the action agency to "insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species…" (ESA Section 7(a)(2)). Action agencies must consult with and seek assistance from the NMFS to meet this responsibility. NMFS must ultimately determine in a Biological Opinion whether the action jeopardizes listed species. To *jeopardize the continued existence of* is defined as "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 a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Thus, in making this determination for each species, we must look at whether the proposed actions directly or indirectly reduce the reproduction, numbers, or distribution of a listed species. Then, if there is a reduction in 1 or more of these elements, we evaluate whether it would be expected to cause an appreciable reduction in the likelihood of both the survival and the recovery of the species.

In the Section 5, we outlined how the proposed action would affect these species at the individual level and the magnitude of those effects based on the best available data. Now, we assess each of these species' response to the effects of the proposed action in terms of overall population effects and whether those effects when considered in the context of the status of the species, the environmental baseline, and the cumulative effects, are likely to jeopardize their continued existence in the wild.

7.1.1 Shortnose Sturgeon

Adverse effects to foraging value will effect adult and juvenile shortnose sturgeon during rare years that reproduction is successful. These effects are expected to be sublethal for individual sturgeon of the existing population, but may temporarily or permanently reduce the river's overall carrying capacity and ability to provide optimal foraging habitat for shortnose sturgeon. We anticipate the dredge footprint will recolonize with prey species and sturgeon are expected to use these areas for foraging once they have been recolonized. Because we anticipate these will be sublethal effects, we do not believe the proposed action will reduce the total number of individuals in the Cooper River population or the species rangewide. For this same reason, we do not believe the proposed action will result in a decrease in the species' distribution.

We anticipate a 1% loss of high-quality foraging value will reduce the overall fitness of the adult shortnose sturgeon in the Cooper River. We estimated between 1,482-1,678 fewer eggs would be produced per sexually mature female, per spawning event. We anticipated 0.82% of those eggs would survive to become larvae and 5.64% of those larvae would grow to become age-0 individuals. If these estimates accurately reflect mean survival rates for shortnose sturgeon in the Cooper River, it is possible that the eggs lost due to the reduced fitness would preclude 0.69-

0.78 age-0 individuals, per mature female, per spawning event, from entering the population. We anticipated the likelihood of these 0.69-0.78 age-0 individuals surviving to adulthood to approximately 5-7%. We suspect that due to low survival rates of larvae, and age-0 individuals, only a fraction of the eggs potential lost as a result of the proposed action would have survived to adulthood. However, even the accuracy of those estimates is confounded by the significant uncertainty around existing habitat and environmental features in the Cooper River. For example, we are currently unable to determine whether shortnose sturgeon could compensate for the lost foraging resources in the action area by foraging elsewhere. We believe the foraging resources in the action area are of high quality, but shortnose sturgeon may be able to offset losses by eating greater amounts of lower quality food or other unidentified high quality resources. Depending on their ability to compensate, the expected sublethal reductions in fitness could range from 1% as predicted (no compensatory foraging) to 0% (complete compensatory foraging). If shortnose sturgeon are unable to compensate for foraging loss, our estimates may be relatively accurate. Conversely, if they are able to completely compensate for the lost foraging resources, there may be no detectable change in reproduction.

Additionally, shortnose sturgeon recruitment appears to be largely unsuccessful in the Cooper River. This potentially effects our estimates in two ways. First, it is possible (if not likely) that the existing shortnose sturgeon population is below carrying capacity. If there are fewer individuals living in the river than could be supported by the existing foraging resources, there are likely no density-dependent factors prohibiting individuals from simply foraging elsewhere. Under this scenario, the loss of resources caused by the action may have minimal impact on the population, causing no changes in individual fitness, leading to no changes in reproductive output. Second, because of the environmental conditions in the Cooper River appear to be limiting recruitment, if reproductive output is affected by the proposed action, no functional manifestation in the population may result because the spawning/recruitment would have been unsuccessful anyway.

As noted, we believe any lost reproductive output will be relatively small and the likelihood of the eggs potentially produced surviving to adulthood is very low. We also anticipate the lost foraging resource causing the decline in reproductive output will be temporary and the reproductive potential will return. These factors, in combination with the potential ability of shortnose sturgeon to compensate for lost foraging resources, suggests that any loss of reproductive potential will likely not be significant.

As described previously, we do not believe the proposed action will cause a reduction in numbers or distribution of shortnose sturgeon. We also anticipate any lost reproductive potential is not likely to be significant to the species. Based on this information, the proposed action will not appreciably reduce the likelihood of the shortnose sturgeon's survival in the Cooper River or rangewide.

In the above analysis, we determined that the loss of foraging value for shortnose sturgeon may restrict future population growth but will not appreciably reduce the likelihood of the shortnose sturgeon's survival. We next analyze whether the potential reduction in reproduction will appreciably reduce the likelihood of the shortnose sturgeon's recovery in the wild by considering the effects of the proposed action relative to accomplishing the conservation goals described in the Recovery Plan (NMFS 1998).

The long-term recovery goal for shortnose sturgeon focuses on recovering each population independently. An increase in the population to a size that maintains a steady recruitment of individuals representing all life stages would provide population stability and enable the population to sustain itself in the event of unavoidable impacts. Goals listed in the 1998 shortnose sturgeon recovery plan (NMFS 1998) that could be affected by the proposed action include:

> *2.1 Ensure agency compliance with the ESA*
> *All federal agencies funding, authorizing or conducting activities where shortnose sturgeon occur must fulfill their responsibilities under Section 7(a)(1) and Section 7(a)(2) of the ESA. As a co-administrator of the ESA, the NMFS should insure that the protective actions and regulatory requirements of the ESA safeguard against impacts and mortalities to shortnose sturgeon. The NMFS should inform federal agencies of their responsibilities under the ESA and encourage federal agencies to adopt programs that support shortnose sturgeon recovery. This should include supporting research that identifies potential impacts (to shortnose sturgeon) resulting from specific development projects.*
>
> *2.4 Mitigate/eliminate impact of adverse anthropogenic actions on shortnose sturgeon population segments*
>
>> *2.4.1 Mitigate impacts of modifications to important habitat and other destructive activities*
>>
>> *Activities such as dredging… affect shortnose sturgeon both directly and indirectly (see Factors Affecting Recovery). These activities should be mitigated or eliminated (if possible) … While dredging and in-river disposal cannot be eliminated in rivers with ACOE Federal Navigation Projects, a number of mitigation alternatives exist: 1) limit dredging windows to non-critical periods, 2) restrict use of in-river disposal sites, and/or 3) use equipment or techniques that minimize impact to sturgeon and their habitat… Researching all of these impacts will refine and increase the number of mitigation alternatives.*

The proposed action does not impede any of these recovery goals from being achieved. This Opinion ensures that USACE is complying with the ESA, specifically by consulting with NMFS to analyze and minimize the effects of the action. The proposed action would have an adverse impact on shortnose sturgeon by negatively affecting foraging resources, with indirect effects on individual fitness, resulting in a possible reduction in reproduction. However, as discussed in Section 5 of this Opinion, we do not expect this will directly cause any mortalities. Additionally, the Terms and Conditions of the Opinion includes monitoring of the recovery of riverine foraging resources in the impacted area. This information can also be used to inform future projects.

As noted previously, NMFS, USACE, and the applicant worked proactively to minimize the dredging footprint to the greatest extent practicable. The dredging footprint was designed to maximize, to the extent practicable, the rate of prey recolonization. Additionally, no in-river disposal sites will be used, and the mechanical dredging equipment employed to do the dredging is the least harmful dredge technique. The proposed action is unlikely to have any significant negative influence on recovery goals, even when considered in the context of the of the Status of the Species, the Environmental Baseline, and Cumulative Effects discussed in this Opinion. Therefore, we conclude that the proposed action will not appreciably reduce the likelihood of recovery for shortnose sturgeon.

Conclusion
While the proposed action will result in adverse effects to shortnose sturgeon, it will not result in an appreciable reduction in the likelihood of either the survival or recovery of the shortnose sturgeon in the wild.

7.1.2 *Carolina DPS of Atlantic Sturgeon*

Adverse effects to foraging resources will affect adult and juvenile Atlantic sturgeon using this portion of the Cooper River. These effects are expected to be sublethal for individual sturgeon of the existing population, but may reduce the river's overall carrying capacity and ability to provide foraging resources for Atlantic sturgeon until the dredged area is recovered. We anticipate the dredge footprint will recolonize with prey species and sturgeon are expected to use these areas for foraging once they have been recolonized. Because we anticipate these will be sublethal effects, we do not believe the proposed action will reduce the total number of individuals in the Cooper River population or the Carolina DPS. For this same reason, we do not believe the proposed action will result in a decrease in the distribution of the DPS.

With respect to the proposed action's impacts on reproduction, we expect the loss of foraging resources may also have an effect on Atlantic sturgeon, but it is likely to be less significant than for shortnose sturgeon. We conservatively estimated a 1% loss of high-quality foraging value, within the high occupancy area previously discussed for shortnose sturgeon, will reduce the overall fitness of the Atlantic sturgeon in the Cooper River. However, unlike shortnose sturgeon, Atlantic sturgeon range much more widely throughout the Cooper River so the effects of that foraging loss is likely to be less pronounced. We estimate, across the entire population of the Atlantic sturgeon in the Cooper River, the probability of an Atlantic sturgeon foraging in the action area at any given time over the course of the year is 56% (Table 7). Because of this wider use of habitat, we suspect the potential impacts to the Atlantic sturgeon will be mitigated by their ability to find foraging resources elsewhere in the river. Consequently, we anticipate a 0.56% sublethal reduction in fitness to occur across all Atlantic sturgeon in the Cooper River.

The lost reproduction caused by diminished foraging resources in the action area may be offset by individuals' ability to find additional foraging resources further upstream or downstream than the shortnose sturgeon area of high occupancy. We also anticipate the lost foraging resource causing the decline in reproductive output will be temporary and the reproductive potential will return. Regardless, because of the similarities in life histories and larval behavior of Atlantic and shortnose sturgeon, even if a 1% loss in egg production is realized, we anticipate survival rates of those eggs and age-0 individuals to be similar to those reported for lake and pallid sturgeon.[14]

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[14] Mean survival rate of eggs becoming larvae = 0.82%; Mean survival rate of larvae to age-0 as 5.64%; Mean survival rate of age-0 pallid sturgeon to age-1 between 5-7%.

These factors, in combination with the potential ability of Atlantic sturgeon to compensate for lost foraging resources, suggests that any loss of reproductive potential will likely not be significant.

As described previously, we do not believe the proposed action will cause a reduction in numbers or distribution of the Carolina DPS of Atlantic sturgeon. We also anticipate any lost reproductive potential is not likely to be significant to the species. Based on this information, the proposed action will not appreciably reduce the likelihood of the Carolina DPS of Atlantic sturgeon's survival in the wild.

A Recovery Plan for Atlantic Sturgeon has not been developed but a Recovery Outline was published to serve as an interim guidance document to direct recovery efforts until a full recovery plan is developed and approved (NMFS 2017). We analyze the likelihood of recovery for the Carolina DPS of Atlantic sturgeon in the wild by considering effects resulting from the proposed action relative to accomplishing the conservation goals described in the recovery outline for the Atlantic sturgeon.

The recovery outline discusses the implications of the major threats facing each DPS with respect to their impacts on overall recovery. Specific to the Carolina DPS, the outline calls out threats from: impeded access to historic spawning grounds because of dams; non-point sources for pollution from terrestrial activities; dredging for navigation channels; and water withdrawals (NMFS 2017). The outline also points to other in-river threats such as predation by non-native species, impingement and entrainment at facilities that withdraw water from the rivers, and vessel strikes.

Of the threats impeding recovery, the proposed action includes both dredging and vessel strikes. We determined vessels strikes were not likely to adversely affect Atlantic sturgeon, so this aspect of the proposed action will not impede recovery. Relative to dredging the final listing rule states dredging can displace sturgeon while it is occurring and affect the quality of the habitat afterwards by changing the depth, sediment characteristics, and prey availability (77 FR 5914; February 6, 2012). Although the proposed action does include dredging, we do not believe it will impede recovery. We have determined only changes in prey availability may adversely affect Atlantic sturgeon from the Carolina DPS and we expect to those changes to be temporary. Also, NMFS, USACE, and the applicant worked proactively to minimize the dredging footprint to the greatest extent practicable. The dredging footprint was designed to maximize, to the extent practicable, the rate of prey recolonization. Additionally, no in-river disposal sites will be used, and the mechanical dredging equipment employed to do the dredging is the least harmful dredge technique.

For these reasons, we believe the proposed action is unlikely to impede recovery of the Carolina DPS of Atlantic sturgeon even when considered in the context of the of the Status of the Species, the Environmental Baseline, and Cumulative Effects discussed in this Opinion. Therefore, we conclude that the proposed action will not appreciably reduce the likelihood of recovery for the Carolina DPS of Atlantic sturgeon.

Conclusion
While the proposed action will result in adverse effects to individuals from the Carolina DPS of Atlantic sturgeon, the nonlethal take of individuals from the Carolina DPS of Atlantic sturgeon associated with the proposed action is not expected to cause an appreciable reduction in the likelihood of either the survival or recovery of the DPS in the wild.

7.2 Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit) Destruction and Adverse Modification Analysis

We also must determine whether the proposed action will destroy or adversely modify Atlantic sturgeon critical habitat. NMFS's regulations define *destruction or adverse modification* to mean "a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02). Alterations that may destroy or adversely modify critical habitat may include impacts to the area itself, such as those that would impede access to or use of the essential features. NMFS will generally conclude that a Federal action is likely to "destroy or adversely modify" designated critical habitat if the action results in an alteration of the quantity or quality of the essential physical or biological features of designated critical habitat and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species.

This analysis takes into account the geographic and temporal scope of the proposed action, recognizing that "functionality" of critical habitat necessarily means that it must now and must continue in the future to support the conservation of the species and progress toward recovery. The analysis takes into account any changes in amount, distribution, or characteristics of the critical habitat that will be required over time to support the successful recovery of the species. Destruction or adverse modification does not depend strictly on the size or proportion of the area adversely affected, but rather on the role the action area and the affected critical habitat serves with regard to the function of the overall critical habitat designation, and how that role is affected by the action.

The final rule designating critical habitat for Atlantic sturgeon (82 FR 39160; August 17, 2017) determined the key conservation objectives of critical habitat for the Carolina DPSs of Atlantic sturgeon are to increase the abundance of each DPS by facilitating increased survival of all life stages and facilitating adult reproduction and juvenile and subadult recruitment into the adult population. Our analysis evaluates whether the anticipated impacts to critical habitat associated with the proposed action would interfere with how the effected PBFs support the defined key conservation objectives. In Sections 3 and 5 we explained only the "salinity gradient and soft substrate" PBF was likely to be adversely affected by the proposed action. Our destruction or adverse modification analysis considers if the proposed action will affect this PBF's ability to retain its ecological function so as to avoid appreciably diminishing the value of critical habitat.

7.2.1 Salinity Gradient and Soft Substrate PBF

We anticipate up to 1.38 acres (0.006 km^2) of salinity gradient and soft substrate PBF will be permanently lost because of the proposed action. We anticipate some of the 1.38 acres (0.006 km^2) removed will occur in areas that were previously uplands (i.e., not previously functioning as critical habitat) so the true impact of these actions to critical habitat, and this PBF, will be less than the estimate 1.38 acres (0.006 km^2). Even if we conservatively assume 1.38 acres (0.006

km^2) is affected, that would only account for less than 0.08% of the total area likely supporting this PBF.[15] Aside from the permanent loss of habitat discussed above, we anticipate the dredging impacts will be relatively temporary and short-term in nature, consisting of a temporary loss of benthic invertebrate populations in the dredged areas. Observed rates of benthic community recovery after dredging range from 3-24 months (Culter and Mahadevan 1982; Saloman et al. 1982; Wilber et al. 2007).

This PBF is intended to provide juvenile Atlantic sturgeon with a soft substrate habitat suitable for foraging throughout the salinity gradient present along the tidally influenced length of the river between spawning beds (further upriver) and waters with higher salinity (at the mouth of rivers) to sufficiently develop the physiological capabilities to survive in saltwater. While we believe that the placements of piles and riprap will reduce the amount of soft substrate portion of the PBF available, we do not believe these impacts will have a measurable impact its ecological function. The movement patterns of Atlantic sturgeon (Figure 12) suggest they do not have high site fidelity for a specific section of the river and are able to find food resources across a large swath of the river. This suggests Atlantic sturgeon have access to soft substrate habitat suitable for foraging over a significantly larger portion of the river than just within the action area. Likewise, we do not anticipate the proposed action will create a measurable a change in the location of the freshwater/saltwater interface, meaning no change to the salinity gradient is expected. Given these factors, we do not believe the proposed action will diminish the PBF's ability fulfill its ecological function.

8 CONCLUSION

After reviewing the current status of the species, the environmental baseline, the effects of the proposed action, and cumulative effects using the best available data, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of the shortnose sturgeon or Atlantic Sturgeon Carolina DPS.

After reviewing the current status of Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit), the environmental baseline, and the cumulative effects, it is our opinion that the loss of up to 1.38 acres (0.006 km^2) of the salinity gradient and soft substrate essential feature from the proposed action will not interfere with the conservation objectives of Atlantic sturgeon critical habitat. Therefore, we conclude the proposed action will not impede the critical habitat's ability to support conservation of the Carolina DPS of Atlantic sturgeon, despite permanent adverse effects. We conclude that the action as proposed, is likely to adversely affect, but is not likely to destroy or adversely modify Atlantic Sturgeon Critical Habitat: Carolina Unit 7 (Santee-Cooper Unit).

[15] The total area of the Carolina Unit 7 of Atlantic sturgeon critical habitat has not been estimated. It extends from RKM 0 to 77 (excluding the area adjacent to the Joint Base Charleston), we anticipate a vast majority of that area (if not all) would contain PBF 2. We estimated the area of Carolina Unit 7 from RKM 26 to ~49 has being 1,737 acres (7.03 km^2). The pile driving and riprapping of 1.38 acres (0.006 km^2) accounted for 0.08% of that 1,737 acres (7.03 km^2) area. Given that the total area of the critical habitat unit is more than 1,737 acres (7.03 km^2), the pile driving and riprapping impacts to the entire critical habitat unit is likely significantly less than 0.08%.

9 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and protective regulations issued pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption.

Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. *Incidental take* is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that would otherwise be considered prohibited under Section 9 or Section 4(d), but which is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the reasonable and prudent measures and the terms and conditions of the incidental take statement (ITS) of the Opinion.

9.1 Anticipated Amount of Incidental Take

NMFS anticipates only sublethal take caused by lost foraging resources. We are unable to reliably predict or estimate the specific number of individuals that may be adversely affected by the proposed action primarily due to uncertainty regarding ecosystem/habitat response, and uncertainty regarding the response of individuals or populations to the habitat alterations. Due to this uncertainty, we have conservatively estimated the entire population of shortnose sturgeon in the Cooper River will have their overall fitness reduced by 1%. We also estimate the Atlantic sturgeon using this portion of the Cooper River will suffer the same sublethal effects. The take estimates in Table 11 represent our estimates of how much habitat supportive of Atlantic and shortnose sturgeon will be lost as a result of the expansion of the navigation channel.

Because we cannot accurately measure the reduction in fitness to shortnose or Atlantic sturgeon caused by the proposed action, we use of habitat loss as a surrogate. Therefore, monitoring of habitat effects will be used to determine the extent of the effects to these species and to determine the need to reinitiate consultation. Specifically, if more than 6.68 acres (0.027 km^2) of river bottom supporting sturgeon foraging resources is removed reinitiation would be required. Likewise, if the BACI design required in the Terms and Conditions of this Biological Opinion shows a statistically significant difference of fewer polychaetes and amphipods, between the area impacted and the reference area, after 24 months from the cessation of dredging, reinitiation of consultation will be required.

We do not anticipate any direct take (lethal or otherwise) associated with the proposed action. Nonetheless, any take of shortnose or Atlantic sturgeon shall be immediately reported to takereport.nmfsser@noaa.gov. Refer to the present Opinion by title, issuance date, NMFS tracking number, SERO-2019-01935, and USACE permit number, SAC-2019-00767. At that time, consultation must be reinitiated.

Table 11. ITS surrogate (Foraging Habitat Loss) for Atlantic and Shortnose Sturgeon Resulting from Proposed Action

Species	Adverse Effects	ITS
Shortnose sturgeon	Reduced fitness of approximately 1.0% of entire population using this stretch of the Cooper River	Temporary loss of approximately 5.3 acres of river bottom supporting sturgeon foraging resources. Permanent loss of up to 1.38 acres of habitat due to rip rap and piling installation.
Atlantic sturgeon, Carolina Atlantic DPS	Reduced fitness of approximately 1.0% of entire population using this stretch of the Cooper River	Temporary loss of approximately 5.3 acres of river bottom supporting sturgeon foraging resources. Permanent loss of up to 1.38 acres of habitat due to rip rap and piling installation.

9.2 Effect of the Take

NMFS has determined the level of anticipated take associated with the proposed action and specified in Section 9.1 is not likely to jeopardize the continued existence of the shortnose sturgeon, or the Atlantic sturgeon Carolina DPS.

9.3 Reasonable and Prudent Measures (RPMs)

Section 7(b)(4) of the ESA states that RPMs necessary or appropriate to minimize the impacts of take, and terms and conditions to implement those measures, must be provided and implemented. Only incidental taking by the federal agency or applicant that complies with the specified terms and conditions is allowed.

The RPMs and terms and conditions are required, per 50 CFR 402.14(i)(1)(ii) and (iv), to minimize the impact of that take on ESA-listed species. These measures and terms and conditions are non-discretionary, and must be implemented by USACE or applicant for the protection of Section 7(o)(2) to apply. The USACE has a continuing duty to regulate the activity covered by this incidental take statement. If it fails to adhere to or require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms of permits or other documents, and/or fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse for prohibited take. To monitor the impact of the incidental take, USACE must report the progress of the action and its impact on the species to NMFS (F/SER3), as specified in the incidental take statement [50 CFR 402.14(i)(3)].

We have determined that the following RPM is necessary or appropriate to minimize the impacts of future shortnose sturgeon and Atlantic sturgeon Carolina DPS takes or to limit adverse effects to these species to predictable levels, and to monitor levels of incidental take during the proposed action:

1. USACE must ensure that benthic samples are collected and analyzed to monitor recovery of the dredged habitat. USACE must coordinate with NMFS on the proposed benthic sampling design to ensure it will accurately characterize changes to, and possible recovery of, benthic infauna. At a minimum, all benthic sampling should follow a "BACI (Before After Control Impact) design". BACI sampling designs are used to detect where

an environmental disturbance, such as dredging, causes a pattern of change in populations of animals that is different from naturally occurring changes due to season, river flow, rainfall, etc. in places unaffected by the disturbance. Sample collection and processing, for benthic infauna samples and other habitat characteristics, should follow that used throughout the majority of the southeast (Cooksey et al. 2007, Sanger et al. 2018).

9.4 Terms and Conditions

To be exempt from take prohibitions established by Section 9 of the ESA, USACE must comply with or ensure compliance with the following terms and condition, which implements the RPM described above. These terms and conditions are non-discretionary.

The following terms and conditions (T&Cs) implement the above RPM:

1. While USACE must coordinate with NMFS prior to any sampling to ensure a proper design, sampling will generally require bottom sediments be collected at each station with a $0.04m^2$, Young modified van Veen grab. Collected benthic sample sediments should be sieved on site through a 0.5-mm screen and preserved in 10% buffered formalin with rose bengal stain. The upper 2-3 cm of sediment from additional grabs taken at each station can be sub-sampled for analysis of habitat characteristics such as total organic carbon, and grain size. Once in the laboratory, benthic infauna samples should be transferred from formalin to 70% ethanol. Macroinfaunal invertebrates should be sorted from the sample debris under a dissecting microscope and identified to the lowest practical taxon (usually species).

10 CONSERVATION RECOMMENDATIONS

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

1. NMFS recommends the USACE conduct studies similar to those carried out the SCECAP to better categorize benthic foraging resources in the Cooper River. A better understanding of distribution and type of prey species available in the river may improve our ability to estimate where sturgeon are likely to congregate. Such an understanding could lead to proactive conservation measures and potentially reduce threats to sturgeon proactively.
2. NMFS recommends USACE fund research, using hatchery raised sturgeon, to better understand how changes in foraging resources affects: mean daily energetic requirements; fitness; and fecundity

To stay abreast of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, we request notification of the implementation of any conservation recommendations.

11 REINITIATION OF CONSULTATION

This concludes NMFS's formal consultation on the proposed action. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal action 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 on 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 on the listed species or critical habitat not considered in this Opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

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