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

F/SER31:AH
SER-2012-00004

Ms. Debbie-Anne Reese, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Ref.: FERC Project No. 11810-004, Biological Opinion for the Licensing of the Augusta Canal Project

Dear Ms. Reese,

The enclosed Biological Opinion responds to your request for consultation with us, the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.) for the above referenced action. The Opinion has been given the NMFS tracking number SER-2012-00004. Please use the NMFS tracking number in all future correspondence related to this action.

The Opinion considers the effects to shortnose sturgeon and the South Atlantic Distinct Population Segment of Atlantic sturgeon from the Federal Energy Regulatory Commission's (FERC) proposed licensing of the Augusta Canal Project on the Savannah River. The Opinion is based on information provided by the FERC, the city of Augusta, South Carolina Department of Natural Resources, and the published literature cited within. NMFS concludes that the proposed action is likely to adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon and the South Atlantic Distinct Population Segment of Atlantic sturgeon.

NMFS is providing an Incidental Take Statement with this Opinion. The Incidental Take Statement describes Reasonable and Prudent Measures that NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The Incidental Take Statement also specifies Terms and Conditions, including monitoring and reporting requirements with which FERC and licensee must comply, to carry out the Reasonable and Prudent Measures. FERC must ensure compliance with the Terms and Conditions, and Reasonable and Prudent Measures described in the Opinion once fish passage at the New Savannah Bluff Lock and Dam is operationally able to pass sturgeon. NMFS will monitor construction of the fish passage and notify FERC and applicant when it is operational.

We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered species and critical habitat. If you have any questions regarding this consultation, please contact Andrew Herndon, Consultation Biologist, by phone at 727-824-5367, or by email at Andrew.Herndon@noaa.gov.

Sincerely,

STRELCHECK.ANDREW.JAMES.1365863152 Digitally signed by STRELCHECK.ANDREW.JAMES.1365863152 Date: 2024.05.20 09:23:36 -04'00'

Andrew J. Strelcheck
Regional Administrator

Enclosure (s):
NMFS Biological Opinion SER-2012-00004
File: 1514-22.n.

Endangered Species Act – Section 7 Consultation
Biological Opinion

Action Agency:	Federal Energy Regulatory Commission (FERC)
Activity:	Licensing of the Augusta Canal Project (FERC Project No. 11810-004)
Consulting Agency:	National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS), Southeast Regional Office, Protected Resources Division, St. Petersburg, Florida (SERO-2012-00004)
Approved By:	STRELCHECK.ANDREW.JAMES.1365863152 Digitally signed by STRELCHECK.ANDREW.JAMES.1365863152 Date: 2024.05.20 09:29:08 -04'00' Andrew J. Strelcheck NMFS, Southeast Regional Office St. Petersburg, Florida
Date Issued:	05/20/2024

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ACRONYMS AND ABBREVIATIONS

ACE Basin	Ashepoo, Combahee, and Edisto Basin
ADD	Augusta Diversion Dam
AOR	Area of Responsibility
ATONs	Aids to Navigation
ASSRT	Atlantic Sturgeon Status Review Team
ATS	Atlantic Sturgeon (used in figures)
CAFOs	Concentrated Animal Feed Operations
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CI	Confidence Interval
CITES	Convention on International Trade of Endangered Species
CRD	Coastal Resources Division
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EA	Environmental Assessment
ELS	Early Life Stage
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FL	Florida
FMPs	Fishery Management Plans
FPA	Federal Power Act
fps	Feet per Second
FR	Federal Register
GA	Georgia
GADNR	Georgia Department of Natural Resources
GADOT	Georgia Department of Transportation
gpd	Gallons per Day
HMS	Highly Migratory Species
JST Dam	J. Strom Thurmond Dam
km	Kilometer
LLP	Limited Liability Partnership
LNG	Liquefied Natural Gas
mg/L	Milligrams per Liter
mgd	Million Gallons per Day
mm	Millimeter
mtDNA	Mitochondrial Deoxyribonucleic Acid
NC	North Carolina
nDNA	Nuclear Deoxyribonucleic Acid
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NSBL&D	New Savannah Bluff Lock and Dam
NWR	National Wildlife Refuge
P.L.	Public Law
PCBs	Polychlorinated Biphenyls
PCWS	Phinizy Center for Water Sciences
PHABSIM	Physical Habitat Simulation
PIT	Passive Integrated Transponder
RAI	Request for Additional Information
RM	River Mile
RKM	River K
RPMs	Reasonable and Prudent Measures
SAS	U.S. Army Corps of Engineers, Savannah District
SC	South Carolina
SCDNR	South Carolina Department of Natural Resources
SCDOT	South Carolina Department of Transportation
SEPA	Southeastern Power Administration
SNS	Shortnose Sturgeon (used in figures)
TEDs	Turtle Excluder Devices
TL	Total Length
TMDL	Total Maximum Daily Load
U.S.C.	U.S. Code
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WGS84	World Geodetic System 1984
WUAs	Weighted Useable Areas
YOY	Young-of-the-Year

1 BACKGROUND

Section 7(a)(2) of the ESA, requires that each federal agency ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. Section 7(a)(2) requires federal agencies to consult with the appropriate Secretary in carrying out these responsibilities. The NMFS and the USFWS share responsibilities for administering the ESA. Consultations on most ESA-listed marine species and their critical habitat are conducted between the federal action agency and NMFS (hereafter, may also be referred to as we, us or, our).

Consultation is required when a federal action agency determines that a proposed action "may affect" ESA-listed species or critical habitat and can be conducted informally or formally. Informal consultation is concluded after NMFS issues a Letter of Concurrence that concludes that the action is "not likely to adversely affect" ESA-listed species or critical habitat. Formal consultation is concluded after we issue a Biological Opinion (hereafter, referred to as an/the Opinion) that identifies whether a proposed action is "likely to jeopardize the continued existence of an ESA-listed species" or "destroy or adversely modify critical habitat," in which case Reasonable and Prudent Alternatives to the action as proposed must be identified to avoid these outcomes. An Opinion often states the amount or extent of anticipated incidental take of ESA-listed species that may occur, develops Reasonable and Prudent Measures necessary or appropriate to minimize the impact of the incidental take on the species, and lists the Terms and Conditions to implement those measures. An Opinion may also develop Conservation Recommendations that help benefit ESA-listed species.

This document represents NMFS's Opinion based on our review of potential effects of the FERC's proposal to license the August Canal Project (FERC Project No. 11810-004) by the city of Augusta (the applicant) in Augusta, Georgia, on the following listed species: shortnose sturgeon (*Acipenser brevirostrum*) and the South Atlantic distinct population segment (DPS) of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Our Opinion is based on information provided by the FERC, the applicant, South Carolina Department of Natural Resources, Georgia Department of Natural Resources, and the published literature cited within.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

2 CONSULTATION HISTORY

This section includes information associated with the history of NMFS' involvement with the Augusta Canal Project pursuant to the FERC licensing process specified in 18 CFR Subpart D. In addition to its role as the consulting agency under the ESA, NMFS also has specific authorities under the Federal Power Act (FPA) regarding fish passage for hydropower facilities.

December 11, 2002: NMFS received notification from FERC of the license application for the Augusta Canal Project.

March 18, 2003: NMFS sent FERC information on species listed under the ESA that may be present in the project area.

July 30, 2004: NMFS and USFWS jointly filed a preliminary prescription for fishways pursuant to Section 18 of the FPA.

August 16, 2004: Troutman Sanders LLP, a designated non-federal representative, sent NMFS a letter requesting concurrence with FERC's no effect determination and conclusion of the ESA Section 7 consultation.

May 20, 2005: FERC issued a draft environmental assessment (EA) for the Augusta Canal Project.

July 1, 2005: NMFS filed a letter with FERC indicating that shortnose sturgeon congregate at the base of the New Savannah Bluff Lock and Dam (NSBL&D) and that the Augusta Shoals contain areas that are considered preferred habitat for this species.

August 4, 2005: NMFS filed FPA Section 18 modifications.

October 7, 2005: NMFS filed corrected FPA Section 18 modifications.

January 13, 2006: The applicant provided NMFS and USFWS a Letter of Intent of Settlement (draft settlement) which outlines a proposal for project operation, flows, and fishways for the Augusta Canal Project.

February 3, 2006: NMFS signed and filed the draft settlement agreement, which outlined a proposal for project operation, flows, and fishways for the Augusta Canal Project.

September 22, 2006: FERC issued a Final EA on the Augusta Canal project that concluded that issuing a license, with appropriate environmental measures, would not constitute a major federal action that would significantly affect the quality of the human environment.

October 2, 2006: FERC sent a letter to NMFS indicating that the license application for the Augusta Canal Project included provisions for upstream fish passage, downstream fish passage at such time as sturgeon are documented to be present upstream of the Augusta Diversion Dam, and aquatic base flows that, though not specifically developed for shortnose sturgeon, would nevertheless benefit the species. FERC concluded that licensing the project, with the recommended measures, was "not likely to adversely affect" the shortnose sturgeon.

November 9, 2007: FERC sent a letter to NMFS referring to the October 2, 2006, correspondence and requested a written response from NMFS indicating whether we agreed or disagreed with FERC's assessment of the project's impacts to shortnose sturgeon.

January 8, 2008: The Regional Administrator for the NMFS Southeast Region signed the revised draft settlement agreement for the Augusta Canal Project, which addressed (1) the allocation of water flow between the Savannah River and the Augusta Canal, and (2) installation and operation of upstream and downstream fish passage facilities at the Augusta Canal Project.

January 30, 2009: NMFS called FERC to clarify the Section 7 consultation process.

September 4, 2009: NMFS informed FERC by letter that the Augusta Canal and King Mill projects (FERC Project No. 9988-015) may adversely affect the shortnose sturgeon and would require formal consultation. NMFS also submitted a request for additional information (RAI) in the letter to FERC on (1) the feasibility of constructing a barrier to prevent the passage of shortnose sturgeon into the Augusta Canal while allowing their upstream and downstream passage across the Augusta Diversion Dam within the Savannah River; (2) confirmation of the aquatic base flows recommended for inclusion in the license; and, (3) the complete table of flows and calculated weighted usable areas (WUAs) from the instream flow study completed by the city of Augusta. NMFS informed FERC that formal consultation would begin once all of the requested information is received.

October 2, 2009: FERC responded to NMFS' RAI via letter stating that a barrier to keep sturgeon out of the Augusta Canal had not been identified as a needed measure and that there is little danger to sturgeon in the Augusta Canal. FERC also stated that the aquatic base flows are still being negotiated and cannot be confirmed. FERC provided the requested information on WUAs from the instream flow study.

November 12, 2009: NMFS contacted FERC via e-mail to get additional clarification on the fish passage and aquatic base flow issues discussed in the September and October 2009 letters between NMFS and FERC.

November 13, 2009: FERC responded via e-mail that the aquatic base flows being proposed were those contained in the draft settlement agreement and that the aquatic base flows contained in the Final EA contained an error. FERC also indicated that the fish passage issues should be discussed with USFWS and the applicant.

December 15, 2009: NMFS and USFWS conducted a conference call to discuss the history and remaining issues regarding the Augusta Canal and King Mill projects.

January 13, 2010: NMFS and representatives of the South Carolina Department of Health and Environmental Control conducted a conference call to discuss South Carolina's Water Quality Certification for the Augusta Canal Project and the NMFS Section 7 consultation.

April 25, 2011: NMFS and a representative for the applicant for the Augusta Canal Project had a conference call to discuss the draft settlement agreement and fish passage/fish barrier issues.

December 5, 2011: NMFS informed FERC by letter that a final listing determination on the Atlantic sturgeon would soon be published and that effects to Atlantic sturgeon from the Augusta Canal and King Mill projects would likely be similar to the effects on shortnose sturgeon. NMFS stated that, as the agency with jurisdiction over shortnose and Atlantic sturgeon, it identified exclusion of sturgeon from the Augusta Canal as a needed measure and it will work with FERC and the applicants to identify a safe and effective sturgeon barrier.

December 14, 2011: NMFS clarified for FERC via telephone the issues discussed in the December 5, 2011, letter and planned the next steps in resolving the fish passage/barrier issues.

January 17, 2012: NMFS determined that even though the Section 18 prescription for the Augusta Diversion Dam was for fish passage capable of passing sturgeon species, sturgeon are not likely to utilize the type of passage prescribed. Therefore, concerns about the fate of sturgeon species passing above the Augusta Diversion Dam were decreased. NMFS informed FERC via telephone that fish passage issues were no longer precluding moving forward with the consultation and NMFS would begin to review the other outstanding issues with the project.

May 18, 2012: NMFS requested via e-mail that FERC clarify the action that is being proposed for authorization in the license. The Final EA for the Augusta Canal Project was issued in September 2006 and incorporated terms of the draft settlement agreement (which NMFS signed in February 2006) as part of the preferred staff recommended alternative. NMFS signed a revised draft settlement agreement in January 2008. NMFS specifically requested clarification on the aquatic base flows being proposed, since the flows listed as the preferred staff-recommended alternative differed from the aquatic base flows agreed to in the 2006 and 2008 draft settlement agreements.

May 31, 2012: FERC informed NMFS via telephone that the aquatic base flows in the Final EA for the Augusta Canal Project were in error. FERC also clarified that since the intent of the preferred staff recommended alternative in the EA was to adopt the terms of the 2006 draft settlement agreement signed by NMFS and other agencies, that the terms of the revised 2008 draft settlement agreement (signed after publication of the Final EA) are being recommended by FERC staff for inclusion in any license issued for the Augusta Canal Project, therefore the terms of the 2008 draft settlement agreement should be included as part of the proposed action instead of the 2006 draft settlement agreement. With this information, NMFS initiated ESA Section 7 consultation on May 31, 2012.

November 29, 2012: NMFS had a conference call with a USFWS fishway engineer to discuss the fish passage currently prescribed for the Augusta Diversion Dam and ways to better ensure safe and effective sturgeon passage in the future, while guaranteeing sturgeon do not pass until safety concerns above the dam are resolved.

June 19, 2013: NMFS had a meeting with USFWS to explain our reasoning for blocking sturgeon from passing above the Augusta Diversion Dam. NMFS also shared a preliminary draft of the proposed revision to the prescription, to which USFWS provided some comments/feedback. USFWS indicated once minor comments/feedback are addressed it would likely take several weeks for DOI approval of the revised prescription.

April 12, 2016: NMFS arranged a site visit to the Augusta Diversion Dam for the city of Augusta, the Georgia Department of Natural Resources, and the South Carolina Department of Natural Resources.

October 5, 2016: NMFS provided USFWS with the second modification of the prescription for review and consideration.

December 13, 2017: NMFS provided the city of Augusta, the Georgia Department of Natural Resources, and the South Carolina Department of Natural Resources with the joint second modification of the prescription for review.

January 26, 2018: city of Augusta responded with comments on the second modification of the prescription.

April 19, 2018: city of Augusta stated they would not be offering any additional comments on the second modification of the prescription.

December 19, 2018: NMFS and USFWS jointly agreed on the language of the second modification of the prescription.

September 23, 2019: NMFS and USFWS filed a modified prescription for the Augusta Canal Project. The revisions include removing the prescription for shortnose sturgeon, reserving authority for NMFS to prescribe for Atlantic and shortnose sturgeon in the future, and minor modifications to the fishway design that will accommodate sturgeon in the future while excluding them in the meantime.

October 23, 2019: The city of Augusta, Georgia (City), filed a request for a trial-type hearing regarding the NMFS and USFWS joint fishway prescription for the Augusta Diversion Dam. The City, USFWS, and NMFS agreed to stay the proceeding until June 22, 2020, for purposes of settlement negotiations; a settlement was not reached.

July 10, 2020: USFWS withdrew from the joint fishway prescription with NMFS and filed their own reservation of authority to prescribe with FERC.

July 20, 2020: NMFS filed their own notice with FERC replacing the joint prescription with respect to NMFS with a reservation of authority to prescribe fish passage. The notice also advised FERC of NMFS' intent to subsequently file a modified fishway prescription, independent from USFWS.

February 3, 2023: NMFS receives a request from the city of Augusta, via the FERC docket, to be provided a copy of the draft biological opinion for the Augusta Canal Project.

April 24, 2023: NMFS provides the city of Augusta with a courtesy copy of the draft Opinion for the Augusta Canal Project, via the FERC docket, noting there is no obligation to solicit or respond to comments from FERC or the applicant on the draft Opinion.

May 22, 2023: The city of Augusta, via the FERC docket, requests a 30-day extension of the deadline to provide comments on the draft Opinion for the Augusta Canal Project.

May 24, 2023: NMFS grants 15-day extension of the deadline to provide comments on the draft Opinion for the Augusta Canal Project.

June 15, 2023: The city of Augusta provides comments on the draft Opinion for the Augusta Canal Project, via the FERC docket.

September 29, 2023: FERC, NMFS, and city of Augusta held a teleconference with representatives from Dominion Energy, Kleinschmidt, South Carolina Department of Natural Resources, and Cranston Engineering observing. The teleconference was intended to address outstanding issues and questions related to the draft Opinion and the city of Augusta's comments on it. During the teleconference, NMFS and the city of Augusta agreed to provide additional information requested by FERC.

November 21, 2023: NMFS provided FERC with three examples of Opinions considering the impacts of other water diversion projects.

January 22, 2024: The city of Augusta provides a partial response to FERC's request for additional information sought following the September 2023 teleconference.

January 24, 2024: NMFS files a letter updating FERC on the status of the Opinion. NMFS indicates that it will begin finalizing the Opinion on February 12, 2024.

In addition to the major correspondence listed above, NMFS staff conducted a site visit to the Augusta Canal Diversion Dam, and exchanged many additional e-mails and held phone conversations with FERC and the applicant throughout the consultation process.

3 DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

3.1 Action Area

The purpose of the Augusta Canal Project is to allow the Augusta Diversion Dam (ADD) to continue to divert water into the Augusta Canal for Augusta-Richmond County's municipal water supply, and for power generation at the Sibley Mill Hydroelectric Project, King Mill Hydroelectric Project, and Graniteville Enterprise Hydroelectric Projects. In the Final EA for the Augusta Canal Project, FERC defined the geographic scope of the project using the physical limits or boundaries of (1) the proposed actions' effect on the resources, and (2) contributing effects from other hydropower and non-hydropower activities within the Savannah River Basin.

The geographic scope used by FERC for this project encompasses areas within the Savannah River, upstream and downstream of the ADD. It also includes the U.S. Army Corps of Engineers' (USACE's) J. Strom Thurmond (JST) Dam (river mile [RM] 220.9; river kilometer [RKM] 353.4), the Stevens Creek Project (RM 208; RKM 332.8), and the NSBL&D (RM 187.4; RKM 299.8) (Figure 1).

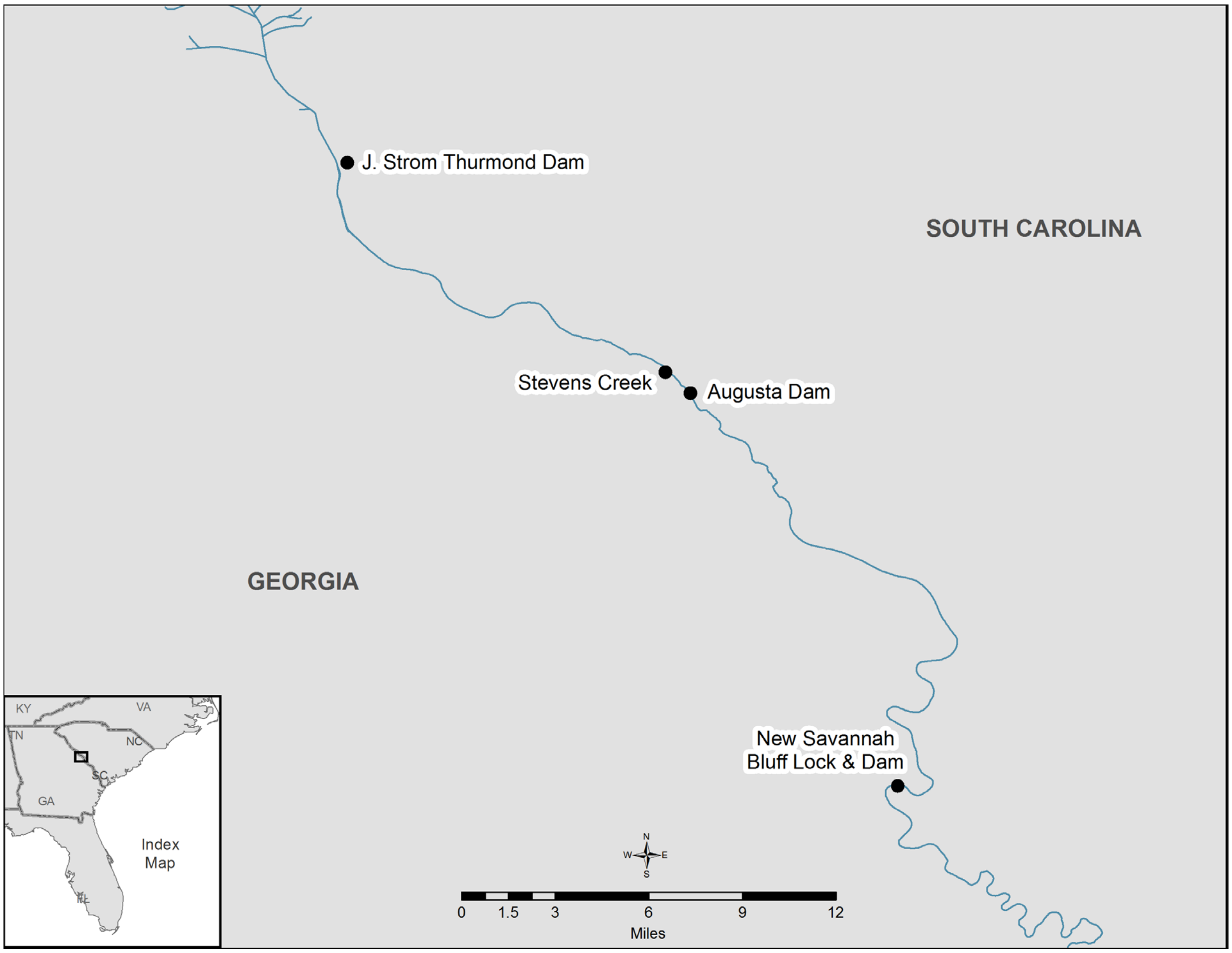

Figure 1. Map of the Savannah River between NSBL&D and the JST Dam

Figures 2-4 shows the locations of the various structures and facilities associated with the Augusta Canal Project. The ADD, the focus of the Augusta Canal Project, is located at RKM 331.7 (RM 207.3) within the Savannah River. The ADD diverts a portion of the water from the Savannah River into the Augusta Canal to be used for Augusta-Richmond County's municipal water supply and for electrical power generation by 3 facilities located on the Augusta Canal. The geographic scope also includes the following structures within the Augusta Canal: (1) the water pumping station (3.5 miles downstream of the ADD); (2) Long Gate Spillway and Tin House Gates via Rae's Creek (not depicted in available Figures), the Sibley Mill Project (5 miles downstream of the ADD); (3) the King Mill Project (5.25 miles downstream of the ADD); and, (4) the Enterprise Mill Project (5.75 miles downstream of the ADD) (FERC 2006).

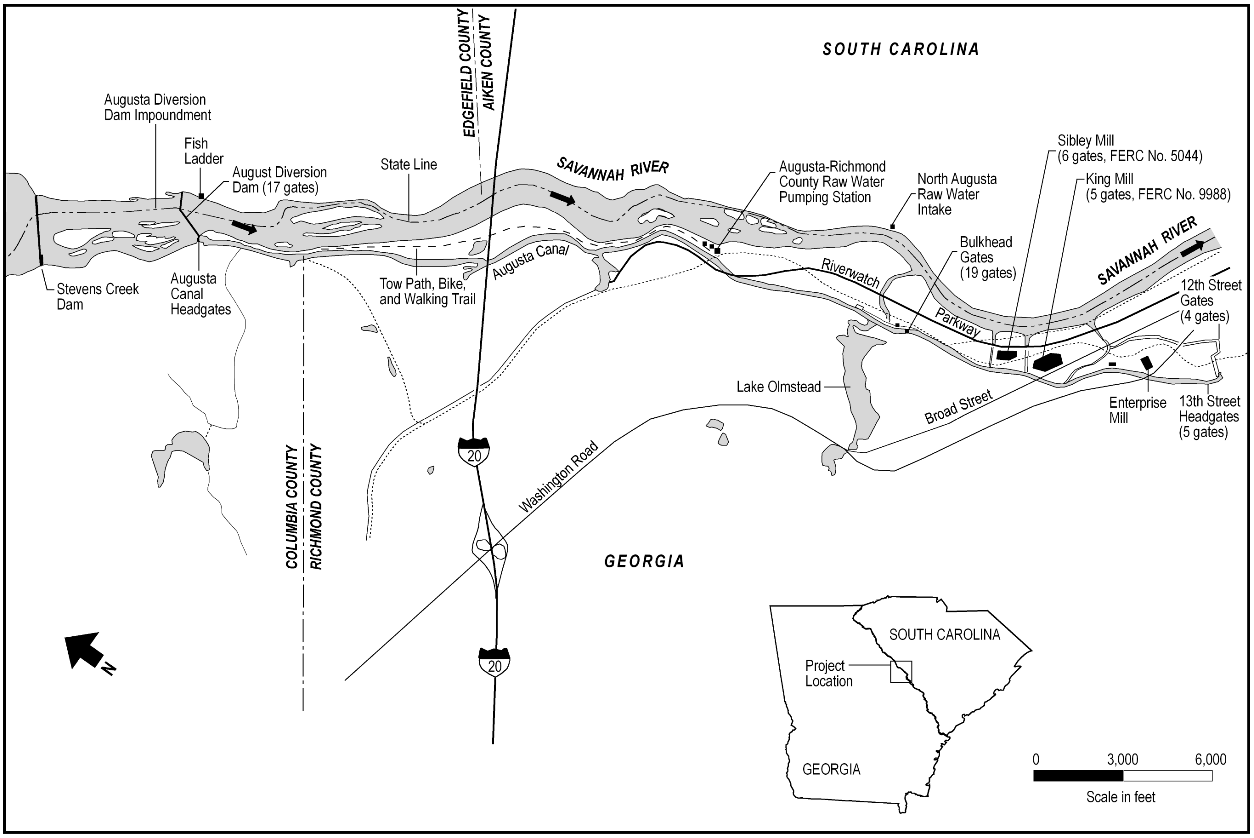

Figure 2. Locations of the Augusta Canal and King Mill Projects.

FERC chose this geographic area for evaluation of effects for the Augusta Canal Project because of ongoing activities throughout the basin, including industry, agriculture, recreational development, and hydropower projects. The licensing and operation of the Augusta Canal Project; the operation of the Sibley Mill, King Mill, and Graniteville Enterprise Hydroelectric Projects; and the removal of water in the Augusta Canal for Augusta-Richmond County's municipal water supply have the potential to cumulatively affect fishery resources in the Savannah River Basin.

In administering Section 7 of the ESA, NMFS and USFWS have issued regulations (50 CFR Part 402) on interagency consultation requirements, including definitions to help guide federal agencies. NMFS updated those regulations in 2019 (84 FR 44976; August 27, 2019). When analyzing the effects of the Augusta Canal Project as part of the proposed action by FERC (the licensing of the Augusta Canal Project), NMFS carefully considered the following definitions:

> *Action area* – means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in 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.

The Final EA states that the Augusta Canal was constructed in 1845 “for hydromechanical power and to supply water to the people of Augusta” (FERC 2006). The purpose of the Augusta Canal Project is to allow the ADD to continue to divert water into the Augusta Canal for Augusta-Richmond County’s municipal water supply, and for power generation at the Sibley Mill, King Mill, and Graniteville Enterprise Hydroelectric Projects. Sibley Mill, constructed in the early 1880s, produced cotton and other textiles until it closed in 2006. In 2016, the Augusta Canal Authority announced it had signed a 75-year lease with Cape Augusta Digital Properties to build a cyber-technology park at the Sibley Mill. The facility will include a campus that supports a wide range of cyber-related employers and educational facilities; construction of the facility is underway. King Mill was also constructed in the early 1880s and produced textiles. The developer working at the Sibley Mill has also purchased the King Mill and intends to turn it into residential space. Graniteville Enterprise Hydroelectric Project was constructed in 1848 and was originally a mill that produced flour. Currently, the space has been renovated to contain office space, residential lofts, and a retail center.

No hydropower is generated at the ADD itself. FERC is requiring a license for the Augusta Canal Project because hydropower cannot be generated at the Sibley Mill, King Mill, or Graniteville Enterprise Hydroelectric Projects but for the diversions of the water into the Augusta Canal via the ADD. Additionally, Augusta-Richmond County’s municipal water supply facility, Sibley Mill, King Mill, and Graniteville Enterprise Hydroelectric Projects, all of which are located in the Augusta Canal, rely on the water diverted by the ADD. Because these entities require water from the Augusta Canal to generate hydroelectric power, they could not exist or function as designed *but for* the existence and continued operation of the ADD, which provides water for the Augusta Canal. Further, the continued operation of these downstream facilities is reasonably certain to occur. Therefore, we determined that the consequences associated with the continued operation of these facilities are effects of the action. Accordingly, these projects are within the area “affected directly or indirectly” by the proposed action, and included in the action area for this opinion.

The JST Dam (RKM 352; RM 220) is the primary regulator of flows in the Savannah River upstream of the ADD (RKM 331.7; RM 207.3). The Stevens Creek Dam (RKM 332.8; RM 208) further regulates flows above the ADD. Both the JST and Stevens Creek Dams would exist and operate regardless of the licensing and operation of the Augusta Canal Project. However, the presence of the ADD prevents aquatic species, such as sturgeon, from accessing upstream habitat and contributes to alterations of upstream habitat (i.e., submergence of existing shoal habitat.). Thus, the upstream effects of the ADD are considered to be effects of the action and contribute to the definition of the action area for this opinion.

Water diversions for Augusta-Richmond County’s municipal water supply is the only consumptive use of water from the Augusta Canal Project. All other diverted water eventually flows back into the Savannah River, though after having bypassing spawning habitat. The water use for the municipal water supply reduces the amount of water available in the river relative to no diversions occurring. Thus, the downstream effects from licensing and operation of the

Augusta Canal Project are considered effects of the action and contribute to the definition of the action area for this opinion. However, the effects of the ADD on the amount of water available for the spawning habitat in the river end at the NSBL&D, because it creates an impediment to water flowing downstream. Water flowing over the ADD or through the canal is eventually impounded behind the NSBL&D. Upon reaching the NSBL&D, downstream flows are dictated by the NSBL&D rather than the ADD. Thus, the effects associated with the ADD and the canal end at the NSBL&D.

Therefore, the action area includes:

- the ADD
- the pool above the ADD (i.e., the Savannah River downstream of the Stevens Creek Dam to the ADD)
- the entire Augusta Canal
- the Savannah River downstream of the ADD to the NSBL&D

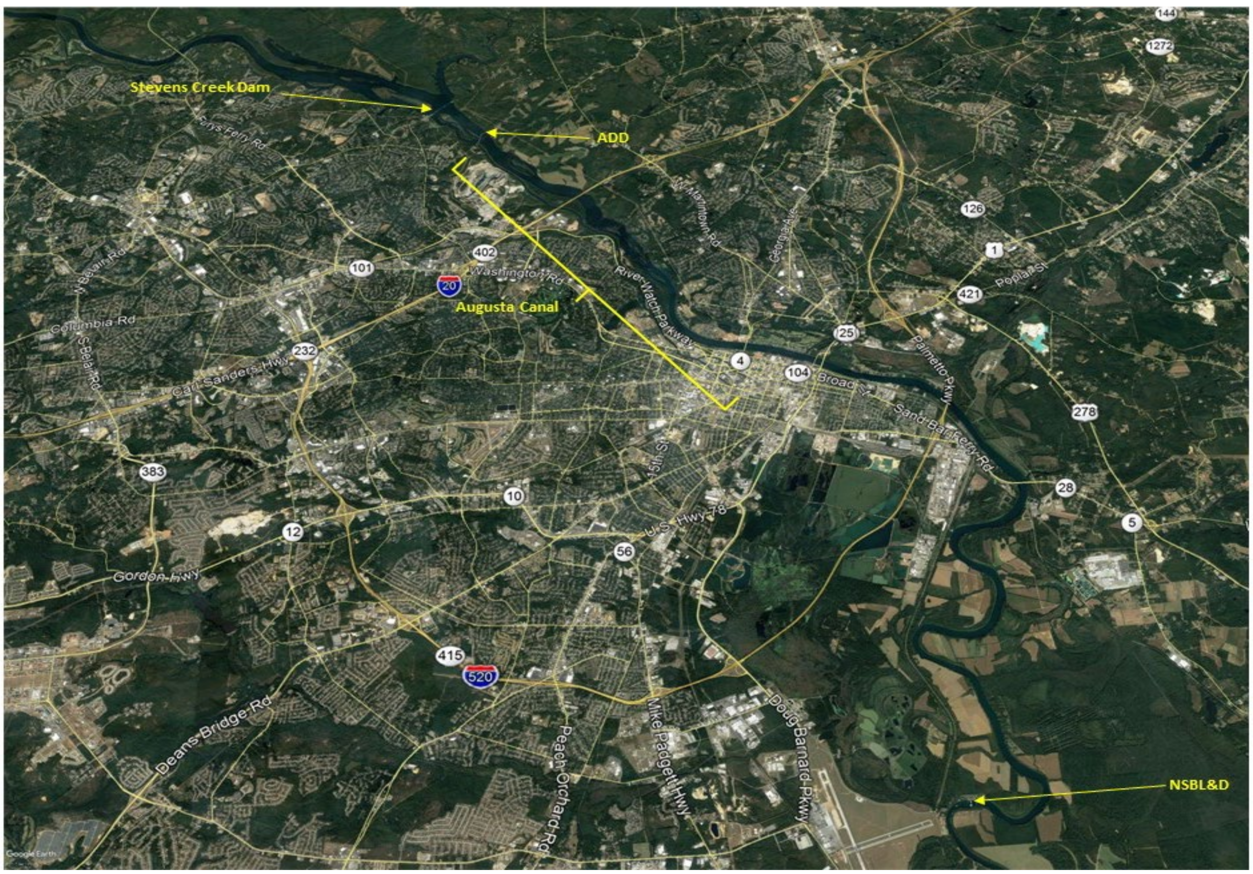

Figure 3. Overview of Action Area (© 2019 Google)

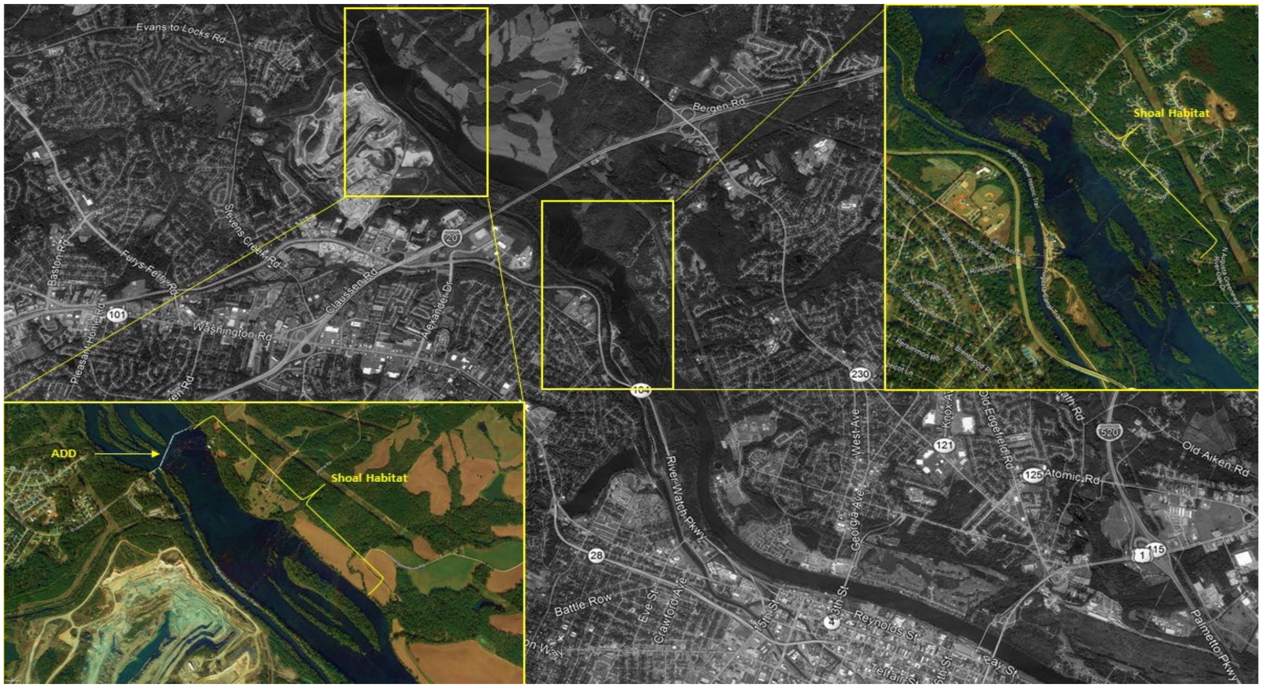

Figure 4. “Augusta Shoals” below the Augusta Diversion Dam (© 2019 Google)

The Augusta Shoals provides important habitat for a variety of aquatic species. It is estimated that dams and their impoundments currently render 92% of historically available sturgeon spawning habitat in the Savannah River unusable (ASSRT 2007). The NSBL&D currently obstructs Atlantic and shortnose sturgeon access to Augusta Shoals; however, the planned construction of fish passage at the present location of NSBL&D will provide these species access to the Shoals, which constitute 8% of their historically available habitat in the Savannah River (ASSRT 2007). While the habitat between NSBL&D and ADD represents only 8% of historically available spawning habitat for Atlantic and shortnose sturgeon in the Savannah River (ASSRT 2007), it represents an estimated 90% to 95% of the suitable or marginally suitable spawning substrate in the river. The Augusta Shoals are occasionally rendered completely dry when water is diverted from the Savannah River into the Augusta Canal. In 2010, Dial-Cordy was contracted to characterize the habitat of the Augusta Shoals. The report indicates the NSBL&D creates a pool that backs up into approximately downtown Augusta, Georgia and North Augusta, South Carolina (Dial-Cordy 2010). As a result, the Augusta Shoals occur from the base of the ADD, extending downstream approximately 4.5 RM (7.2 RKM) before meeting the NSBL&D “pool” (Dial-Cordy 2010). Over the length of the Augusta Shoals, the Savannah River ranges from 400 to 1,700 ft. wide, and includes some islands. For the purposes of this consultation, when referring to the “Augusta Shoals” or “Shoals” we are generally referring to this entire 4.5 RM river reach.

The Augusta Shoals are comprised primarily of shoals and runs (Entrix 2002). Shoal habitats include large stretches of shallow bedrock and boulder areas with occasional large cobble substrates (Entrix 2002). At low flows (1,929-2,317 cfs), many shoal habitats stretch across the entire width of the river and are present in long complexes separated by deep pools (Entrix 2002). Of the 57 sites for which Dial-Cordy (2010) was able to collect specific substrate data, they determined 40% of those sites would be considered suitable for shortnose sturgeon spawning (based on the habitat parameters described in (NMFS 2007)) and 37% of sites would be considered marginally suitable (Dial-Cordy 2010). The remaining 23% of sites were classified as unsuitable substrates for spawning (Dial-Cordy 2010).[1]

3.2 Existing Project Facilities

The existing Augusta Canal Project is located on the Savannah River at 331.7 RKM (RM 207.3) in Augusta, Richmond County, Georgia, centered at latitude 33.55365°N and longitude 82.037939°W (ADD); datum World Geodetic System 1984 (WGS84; Figure 5).

Figure 5. Augusta Diversion Dam. (© 2018 Google)

According to the Final EA, the Augusta Canal Project includes (1) the 1,666-foot-long by 11.5-foot-high stone-masonry ADD; (2) the 190-acre Savannah River Impoundment located between Stevens Creek Project and the ADD; and, (3) the first level of the Augusta Canal, which extends about 7 miles between the ADD and the Thirteenth Street gates. Structures included in the first level of the Augusta Canal include: (i) the canal head gates, consisting of 4 steel and 9 wooden motor-operated gates for admitting flow to the canal; (ii) a 100- by 15-foot navigation lock; (iii)

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[1] The Dial-Cordy report contains a computational error. It erroneously states: "Of the 57 sites where substrate data were observed/collected in Augusta Shoals/Savannah Rapids (see Figure Series C in Appendix A), the combined frequency of sites associated with substrate types considered suitable by NOAA (2007) was 40% and the combined frequency of marginally suitable sites was 37%. *Approximately 33% of sites appeared to have unsuitable substrates* [emphasis added]." The percentage of unsuitable substrates should be 23% (i.e., 40% suitable + 37% marginally suitable + 23% unsuitable = 100%). This Opinion uses the corrected 23%.

the Reed Creek waste gate; (iv) the Rock Creek waste gate; (v) the Long Gate Spillway and pedestrian bridge; (vi) the Tin House gates; (vii) the Bulkhead gates, consisting of 8 gate bays, 1 navigation bay, and a 196-foot-long pedestrian bridge spanning the canal; (viii) Weigles Gate that consists of a single steel gate discharging to Hawk's Gully; and, (ix) the Thirteenth Street Headgates consisting of 5 steel gates.

3.3 Existing Project Operations

Flows in the Savannah River are regulated by 3 major dams, upstream of the action area, operated by USACE Savannah District (SAS):

- Hartwell Project (RM 279; RKM 446.4)
- Russell Project (RM 253; RKM 404.8)
- JST Project (RM 220.9; RKM 353.4)

Due to the regulation of flows by these projects, flows in the Savannah River have become more uniform on a seasonal basis, though they vary widely on an hourly and daily basis (e.g., flow releases from JST Project can range from less than 100 cfs to a little more than 30,000 cfs on an hourly basis). Flows in the Savannah River at the Augusta Canal Project are determined primarily by the daily operations of the JST Project and flow re-regulation at Stevens Creek.

Operation of the Strom Thurmond Project (JST Project)

The JST Project, along with 2 other projects, (Hartwell and Richard B. Russell), are operated under the guidelines described in the "Water Control Manual - Savannah River Basin Multiple Purpose Projects". Under normal conditions, the water management goals of the 3 projects are to maximize the public benefits of hydroelectric power, flood damage reduction, recreation, fish and wildlife, water supply, and water quality. Under flood conditions, the water management objective of the projects is to minimize flooding downstream. Under drought conditions, the water management objective of the projects include limiting lake drawdowns, making use of most of the available storage in the lakes during the drought of record, maintaining hydroelectric plant capacity throughout the drought, and minimizing adverse impacts to recreation during the recreation season. The JST Project, in coordination with the Southeast Power Administration (SEPA), also provides "peaking" hydroelectric power. At periods of high-energy consumption, the JST Project can release more water through its hydroelectric turbines, creating more electricity to meet the increased demand. However, depending on the amount of flow released from the JST Project, the water levels in the river below the dam can change significantly. For example, during periods of peak energy demand, the JST Project may release upwards of 30,000 cfs into the river. Conversely, during periods of low demand flows of as little as 100 cfs may be released.

Operation of the Stevens Creek Project

Flow releases from the JST Project are re-regulated in part by the Stevens Creek Project, located approximately 1 mile upstream of the ADD. The Stevens Creek Project operates as a re-regulating project, redistributing the varying discharges from the upstream JST Project to provide a more uniform flow in the Savannah River below Stevens Creek. The normal operating target range for Stevens Creek is to provide an hourly discharge of +/-15% of the scheduled daily average discharge from the JST Dam, if the actual discharge from JST Project is within 500 cfs of the scheduled discharge (Kleinschmidt 2020).

During periods of high flow or flood conditions (i.e., periods of sustained flows of greater than 8,300 cfs from the Savannah River and Stevens Creek), the Stevens Creek Project will generate to its full capability (approximately 8,300 cfs), while spilling all additional flow over the 2,000-foot-long overflow section of the dam (flashboards may be tripped at very high flows). In this situation, all water coming down the Savannah River passes directly through the Stevens Creek Reservoir (Kleinschmidt 2020).

During normal flows (4,200 to 8,300 cfs inflow), the Stevens Creek project generates power in accordance with a generation schedule outlined in its FERC license. This schedule approximates the planned daily average discharge from JST Project on weekdays. The Stevens Creek reservoir levels fluctuate within its normal operating range on a daily basis, but over the course of the week, the water level in the reservoir is allowed to gradually increase until midnight on Fridays. Because the JST Project historically releases less flow on weekends, this gradual increase in the Stevens Creek reservoir during the week ensures sufficient water is available for release on weekends, when discharges from the JST Project are typically low (Kleinschmidt 2020).

During periods of low inflow (4,000 to 4,200 cfs), drought (3,800 to 4,000 cfs inflow), and severe drought (less than 3,800 cfs inflow) the Stevens Creek Project will continue to generate in accordance with the generation schedule outlined in its FERC license that is intended to approximate the scheduled daily average discharge from the JST Dam. Under these conditions, the primary difference from normal conditions (4,200 to 8,300 cfs) is that the discharge from Stevens Creek Project does not exceed the maximum inflow (e.g., 4,200 cfs for low inflow conditions or 4,000 cfs for drought conditions) (Kleinschmidt 2020).

The Stevens Creek Project is operated to minimize pool fluctuations in Stevens Creek Reservoir while discharging a continuous flow in response to the weekly release projections of the JST Project. Flows discharged from Stevens Creek Project reach the ADD, some of the flow diverts into the Augusta Canal and any remaining flow continuing over the ADD into Augusta Shoals and beyond in the Savannah River. The flows at the ADD have ranged from 2,300 cfs to over 20,000 cfs (FERC 2006). Currently, there are no operational requirements or minimum flows required for the ADD. Stevens Creek is FERC-licensed facility. NOAA Fisheries will engage with FERC during the upcoming re-licensing of that facility to analyze and mitigate potential effects to sturgeon from flows passing through the project area of Stevens Creek.

Operation of the Augusta Canal Project

The ADD’s headgates at the entrance of the Augusta Canal are manually set to provide flow in the Augusta Canal adequate to meet canal user needs. Changes in the Augusta Canal gate configuration are infrequent. Water needs include: (1) flows for Augusta-Richmond County’s municipal water supply; (2) the Sibley Mill, King Mill, and Graniteville Enterprise hydroelectric projects; and (3) aesthetics and recreation. Excess river flows are mostly passed over the ADD, but excess water in the Augusta Canal is also passed out of the Thirteenth Street gates located at end of the Augusta Canal, as well as the Long Gate Spillway and Tin House Gates located along the Augusta Canal. Downstream of the ADD, the Savannah River is again impounded by the

USACE-operated NSBL&D at RM 187.4 (RKM 299.8), the farthest downstream dam on the Savannah River.

Since the 1870s, the city of Augusta has had agreements with the mills to provide water for operation of their hydropower units. In return, the mills provide revenue to the Augusta Canal Authority, which is used to support cultural, historic, and recreational activities on the Augusta Canal. Collectively, the mills could generate 40,121 megawatt-hours of electricity annually.

The theoretical maximum flow capacity of the Augusta Canal is approximately 6,900 cfs (FERC 2006). However, due to extensive deposition of sediments and aquatic plants, the actual capacity is much less (FERC 2006). Diversions into Augusta Canal exceeded 3,500 cfs on less than 1% of days from 1996-2019, with a maximum draw of 4,000 cfs. The average flow in the Augusta Canal over the last 20 years has been about 2,500-2,700 cfs; however, the demand for water is seasonal and not all hydropower projects were in operation during all years (FERC 2006).

The city of Augusta projected the seasonal Augusta Canal water needs through 2035 (FERC 2006). Maximum city-estimated Augusta Canal needs ranged from 3,656 cfs in 2000 (based on the city of Augusta's raw water pumping station needs of 1,041 cfs, 1,024 cfs for Sibley, 881 cfs for King, 560 cfs for Enterprise, 100 cfs for a kayak course, and a 50 cfs aesthetic flow) to 4,353 cfs in year 2035 (based on the city of Augusta's raw water pumping station needs of 1,738 cfs and all other water demands the same as in 2000).[2] During a meeting between FERC, NMFS and the city of Augusta, held virtually on September 29, 2023, the City indicated the kayak course requiring 100 cfs had not been built and plans to do so were on hold.

The reach of the Savannah River bypassed by the Augusta Canal extends from the ADD to the tailrace of the Enterprise Mill. While the flow regime of the Savannah River at the ADD is largely determined by upstream reservoir operation, flows in the bypassed reach of the Savannah River are also influenced, particularly during low-flow conditions, by diversion of water into the Augusta Canal. The Augusta Shoals is contained within this bypassed reach of the Savannah River.

3.4 Proposed Project Operations

A draft settlement agreement, which NMFS signed in 2006 but was never signed by the city of Augusta, outlined a proposal for project operation, flows, and fishways for the Augusta Canal Project. The terms of the 2006 draft settlement agreement are presented in the Final EA as part of the preferred staff recommended alternative with some additional measures added by FERC. After the Final EA was published in 2006, the draft settlement agreement was revised and signed by NMFS in 2008. In 2012, FERC confirmed to NMFS that they intended to incorporate the terms of the 2008 revised draft settlement agreement into any license issued for the Augusta Canal Project. Therefore, the proposed action includes:

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[2] The Revised Augusta Canal Hydropower Project Operations Plan of 2003 states 1,628 cfs is withdrawn from the Augusta Canal to drive the hydro-mechanically powered pumps, which move approximately 100 cfs [60 million gallons day] of raw water from the Canal to the Highland Avenue filter plant. The water used to drive the hydro-mechanical pumps returns to the mainstem Savannah River via a small tailrace located approximately a half mile upstream from the beginning of the of the Augusta Shoals.

(1) The terms of the 2008 draft settlement agreement (attached as Appendix 1) except where superseded by different terms in the Draft Third Modified Fishway Prescription,

(2) Additional measures included by FERC in the Final EA as part of the staff-recommended preferred alternative (including, but not limited to, the *Measures for Drought Conditions*[3] and *Canal Operating Plan*),[4] and

(3) Terms of the Draft Third Modified Fishway Prescription.

3.4.1 Terms of 2008 Draft Settlement Agreement (Appendix 1) - Minimum Aquatic Base Flows

The aquatic base flows in the 2008 draft settlement agreement stipulate the daily average flow that can be diverted into the Augusta Canal based on the flow levels within the Savannah River to ensure a minimum base flow is maintained for the Augusta Shoals. Section 4 of the 2008 draft settlement agreement (Appendix 1) contains the following stipulations regarding flows within the Savannah River, operation of the ADD, and the minimum base flows reserved for the Shoals:

4. Flow Conditions

4.1 The Parties agree that aquatic base flow reservations for the Augusta Shoals will be as stated in Section 4.3. All numbers are in cfs. The first column identifies the levels of inflows to the Augusta Diversion Dam, which are sometimes described as "Tier 1" (Augusta Diversion Dam inflows greater than 5,400 cfs), "Tier 2" (Augusta Diversion Dam inflows between 4,500 and 5,399 cfs), "Tier 3" (Augusta Diversion Dam inflows between 3,600 and 4,499 cfs), and "Tier 4" (Augusta Diversion Dam inflows less than 3,600 cfs).

4.2 Inflows to the Augusta Diversion Dam are described as the "Augusta Declaration." The Augusta Declaration will be calculated as follows:

(1) Acquire daily Southeastern Power Administration (SEPA) Declaration for the JST Dam.

(2) Determine additional inflow between the JST Dam and the ADD for same date as SEPA Declaration. The agreed method of calculating additional inflow is described

[3] With respect to managing flows during drought conditions, FERC 2006 states:

> The City proposes to reduce Aquatic Base Flows when flows to the project are reduced. This would happen when the Corps reduces discharges at the JST Dam in response to declared drought conditions. JST discharges under non-drought and drought conditions are outlined in Table 3 [in FERC 2006]. The City does not propose Aquatic Base Flows during a Drought Level 4. The Corps has never declared a Drought Level 4 condition in the 12 years that the drought contingency plan has been in place. Since this 12-year period includes the worst period of drought (1999 to 2002) on record, Level 4 is unlikely to occur. In the event of an extremely severe drought, the City proposes to consult with the resource agencies regarding an appropriate interim flow regime for the Shoals.

[4] Aside from laying out the process for determining flow allocations to Canal and Shoals based flows arriving at the ADD (discussed in detail in Section 3.4.1 of this Opinion, the *Canal Operating Plan states:* "…If the daily allowable diversion flow rate is greater than the daily demand flow rate, then no action is needed and the flow in the Shoals will be greater than the Aquatic Base Flow. If the daily allowable diversion flow rate is less than the daily demand flow rate, then one or more Canal users must curtail operations to account for the shortage."

in Attachment 2, which is incorporated into and made a part of this Settlement Agreement. The Parties will agree to standardize the time of day to read the United States Geological Survey (USGS) Modoc gauge (as described in Attachment 2) for the purpose of calculating inflows.

(3) The sum of the daily SEPA Declaration and additional inflow from Step (2) equals the daily Augusta Declaration.

4.3 Agreed Aquatic Base Flows:

	FEB/MAR	APR	MAY 1-15	MAY 16-31	JUNE- JAN
Tier 1 ≥5400	3300	3300	2500	1900	1900
Tier 2 4500-5399	2300	2200	1800	1800	1500
Tier 3 3600-4499	2000	2000	1500	1500	1500
Tier 4 <3600	1800	1800	1500	1500	1500

4.4 The difference between the Augusta Declaration and the agreed aquatic base flow for each day will be the amount that may be diverted to the Augusta Canal, as needed, sometimes referred to as the daily allowable diversion flow rate. For purposes of determining compliance, the quantity of water that will flow in the Canal shall not exceed 105 percent of the daily allowable diversion flow rate.

4.5 The City will make one flow setting for the Canal Headgates on a daily basis, based upon the daily Augusta Declaration. There will be no adjustments to the canal flow setting during such 24 hour period, except for compliance purposes or an emergency.

4.6 The flows stated in Section 4.3 are not minimum flows but base flows. This means that based on a 40 year historical average and as projected over the expected FERC license term, the flows will be greater than stated, especially at the Tier 1 Level, a majority of the time. This is because total flow in the Savannah River will often exceed the sum of the allocations for the Canal and Augusta Shoals, and any surplus water will flow into the Augusta Shoals.

4.7 Between May 16 and the following January 31 of each year, the specified aquatic base flows will be reserved at least 90 percent of the time under Tier 1 (≥ 5400 cfs) flow conditions, based on a 60-day rolling period. Stated otherwise, the aquatic base flow reservation will be satisfied at least 54 days of any consecutive 60-day period (subject to the 5 percent "margin of error" condition set out in Section 4.4, which states that for purposes of determining compliance the quantity of water that will flow in the Canal shall not exceed 105 percent of the daily allowable diversion flow rate). During the balance (no more than 10 percent or 6 days) of each consecutive 60-day period, Augusta will reserve a daily average flow at not more than 500 cfs below the aquatic base flow level.

4.8 Between February 1 and May 15 of each year, the specified aquatic base flows will be reserved at least 95 percent of the time under Tier 1 (≥ 5400 cfs) flow conditions, based on a 60-day rolling period. Stated otherwise, the aquatic base flow reservation will be satisfied at least 57 days of any consecutive 60-day period (subject to the 5 percent "margin of error" condition set out in Section 4.4, which states that for purposes of *determining compliance the quantity of water that will flow in the Canal shall not exceed 105 percent of the daily allowable diversion flow rate). During the balance (no more than 5 percent or 3 days) of each consecutive 60-day period, Augusta will reserve a daily average flow at not more than 500 cfs below the aquatic base flow level.*

4.9 The aquatic base flow will be met 90 percent of the time in a running count of any 60-day period year-round. In addition, the aquatic base flow will be met 95 percent of the time in a running count for any 60-day period that begins on or after February 1 or ends on or before May 15. In other words, the specified aquatic base flows will be reserved at least 90 percent of the time under Tier 1 (≥ 5400 cfs) flow conditions for the full 60-day rolling period year-round (subject to the 5 percent "margin of error" condition set out in Section 4.4, which states that for purposes of determining compliance the quantity of water that will flow in the Canal shall not exceed 105 percent of the daily allowable diversion flow rate). The deviation will be not more than 6 days during any 60-day period year-round, and in addition, will be not more than 3 days during any 60 day period between February 1 and May 15.

4.10 For purposes of determining compliance with either the 90 percent/60 day rule or the 95 percent/60 day rule, circumstances beyond the control of Augusta shall not be counted as a violation of Augusta's license, including but not limited to the following: downstream users violating anticipated allocations, downstream users' violations of their license conditions, catastrophic failure of the gates or canal banks, or operational emergencies. Further, periods of canal re-watering shall not be counted in the allowed percentage deviations. The purpose of the 5 percent/10 percent deviation allowed, as provided herein, is to give Augusta operational flexibility, at its discretion, to meet the needs of the canal users. The 90 percent/60-day rule and the 95 percent/60-day rule shall apply only to Tier 1 flow conditions.

4.11 Augusta will, at its option, either:

a. Within 90 days following the execution of this Settlement Agreement, submit the procedure for determining the "Augusta Declaration," described in Section 4.2 and Attachment 2 hereof, to an independent third party agreeable to all Parties to verify that the procedure is a reasonable method to determine how much water would be available to meet the needs of the Augusta Canal after first reserving the aquatic base flows (averages over a twenty-four hour period) indicated in Section 4.3. The independent third party will be a qualified hydrologist. The hydrologist will be asked to render an opinion, based on the historic record, on the likelihood that the aquatic base flow or larger quantity of water will reach the Augusta Shoals on a daily average basis. In the event such verification cannot be provided for any reason, Augusta agrees to implement option (b) below; or

b. Upon acceptance of FERC license, place at its expense into the pool above the Augusta Diversion Dam a device for monitoring the pool daily average stage in that section of the River.

4.12 Augusta will work with USACE and/or USGS to provide appropriate gauging equipment in the Canal. In so doing, Augusta will consult with USFWS, NMFS, Georgia Department of Natural Resources (GADNR), and South Carolina Department of Natural Resources (SCDNR). Augusta will not monitor the flow in the Augusta Shoals, nor will there be any instantaneous, or continuous, minimum flow condition for the Augusta Shoals, except for the 1000 cfs provided in Section 5.3 and Attachment 1 to this Settlement Agreement.

4.13 Should Augusta's demands for water from the Canal exceed 4,600 cfs during the term of the expected FERC license, Augusta agrees to submit any proposed future increase in Canal flows and an evaluation of any impacts such flows would have on the Augusta Shoals to a technical committee composed of representatives of the GADNR, SCDNR, and Augusta Utilities Department, which committee shall make a recommendation to FERC regarding any such proposed increase in Canal flows. The technical committee shall notify USFWS and NMFS regarding any proposed increase in Canal flows and shall keep USFWS and NMFS advised of discussions regarding same. The technical committee shall provide USFWS and NMFS with a copy of any proposed increase in Canal flows and shall allow USFWS and NMFS to review and provide written comments. Any comments by USFWS and NMFS shall be forwarded to FERC by the technical committee as a part of any report from the committee. Any Party may also comment separately to FERC regarding such increase, but it is the intent of the Parties not to reopen the FERC license (this clause is applicable only to this Section 4.13). FERC shall make the final decision regarding such increases in Canal flows and any impacts those flows would have on the Augusta Shoals.

3.4.2 Proposed Fish Passage at NSBL&D

The NSBL&D is located approximately 18 miles downriver from the ADD and presents a significant barrier to upstream passage of shortnose and Atlantic sturgeon within the Savannah River. As a requirement of the city of Augusta's lease to operate the NSBL&D, the lock must be operated twice a week during the spring to pass various fish species (e.g., shad and herring) upriver. Monitoring studies show this approach has had only limited success for American Shad and may not have been successful for Atlantic and Shortnose Sturgeon. Due to safety concerns with the aging lock structure, the USACE and the city of Augusta ended springtime operation of the lock for fish passage on May 14, 2014. The USACE made a draft recommendation in the Section 216 Disposition Study of 2000 to remove the NSBL&D. Public opposition to the potential loss of the impounded pool occurring upriver resulted in Congress declaring, in an amendment to the Section 216 Disposition Study, that the NSBL&D would be repaired and may be turned over to a local government to maintain. The repair work was not funded and the NSBL&D has not been rehabilitated.

NMFS completed an ESA Section 7 consultation with the USACE regarding the Savannah Harbor Expansion Project (SHEP) on November 4, 2011 ("2011 Opinion"), which included a requirement for constructing a fish passage, specifically an off-channel rock ramp, capable of effectively passing shortnose and Atlantic sturgeon upriver of the NSBL&D (NMFS 2011). Fish passage was intended to avoid and minimize effects resulting from deepening and expansion of the navigation channel by providing improved access to upstream spawning habitat by constructing an 'out-of-river' passage adjacent to the NSBL&D. This design would require construction of an entirely new artificial channel adjacent to the Savannah River to provide a bypass around the dam structure. Section 1319 of the WIIN Act of 2016 deauthorized the federal interest in the NSBL&D project, and directed USACE to re-evaluate fish passage alternatives for SHEP. Specifically, Section 1319 directs USACE to evaluate 2 possible options for an 'in-river' fish passage design, both of which would result in removal of the NSBL&D structure entirely. The mandate provided in the WIIN Act delayed the beginning of construction and also completion of fish passage at NSBL&D required in the 2011 Opinion (NMFS 2011). Originally, construction of fish passage was to commence prior to or concurrently with initiation of inner harbor dredging (scheduled to begin in 2018) and be completed within 2 years. A design for the fish passage structure at NSBL&D was completed and its construction was slated to begin in 2020 before litigation halted construction. Construction remains suspended while the issue is resolved in court. With construction of the fish passage, sturgeon presence is expected to increase in the portion of the Savannah River between NSBL&D and the ADD during the 30-year to 50-year authorization period of the FERC license issued for the Augusta Canal Project.

Section 18 of the FPA states that FERC shall require the construction, maintenance, and operation by a licensee of such fishways as the Secretaries of the U.S. Department of Commerce (NMFS), and the U.S. Department of the Interior (USFWS) may prescribe. By letter filed July 30, 2004, NMFS and USFWS jointly filed a preliminary prescription for fishways pursuant to Section 18 of the FPA. In October 2005, NMFS and USFWS amended that modified prescription to correct typographical errors and formally added NMFS and USFWS responses to comments the applicant had provided on the Preliminary Prescription for Fishways. Following the 2005 filing, the city of Augusta, USFWS, and NMFS pursued a settlement agreement to address water flows and some aspects of fishway design and timing.

The 2005 fishway prescription was intended to restore American shad, blueback herring, striped bass, robust redhorse, American eel, and shortnose sturgeon. Atlantic sturgeon were not listed under the ESA in 2005 and were not included in the 2005 fishway prescription. Aspects of the fishway prescriptions were modified by the 2008 draft settlement agreement.

Section 5 of the 2008 draft settlement agreement (Appendix 1) contains the following stipulations regarding design and operation of the fishway at the ADD:

> *5. <u>Fish Passage</u>*
>
> *5.1 The Parties agree that upstream fish passage will be as described by USFWS and NMFS in the Modified Prescriptions for Fishways dated August 4, 2005, and August 24, 2005, with attraction flows supplied by either a permanent notch, Obermeyer type inflatable crest gates, or other similar structure, as specified in Section 5.3 herein, waiving the conditions that Augusta expressed in its license application. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install upstream fish passage in accordance with the provisions of Attachment 1.*
>
> *5.2 The Parties agree that downstream fish passage shall be fully operational within three years of USFWS or NMFS notifying the licensee that shortnose sturgeon have been*

documented to successfully pass above the ADD through the upstream fishway. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install downstream fish passage in accordance with the provisions of Attachment 1.

5.3 The Parties agree that until such time as upstream fish passage facilities are constructed at the Augusta Diversion Dam, Augusta will provide a temporary notch or other similar structure (within one year of the issuance of a FERC license) using existing facilities (e.g., stoplogs). The temporary notch or other similar structure will be sized to provide a minimum flow of approximately 1,000 cfs over or through the Dam at all times, including leakage (which includes leakage from any part of the Dam, including but not limited to flow through the existing fish ladder). When fish passage facilities are constructed at the Augusta Diversion Dam, the City of Augusta will provide either a permanent notch in the dam adjacent to the new fishway, which will be incorporated into the new fishway design, or Obermeyer type inflatable crest gates, or other similar structure, either of which will be sized to provide a minimum flow of approximately 1,000 cfs over or through the Dam at all times, including leakage. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install the temporary notch or other similar structure and either the permanent notch, Obermeyer type inflatable crest gates, or other similar structure in accordance with the provisions of Attachment 1.

However, discussions between NMFS, FERC, the applicant, and sturgeon fish-passage experts in 2012, raised questions about the effectiveness and necessity of the prescribed (vertical slot) fish passage for sturgeon in the draft settlement agreement. NMFS determined the prescribed fish passage was unlikely to safely or effectively pass Atlantic and shortnose sturgeon upstream or downstream of the ADD. Further, NMFS believed it would not be beneficial at that time for sturgeon to be above the ADD. Thus, while the 2008 settlement agreement was never finalized, NMFS and USFWS filed a joint Second Modified Prescription, revising requirements relating to sturgeon passage (removing the prescription for shortnose sturgeon; the South Atlantic DPS of Atlantic sturgeon was not included in the previous prescriptions) and incorporating elements of the draft settlement agreement, in September 2019. In October 2019, the city of Augusta submitted a request to NMFS and USFWS for a trial-type hearing regarding the Second Modified Prescription. On July 17, 2020, and July 20, 2020, respectively, the USFWS and NMFS filed separately to replace the Second Modified Prescription with a Reservation of Authority. Therefore, the previously filed Second Modified Prescription is no longer in effect for either NMFS or USFWS. In its notice to FERC on July 20, 2020, the NMFS expressed its intent to prepare and file a Third Modified Prescription for Fishways.

NMFS intends to maintain the fish passage requirements at ADD for American shad, blueback herring, and American eels. While there is no fish passage prescribed for sturgeon species, the effects of the prescribed fish passage on sturgeon, as well as recommended modifications to passage to protect sturgeon, will be discussed in Section 6.3 and 10.3.

In addition to the terms of the 2008 draft settlement agreement (Appendix 1), the Final EA issued by FERC (FERC 2006) included additional measures for inclusion in any license issued for the Augusta Canal Project as part of the preferred staff recommended alternative. Additional measures relevant to listed species under NMFS' purview are:

- *Finalize and implement a flow and operations monitoring plan which is consistent with the draft Settlement to meet target flows 90-95 percent of the time. The plan should specify that the 5-10 percent operating margin is intended to manage for circumstances beyond the control of the City, and is not intended for discretionary deviations for the purpose of benefiting Augusta Canal water needs (i.e. hydropower). The plan should also include installing gauging equipment in the Augusta Canal adequate to measure flows in the Augusta Canal. The gauging plan should be developed in consultation with USFWS, NMFS, GADNR, SCDNR, and USACE. Details of this plan are further described in Sections I and III.A of the EA;*

- *Should the Augusta Canal flow demand exceed 4,600 cfs the City shall convene a technical committee composed of the GADNR, SCDNR, USFWS, NOAA Fisheries, the Georgia SHPO [State Historic Preservation Office], and City to evaluate Augusta Canal flows and make recommendations to FERC regarding the need to increase Augusta Canal flows;*

- *Until such time that upstream fish passage facilities are constructed at the Diversion Dam, the City should construct a temporary notch in the Diversion Dam sized to provide a 1,000 cfs minimum flow below the dam (through a combination of leakage and flow through the notch). When fish passage facilities are constructed at the dam, the City should provide a permanent notch in the dam to release similar flows.*

3.5 License Term

Pursuant to the FPA and the U.S. Department of Energy Organization Act, FERC is authorized to issue licenses for up to 50 years for the construction and operation of nonfederal hydroelectric dam subject to its jurisdiction. However, that authorization only applies when the project:

> *"... in the judgment of FERC, will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water-power Dam, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational and other purposes referred to in Section 4(e) 16 USC §803(a)."*

FERC may require other conditions consistent with the FPA if they are necessary to provide for the various public interests to be served by the Augusta Canal Project. Compliance with such conditions during the licensing period is mandatory. FERC's Rules of Practice and Procedure allow any person objecting to a licensee's compliance or noncompliance with such conditions to file a complaint noting the basis for such objection for FERC's consideration.

3.6 Reopening the License

Pursuant to license articles reserving the authority to reopen a license, FERC may reopen a license at any time during the license for making reasonable changes in project operations or facilities if supported by substantial evidence. FERC's discretionary authority is seen as a means to address unforeseen effects that were not previously considered, or which may arise over the term of a new license. NMFS believes that timely reopening of the license is critical to managing conservation of endangered and threatened species over the term of a new license, given the lack of specific provision for listed species of fish in the current licensing documents, and considers it an integral part of the proposed action.

3.7 Summary of the Proposed Action

FERC proposes to issue a new license to the city of Augusta for the operation of the Augusta Canal Project for a term of no more than 50 years. FERC proposes to address unforeseen effects that may arise or were not previously considered by reopening the license to modify or add conditions. The proposed action is the licensing and operation of the existing Augusta Canal Project with fishway provisions and the modifications to hydrology and water quality discussed above. Below we summarize the proposed action relevant to routes of potential impacts to shortnose and Atlantic sturgeon:

- The city of Augusta will divert water into the Augusta Canal for municipal and hydroelectric usage only as allowed by Section 4 of the 2008 draft settlement agreement. This will maintain aquatic base flows over the Augusta Shoals.
- The city of Augusta will finalize and implement a flow and operations monitoring plan that is consistent with the draft settlement agreement to meet target flows 90-95% of the time. The plan will specify that the 5-10% operating margin is intended to manage for circumstances beyond the control of the City, and is not intended for discretionary deviations for benefiting Augusta Canal water needs (i.e., hydropower).
- The city of Augusta will install gauging equipment in the Augusta Canal adequate to measure flows in the canal. The gauging plan should be developed in consultation with USFWS, NMFS, the GADNR, SCDNR, and USACE.
- The city of Augusta will construct, operate, and maintain fish passage to provide effective (safe, timely, convenient) passage for target species at the City's expense. A detailed schedule and timeline for all work required shall be developed in coordination with USFWS and NMFS.
- The city of Augusta shall develop in consultation with, and submit for approval by, USFWS and NMFS, all functional and final design plans, construction schedules, and any hydraulic model or other studies for fish passage.

4 SPECIES AND CRITICAL HABITAT OCCURRING IN THE ACTION AREA THAT MAY BE AFFECTED

Following completion of the legally mandated fish passage structure at NSBL&D, we anticipate two ESA-listed species under NMFS jurisdiction are likely to occur within the action area: the shortnose sturgeon (*A. brevirostrum*) and the South Atlantic DPS of Atlantic sturgeon (*A. oxyrinchus oxyrinchus*), both listed as endangered throughout their ranges. There are currently no listed species under NMFS jurisdiction present in the action area. There is no designated or proposed critical habitat in the action area.

4.1 Status of the Shortnose Sturgeon

Shortnose sturgeon were initially listed as an endangered species by 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).

4.1.1 Species Description and Distribution

The shortnose sturgeon 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 1989). Currently, the distribution of shortnose sturgeon across their range is disconnected, with northern populations separated from southern populations by a distance of about 250 miles (400 km) near their geographic center in Virginia (see Figure 6). In the southern portion of the range, they are currently found in North Carolina, South Carolina, and Georgia. Within North Carolina, sampling 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). In South Carolina, shortnose sturgeon have been captured and tagged in the Winyah Bay system, which includes the Winyah Bay proper, the Sampit River, the Black River, the Great Pee Dee River, the Waccamaw River, the Little Pee Dee River, the Lynches River and all connecting creeks (Post et al. 2014). Shortnose have also been captured and tagged in the Santee, Cooper and Savannah rivers, as well as the ACE Basin (Ashepoo, Combahee, and Edisto rivers) (Post et al. 2014). The majority of animals occur in the Winyah Bay System and the Cooper and Savannah rivers (Post et al. 2014). In Georgia, shortnose sturgeon are found in the Oconee, Ocmulgee, and Altamaha rivers (Ingram and Peterson 2018).

In South Carolina, shortnose sturgeon spawning occurs in the Cooper River (NMFS 2010; Ruddle 2018), the Congaree River (Collins et al. 2003; Post et al. 2017b), and the Pee Dee River (NMFS 2010). In Georgia, spawning occurs in the Altamaha (Ingram and Peterson 2018) and Savannah (Bahr and Peterson 2017) rivers. Shortnose sturgeon were believed to be extirpated from the Satilla River in Georgia and the St. Marys River along the Florida and Georgia border but 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).

4.1.2 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 1989).

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 spawned during temperatures ranging from 5–18°C (Post et al. 2014), 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/s (0.4-0.8 m/s) (Hall et al. 1991; Kieffer and Kynard 1996; NMFS 1998). Shortnose sturgeon tend to spawn on rubble, cobble, or large rocks (Buckley

[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

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 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 channel areas within freshwater habitats 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).

4.1.3 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. For example, a 2017 report by the South Carolina Division of National Resources and Georgia Department of National Resources stated shortnose sturgeon were detected as far as 20 km from shore, though of the animals detected in the marine environment, most were detected within 11 km from shore (Arendt et al. 2017). Similarly, in 2020, two telemetered shortnose sturgeon were detected moving from the Winyah Bay to the Savannah River to make presuming spawning runs, before returning (SCDNR 2021b).

Between 1985-1992, 97,483 shortnose sturgeon raised at USFWS' Bears Bluff National Fish Hatchery were released into the Savannah River. The hatchery-produced individuals were stocked at various ages (most were larvae and early juveniles), locations, and across all seasons. Only 18,210 individuals were large enough to be tagged in some fashion. Survival of the very young sturgeon is unknown, but likely low. Population estimates of adult shortnose sturgeon pre- and post-stocking suggest that the numbers had increased substantially, but many tags were shed, few fish were marked, and these estimates were never published, as statistical assumptions were violated and the estimates were biased. Some believe the stocking event was successful; however, without information on the survivability and emigration of both the wild and stocked

[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.

fish, impacts and effects of the stocking event cannot be assessed. Shortnose sturgeon that retained their tags have been found in other rivers, suggesting they emigrated and may have been released at an age too late to imprint on the Savannah River (Smith et al. 2002). Smith et al. (2002) reported that shortnose sturgeon stocked into the Savannah River emigrated and colonized the Edisto River, and that they also substantially supplemented the Ogeechee River population. Other stocked shortnose sturgeon from the Savannah River have been detected in the Cooper River and Winyah Bay, South Carolina.

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.

Aside from 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 6). Shortnose sturgeon in the Southeast comprise a single metapopulation, the "Carolinian Province" (Figure 6) 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 reproductive isolation among these populations is less 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.

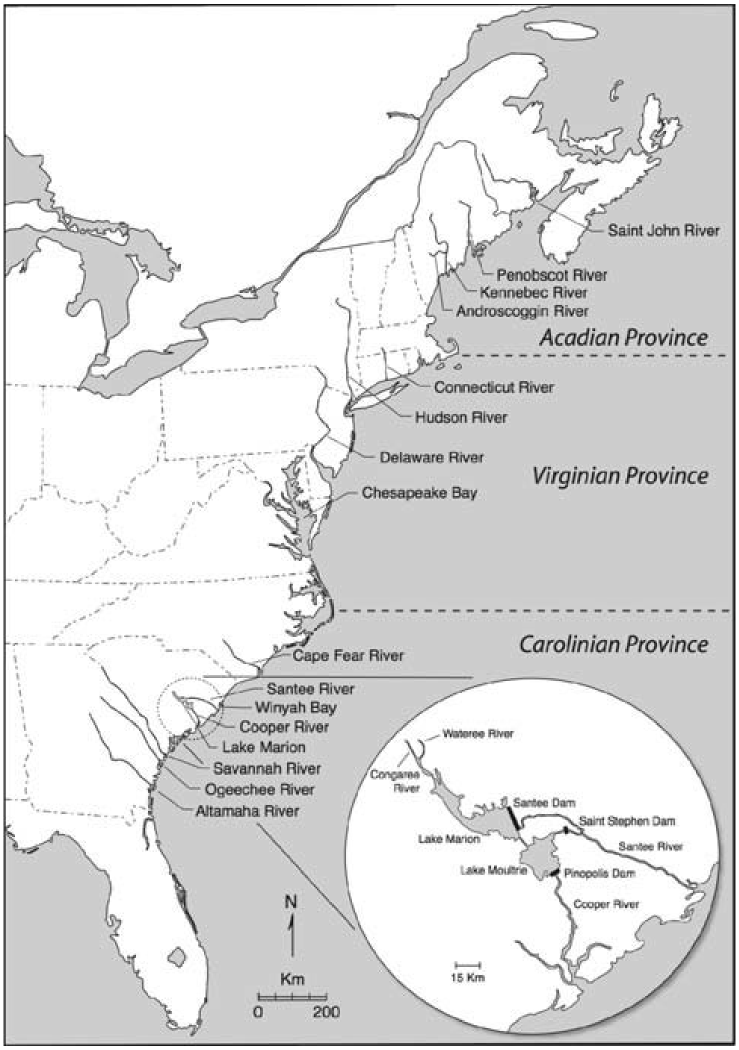

Figure 6. Map of the Three Shortnose Sturgeon Metapopulations (Wirgin et al. 2010).

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. The loss of any metapopulation would result in the loss of evolutionarily significant biodiversity and would result in a significant gap(s) in the species' range. 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 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, gene plasticity, and adaptations to climate change. 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 status of the shortnose sturgeon in the Southeast is variable. Populations within the southern metapopulation are relatively small compared to their northern counterparts. Table 1 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 1. 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 (SC)		unknown		
Santee River (SC)		unknown		
Cooper River (SC)	1996-1998	220 (87-301)	Adults	Cooke et al. (2004)
Lake Marion (SC)	2016	287	Adults	SCDNR (2017)
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	
	2011	2,218 (1,424-3,350)	Total	Ingram et al. (2020)
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]) from different studies should not be directly compared because they are generated using different techniques, consider disparate life stages, and cover different time periods. 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 models and assumptions used by the various studies.

More specifically to the Savannah River, it is likely that the total number of shortnose sturgeon there is greatly decreased based on historical accounts. As noted previously, Bahr and Peterson (2017) estimated abundance for shortnose sturgeon in Savannah River, looking at years 2013-2015. Fox et al. (2020) subsequently used an updated Huggins closed-capture models in RMark to re-calculate the abundance of Age-1 individuals in the Savannah River from 2013-2019 (A. Fox, UGA, to A. Herndon, NMFS, pers. comm. email 10/19/2020). The mean estimates for Age-1 individuals during that period ranged from 34 in 2018 to 471 in 2017 (Fox et al. 2020). The authors stated the relatively low and varying annual abundance estimates supports the hypotheses: that shortnose sturgeon populations in the southern end of their range tend to be smaller than those in the northern end of their range, (Kynard 1997; Peterson and Bednarski 2013); annual recruitment in the Savannah River is variable (Bahr and Peterson 2017; Peterson and Bednarski 2013); and there is rapid population turnover following years of high recruitment (Bahr and Peterson 2017; Peterson and Bednarski 2013). While the Savannah River population is likely the second largest in the southern end of their range (Bahr and Peterson 2017; Fox et al. 2020), it is still relatively small. Its small size puts it at greater risk of extinction than larger populations due to several processes (McElhany et al. 2000), which include: deterministic density effects including depensation (Allee effect) and increased predation; inbreeding resulting in loss of diversity and accumulation of deleterious mutations; and, increased susceptibility to catastrophic events.

Historically, shortnose sturgeon likely utilized the entire Savannah River downriver of the fall line, which is located very close to the Augusta Canal Project area. Sturgeon have been prohibited from reaching their historic spawning grounds since 1937 when the NSBL&D was completed; the NSBL&D is located downstream of the Augusta Canal Project at RKM 299.8 (RM 187.4). Shortnose sturgeon have been tracked from the lowest reaches of the Savannah River up to the NSBL&D (Post et al. 2014; Post et al. 2016; Post et al. 2017a; Post et al. 2018; Post et al. 2019; Post et al. 2020). It is believed that a gravel bar habitat located below the NSBL&D currently serves as spawning habitat for the shortnose sturgeon (Hall et al. 1991).

Figure 7. New Savannah Bluff Lock and Dam

In the late 1990s-early 2000s, USACE attempted two fish passage events at NSBL&D by increasing flows from the JST Project to overtop the spill gates during the spawning season. This method of fish passage proved ineffective for shortnose sturgeon. In addition, it is doubtful that shortnose sturgeon were able to negotiate the 8-foot-high support walls at the bottom of the dam. As a requirement of the city of Augusta's lease, it operated the locks at NSBL&D twice a week during the spring spawning season to lock fish through the dam. However, due to safety concerns with the aging lock structure, the USACE and the city of Augusta ended springtime operation of the lock for fish passage on May 14, 2014. Regardless, limited transmitter studies determined sturgeon had not successfully used the lock when it opened twice a week (like shad and herring). As described in Section 3, passage above NSBL&D is anticipated during the course of the license because of the conservation measures established to offset impacts of SHEP.

4.1.4 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.

<u>Dams</u>
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 riverheads to reach natal spawning grounds (Hightower 1998; Lawson 1709; 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. 1996). In addition, 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.

Aside from blocking passage to upstream habitats, Hill (1996) identified the following impacts of altered flow to anadromous fishes by dams: (1) altered dissolved oxygen (DO) concentrations and temperature; (2) artificial destratification; (3) water withdrawal; (4) changed sediment load and channel morphology; (5) accelerated eutrophication and change in nutrient cycling; and (6) contamination of water and sediment. Activities associated with dam maintenance, such as dredging and minor excavations along the shore, can release silt and other fine river sediments that can be deposited in nearby spawning habitat. Dams may reduce the viability of sturgeon populations by removing free-flowing river habitat. Seasonal deterioration of water quality can be severe enough to kill fish in deep storage reservoirs that receive high nutrient loadings from the surrounding watershed (Cochnauer 1986). Important secondary effects of altered flow and temperature regimes include decreases in water quality, particularly in the reservoir part of river segments, and changes in physical habitat suitability, particularly in the free-flowing part of river segments. The most commonly reported factor influencing year-class strength of sturgeon species is flow during the spawning and incubation period (Bednarski 2012 ; Jager et al. 2002; Vine et al. 2019). Water temperature is another environmental factor that explains year-to-year variation in recruitment (Counihan and Chapman 2018).

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 two reservoirs. Based on survey of the Brown's Lake area (upper Lake Marion), the best available information on the abundance of this dam-locked shortnose sturgeon population is approximately 287 adults (SCDNR 2017); this is the minimum number thought to exist, and is likely an underestimate as a thorough survey of the entire reservoir area has not been conducted.

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 location within the St. Johns River where shortnose sturgeon spawning may have occurred (NMFS 2010).

The Savannah River is segmented by a series of dams and reservoirs (USFWS et al. 2001). The construction of these dams and reservoirs has converted or blocked access to approximately half of the 384 miles of habitat on the Savannah River. The NSBL&D denies Atlantic and shortnose sturgeon access to 8% of its historically available habitat (approximately 19 miles) (ASSRT 2007). However, that historical habitat at Augusta Shoals (Figure 8), represents an estimated 90 to 95% of the suitable or marginally suitable spawning substrate (rapids complex: boulder, bedrock, cobble and gravel substrate) in the Savannah River (Duncan et al. 2003; Marcy et al. 2005; USFWS 2003; Wrona et al. 2007).

In 1994, USFWS, NMFS, SCDNR, and the GADNR completed development of a plan to restore access to a portion of historical anadromous fish spawning habitat in the Savannah River. The plan was filed by USFWS on behalf of the resource agencies in 1994, and was adopted by FERC as a Comprehensive Plan pursuant to Section 10(a)(2) of the FPA. The plan is a guide for resource agency efforts and would restore access to approximately 35 miles of spawning and maturation habitat. The plan includes the following elements: (1) reliable passage of anadromous fish at the NSBL&D; (2) the design and implementation of an upstream fish passage mechanism and safe downstream (out-migrant) passage at the ADD; (3) the design and implementation of an upstream fish passage mechanism and safe downstream (out-migrant) passage at the Stevens Creek Dam; and (4) improvement of poor DO releases from the JST Project during the summer months. In 2004, the NMFS and USFWS sent the FERC a joint prescription for fish passage at the ADD as well as minimum flow requirements necessary over the Augusta Shoals in regards to the proposed licensing of the Diversion Dam. In 1995, FERC issued a license for the Stevens Creek Hydropower Project, which reserved authority for USFWS to prescribe a fishway at that project once upstream passage was achieved at the ADD. Plans are in place to provide fish passage at the ADD and the Stevens Creek Hydroelectric Project (for species other than sturgeon) when fish passage is achieved at the NSBL&D.

Figure 8. ADD and Augusta Shoals (Photo Credit: E. Bettross, GADNR)

The flows at the Augusta Shoals are dictated by water releases from the J. Strom Thurmond (JST) Project, re-regulation of those releases by Stevens Creek Hydroelectric Project, and the diversion of water into the Augusta Canal by the ADD. Similarly, the NSBL&D currently impedes access to the Augusta Shoals. Thus, while not specifically part of the proposed action, the JST Project and NSBL&D play an important role in how the proposed action affects sturgeon.

J. Strom Thurmond (JST) and Stevens Creek Hydroelectric Projects

While not within the action area, the JST hydroelectric facility heavily influences water flows through the action area, which also results in water quality related effects. The JST Project is approximately 13 miles upstream of the Augusta Canal Project. Flow releases from the JST Project can range from less than 100 cfs to 30,000 cfs on an hourly basis. The Stevens Creek

Project, located approximately 1 RM upstream of the Augusta Canal Project, re-regulates the flow releases from the JST Project, which creates more consistent flows arriving at the Augusta Canal Project. The Stevens Creek Project is operated such that its hourly discharge is within 15% of the scheduled daily average discharge released by JST when those releases are within 500 cfs of the projected flow. For example, if the JST Project reports its daily average flow will be 4,500 cfs; the Stevens Creek Project will target releases within ±15% of that daily average (i.e., 3,825 to 5,175 hourly cfs). However, the actual instantaneous flow released from JST Project may range from 0 to 20,000 cfs or more during that 24 hour period depending on power needs. When flows released from JST are more than the Stevens Creek Project can absorb and still re-regulate (this occurs around when instantaneous flows exceed ~8,300 cfs), excess water flows over the Stevens Creek Dam. This exceedance of re-regulatory capacity is a common occurrence.

Similar to water quantity, the JST Project also has a large influence over water quality in the action area. The Final EA for the Augusta Canal Project (FERC 2006) states that seasonal low DO concentrations in the Savannah River at Augusta are mainly due to hypolimnetic (deep water) releases from the JST Project. In the past, DO concentrations in water released by JST Project could be less than 0.5 mg/L during the summer. The USACE has implemented procedures and equipment to improve low DO conditions during these releases. Water monitoring conducted by the Phinizy Center for Water Sciences (PCWS) reports water quality data for the Upper Savannah River; monitoring reports are available from 2014-2017, 2019, 2020, 2021-2022; we were unable to locate a report from 2018. From 2014-2016, the PCWS monitoring reports indicate DO concentrations below the JST Project were never below 5.0 mg/L at all months of the year (PCWS 2014; PCWS 2015; PCWS 2016) (Table 2). From 2017 on, the PCWS did not report the DO concentrations below the JST Project, but the reports do show DO concentrations just below Augusta Shoals remaining at 5.0 mg/L or better at all months of the year (PCWS 2017; PCWS 2019; PCWS 2020; PCWS 2022).[8]

[8] PCWS 2022 reports data for water years 2021 and 2022; however, the monthly mean dissolved oxygen concentrations and mean water temperatures are only reported for 2022.

Table 2. Mean Monthly Dissolved Oxygen Concentration (Mg/L) Below JST Dam and Augusta Shoals, by Year and Location (adapted from PCWS 2014-2017, 2019, 2020, 2022)

Year	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2014	JST Dam	10.74	11.32	11.12	9.85	8.19	6.97	6.29	5.24	5.22	6.31	8.76	9.9
	Augusta Shoals	11.51	11.46	10.9	10.36	9.74	9.1	8.98	8.53	8.14	8.62	9.71	10.55
2015	JST Dam	10.65	11.41	11.18	9.77	7.95	7.51	6.54	5.46	5.49	5.95	7.64	8.59
	Augusta Shoals	11.08	11.39	10.67	9.92	9.67	9.02	NA	8.56	8.28	8.76	9.5	10.04
2016	JST Dam	9.45	10.85	10.69	9.27	7.58	7.14	6.21	5.44	5.94	6.49	7.87	9.58
	Augusta Shoals	10.94	11.14	10.7	10.04	9.46	9.15	8.82	8.43	8.17	8.54	9.33	10.22
2017	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	8.54	9.33	10.22	10.47	10.42	10.05	9.13	8.99	8.47	8.09	8.15	8.36
2018	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2019	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	11.2	11.2	10.9	10.1	9.1	8.5	NA	8.5	8	8.8	9.5	10.9
2020	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	11.11	11.11	10.87	10.44	NA	9.42	8.62	8.33	8.20	8.17	9.60	10.64
2021	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2022	JST Dam	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Augusta Shoals	NA	10.73	10.47	NA	8.96	9.29	8.94	8.86	8.64	8.79	9.78	9.78

Hypolimnetic releases from the JST Project also influence water temperature in the Savannah River below the JST dam. Because those releases come from the bottom of the reservoir, the water released is less likely to be affected by ambient air temperature and therefore the temperature remains relatively stable throughout the year. The functional impact of this varies by season. For example, during the winter, releases of water at the bottom of the lake may be warm relative to the ambient air temperature. Following exposure to cooler ambient air temperatures, these flows grow colder as they move downstream. Conversely, during the summer, water released from the lake may be cooler than ambient air temperatures and warm as they move downstream. This phenomenon is notable in the water quality reports submitted by the Stevens Creek Project (SCE&G 2010; SCE&G 2011), as well as the monitoring done by PCWS (PCWS 2014; PCWS 2015; PCWS 2016; PCWS 2017; PCWS 2019) and grows more pronounced the greater the difference between the ambient air temperatures and water temperatures.

Water temperatures are ecologically relevant to sturgeon because of their suspected impact on spawning. The hypolimnetic releases from the JST Project, directly affect the water temperatures at the Augusta Shoals, as well as the gravel bar near NSBL&D. Since we believe spawning has been successful in the Savannah River (Bahr and Peterson 2016; Bahr and Peterson 2017; Hall et al. 1991; Vine et al. 2019), we expect that if water temperatures at the Shoals are similar to those at the gravel bar, there is a reasonable expectation the environment at the Shoals will not adversely affect sturgeon spawning.

The available water temperature data, reported mean monthly water temperatures at locations just below the Augusta Shoals (RM 202) and just above NSBL&D (RM 190) (PCWS 2014; PCWS 2015; PCWS 2016; PCWS 2017; PCWS 2019; PCWS 2020; PCWS 2022). Those data suggest little difference in water temperature at the Augusta Shoals and near NSBL&D during the period we believe shortnose sturgeon are at the spawning grounds (January, February, March, and April) (PCWS 2014; PCWS 2015; PCWS 2016; PCWS 2017; PCWS 2019; PCWS 2020; PCWS 2022).

Table 3. Mean Monthly Water Temperatures (Celsius) Recorded near Augusta Shoals (RM 202) and NSBL&D (RM 190) (adapted from PCWS 2014-2017, 2019, 2020, 2022)

Year	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2014	Augusta Shoals	9.11	8.7	10.97	15.12	18.86	21.25	21.35	22.52	23.18	21.66	15.09	12.47
	NSBL&D	9.42	8.8	11.08	14.87	19.02	21.86	21.65	22.7	23.38	22.12	15.89	12.8
2015	Augusta Shoals	9.76	8.91	12.51	15.93	18.23	20.40	NA	22.72	23.14	20.28	17.45	15.12
	NSBL&D	10.27	9.45	12.35	15.89	18.44	21.27	22.26	23.15	23.40	20.79	18.03	15.22
2016	Augusta Shoals	11.82	10.54	13.58	16.63	18.71	22.15	22.97	24.21	24.49	22.22	18.17	13.61
	NSBL&D	12.09	10.57	13.52	16.84	19.1	23.22	23.82	25.84	25.36	22.49	18.63	13.5
2017	Augusta Shoals	12.3	13.57	15.32	19.03	21.23	23.29	25.00	25.54	24.56	NA	NA	NA
	NSBL&D	12.84	13.14	N/A	19.89	21.8	23.36	25.16	25.74	24.8	NA	NA	NA
2018	Augusta Shoals	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.60	17.00	11.80
	NSBL&D	NA	NA	NA	NA	NA	NA	NA	NA	NA	23.50	17.20	11.30
2019	Augusta Shoals	10.70	10.90	12.70	15.80	19.50	21.10	22.60	22.70	24.00	NA	NA	NA
	NSBL&D	10.30	10.90	12.70	15.70	20.20	22.10	22.80	24.10	25.20	NA	NA	NA
2020	Augusta Shoals	12.02	11.39	12.58	14.17	NA	17.65	23.68	23.67	23.38	22.84	16.70	12.15
	NSBL&D	11.54	10.21	11.77	15.81	17.68	21.70	24.57	24.49	22.55	23.33	17.09	12.69
2021	Augusta Shoals	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	NSBL&D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2022	Augusta Shoals	NA	12.93	13.19	NA	20.42	20.8	21.29	21.95	22.0	20.4	16.28	15.23
	NSBL&D	11.81	11.34	13.3	16.67	20.21	21.96	22.13	22.51	23.18	21.16	17.39	14.68

Telemetry-tagged shortnose sturgeon in the Savannah River make presumed spawning runs in January, February, March, and April to locations just below NSBL&D where the dam stops their migration.

Table 4 illustrates that while monthly mean water temperatures during shortnose sturgeon spawning season (January, February, March, and April) varied from year to year, the mean difference between the water at the Shoals and NSBL&D was generally no more than 0.5°C. This difference is notably small when compared to temperature changes shortnose sturgeon would encounter just moving from downstream locations near the Savannah Harbor to the spawning grounds. For example, Table 4 reports the mean water temperatures sturgeon would have encountered in 2021-2022 (PCWS 2022). While the temperature gradient from downstream to upstream is relatively small in January (0.8°C, as measured near NSBL&D), by March the mean difference is 1.2°C (PCWS 2022).

Table 4. Mean Monthly Water Temperatures (Celsius) Recorded at Multiple Locations from Augusta Shoals and NSBL&D Downstream to Hwy 119 (Oct 2021-Sep 2022) (PCWS 2022)

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
RM 202	20.40	16.28	15.23	NA	12.93	13.19	NA	20.42	20.8	21.29	21.95	22
RM 190	21.16	17.39	14.68	11.81	11.34	13.3	16.67	20.21	21.96	22.13	22.51	23.18
RM 179	22.53	17.41	14.68	13.18	NA	NA	20.37	21.57	24.35	NA	NA	23.95
RM 146	NA	15.69	14.6	9.86	11.85	14.23	16.12	23.03	24.39	24.19	24.33	25.6
RM 61	23.54	15.69	14.46	11.73	14.3	14.42	NA	NA	NA	NA	24.22	25.51
RM 202 - Just below Augusta Shoals; RM 190 - 2.5 miles upstream of NSBL&D; RM 179 - 8.5 miles downstream of NSBL&D; RM 146 - 3 miles downstream of USGS gage 021973269; RM 61 - 0.5 miles downstream of USGS gage 02198500 at HWY 119												

As noted previously, telemetry-tagged Atlantic sturgeon in the Savannah River make presumed spawning runs in April and May, as well as July, August, September, and October. Differences in monthly mean temperatures between the Shoals and NSBL&D from April-May were generally no more than 0.5°C (Table 3), though differences grew more pronounced as the water warmed. However, just like with shortnose sturgeon, the water temperature difference between the Shoals and the gravel bar are within the range of temperatures experienced by sturgeon moving from the Savannah Harbor up to spawning grounds (see Table 4).

The relatively cold water released from JST Project may also prove beneficial to sturgeon eggs laid in the Shoals during warmer months. Because DO concentrations are higher in cold water, cold water pulses may help oxygenate eggs/larvae. Little is known about the effect of relatively acute temperatures changes on Atlantic and shortnose sturgeon eggs and larvae. Research into such impacts into Lake sturgeon suggests exposure to variable temperatures cause the release of cryptic genetic variations that may allow the expression of adaptive phenotypes, though the expression of maladaptive phenotypes is also possible (Dammerman et al. 2016).

New Savannah Bluff Lock and Dam (NSBL&D)
The NSBL&D is the first impediment encountered by all anadromous fish species migrating between estuarine/marine coastal waters into freshwater habitats of the Savannah River and currently impedes Atlantic and shortnose sturgeon from accessing the Augusta Shoals below the ADD. USACE has proposed construction of a fish-passage facility at the dam as mitigation for the effects of the deepening in the lower Savannah River (NMFS 2017a). Establishing fish passage at the NSBL&D will enhance spawning potential by providing access to sites located upstream of this structure, provided sufficient flow is available in the area to support associated life history requirements.

Currently, NSBL&D blocks Atlantic and shortnose sturgeon from accessing upstream spawning habitat. Upon completion of fish passage at NSBL&D, spawning adult Atlantic and shortnose sturgeon, eggs, larvae, and young juveniles are expected to all be present in the action area for the first time since the 1930s. Due to its location near the fall line, the Augusta Shoals area is an important historical spawning habitat for both species.

Once fish passage for sturgeon is constructed at NSBL&D, both species will have access to these higher quality benthic spawning habitats, including the Augusta Shoals. Although there is some uncertainty about the exact percentage of spawning habitat that will become available to sturgeon above NSBL&D, it clearly represents a substantial increase in quantity and quality of spawning habitat. Approximately 20 RM of freshwater growth and rearing habitat exists between the NSBL&D and the ADD. Therefore, sturgeon spawned in the Augusta Shoals will have access to these additional developmental habitats. This will provide young sturgeon additional time and habitat to grow prior to reaching the saltwater interface, even when considering the anticipated upstream movement of the saltwater wedge associated with the deepening in Savannah Harbor. Therefore, providing fish passage above NSBL&D is expected to substantially increase sturgeon egg production and larval survival relative to the status quo.

Additional benefits to sturgeon reproductive output are anticipated beyond simply increased spawning substrate. Access to additional spawning habitats may decrease density-dependent egg predation. Because current spawning is likely concentrated at a single location (i.e., gravel bar downstream of the NSBL&D), egg predation at the location can have a significant impact on recruitment for a given year. Providing access to more habitats and greater area of habitat can decrease the likelihood of egg predation, increasing annual recruitment.

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 and burial of prey species; turbidity and siltation effects; contaminant resuspension; noise and disturbance; alterations to the 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 from 1990-2013: 3 Gulf, 11 shortnose, and 23 Atlantic, and 1 unidentified due to decomposition. Of the 3 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, and the level of coverage relative to total effort is unspecified. However, the 1997 biological opinion authorizing hopper dredging in the Southeast required observers on all hopper dredging trips, except during the months of January and February when observers were optional (NMFS 1997). To offset the adverse effects associated dredging relocation trawling is used at times. The USACE has successfully used this technique to relocate 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 times (spawning, migration, feeding) when anadromous fish are present.

The Savannah Harbor Expansion Project (SHEP) was a port deepening project carried out by the Savannah District of the USACE. The project deepened the federal navigational channel of the Savannah Harbor from the existing depth of -42 feet mean lower low water (MLLW), to -47 ft MLLW. The harbor and deep-draft navigation channel comprise the lower 19.5 miles of the Savannah River and 16.1 miles of channel across the ocean bar to the Atlantic Ocean. The deepening also included the Kings Island Turning Basin and eight berths (Berths 2, 3, 4, 5, 6, 7, 8, and 9) at the Garden City Terminal. Approximately 23.6 million cubic yards of sediment was expected to be removed during the deepening. The deepening allows higher salinity water to travel further up the river. The salt water affects freshwater habitats found within the Savannah National Wildlife Refuge adjacent to the project area along the Middle and Back river. To address this project effect, the USACE developed a flow re-routing modification plan to re-direct freshwater to areas adjacent to (and found within) the refuge with the intent of minimizing the loss of the freshwater tidal marsh. The intent was to identify alterations to reduce salinity levels in critical areas of the estuary. The deepening also adversely impacted dissolved oxygen levels in the harbor. The USACE attempted to mitigate for this issue with the installation of several dissolved oxygen injection sites (i.e., Speece Cones).

Ultimately, NMFS (2011) determined that juvenile and adult shortnose sturgeon within the Savannah River would be affected by the habitat changes caused by the deepening. NMFS (2011) concluded approximately 251 acres of foraging and resting habitat used by juvenile shortnose sturgeon during the winter would be lost representing 7.6% of the total habitat available to juvenile shortnose sturgeon in the lower river. Modeling also indicated that approximately 266 acres of foraging and resting habitat used by adult shortnose sturgeon during the winter would be lost. This represents 6.9% of the total habitat available to adult shortnose sturgeon in the lower river. NMFS (2011) determined these habitat impacts would result in reduced fitness potentially leading to disease or mortality, for 6.9% and 7.6% of the adult and juvenile shortnose sturgeon populations, respectively.

Water Quality

Shortnose sturgeon rely on a variety of water quality parameters to carry out their life functions. Low 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 (1995) 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 72.5°F (22.5°C) 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) considered the relationships between DO, salinity, and temperature on shortnose sturgeon fitness. 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 ppt salinity, a temperature of 77°F (25°C), 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 71.6°F (22°C) 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 86°F (30°C), even if the salinity decreased to 2 ppt.

These studies highlight concerns regarding the high occurrence of low DO 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 86°F (30°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. 1981), 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).

The lower Savannah River is heavily industrialized, and nursery habitat for many species of fish in the lower river has been significantly impacted by diminished water quality and channelization. Contaminants in the Savannah River include those from both municipal and industrial effluents. The area adjacent to Savannah Harbor is especially heavily developed by a wide variety of industries. Other contaminants arise from 2 nuclear facilities farther upriver; nuclear isotopes have been detected in the sediment downriver in the estuary. Point source discharges and compounds associated with discharges contribute to poor water quality and may affect the health of adult sturgeon. Poor water quality can have substantial deleterious effects on aquatic life, including production of acute lesions, growth retardation, and reproductive impairment (Cooper 1989; Sindermann 1994). Ultimately, toxins introduced to the water column become associated with the benthos and can be particularly harmful to benthic organisms like sturgeon (Varanasi 1992). Available data suggest that early life stages of fish are more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976).

In October 2006, the Environmental Protection Agency (EPA) finalized a total maximum daily load (TMDL) for Savannah Harbor and concluded that the Savannah River cannot withstand the introduction of anthropogenic, oxygen-demanding substances and still provide acceptable habitat for critical aquatic life that reside in the reaches of the river (NMFS 2011). The finding meant that South Carolina and Georgia would have to revise their permits for point source discharges as they expire and come up for renewal. As part of its analysis, EPA evaluated the DO requirements for several fish species and for natural conditions of the river. At that time, the applicable DO site-specific criteria for the Savannah Harbor, as established by Georgia, was a minimum instantaneous DO criterion of no less than 3.0 milligrams per liter (mg/L) in June, July, August, September, and October; no less than 3.5 mg/L in May and November; and no less than 4.0 mg/L in December, January, February, March, and April. However, Georgia revised its DO standard for the Savannah Harbor in 2009 and it now requires a daily average of no less than 5.0 mg/L throughout the year, with an instantaneous minimum of 4.0 mg/L throughout the water column. The new standard matches the South Carolina standard for waters of the same use classification and applies throughout the water column. Average sensitivity of sturgeons to hypoxia is higher than in other fishes (Niklitschek and Secor 2009b). As discussed above, DO levels below 5 mg/L can be physiologically stressful, impair animal growth and the complete lack of oxygen (anoxia) will kill animals.

Secor (1995) 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 conditions. The 2016 list of impaired waters published by GADNR as required by Section 303(d) of the Clean Water Act indicated 90 reaches of the Savannah River are not supporting their designated uses (https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/303d_Draft_Streams_Y2016.pdf). Waters were listed as impaired for low DO, impacted fish and macroinvertebrate communities, and the presence of toxins (copper, cadmium, zinc, and mercury). Impairment was attributed to municipal facilities, non-point source pollution and urban runoff, and industrial facilities.

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). Water quality within the river systems in the range of the shortnose sturgeon is negatively affected by large water withdrawals. For example, over 630 million gallons per day are permitted to be withdrawn from the Savannah River for power generation, municipal uses, and industrial uses in the state of Georgia (https://epd.georgia.gov/watershed-protection-branch-lists), exclusive of South Carolina's water needs. However, permits for users withdrawing less 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. The removal of large amounts of water from the 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.

Two nuclear sites – Plant Vogtle in Georgia and the U.S. Department of Energy's Savannah River Site in South Carolina – withdraw water for their facilities. The Savannah River site no longer operates its nuclear reactors. However, they continue to withdraw water from the Savannah River. They used a total of 3,550 million gallons in 2018 (SCDHEC 2019). The Vogtle Electric Generating Plant currently consists of 2 nuclear reactors (Units 1 and 2). These units are authorized to withdraw up to 127 millions of gallons/day (mgd) of water from the Savannah River to cool the reactors and generate power (GADNR 2018) (https://epd.georgia.gov/watershed-protection-branch-lists). An additional 2 nuclear reactors are under construction at the site (Units 3 and 4). Upon completion, the Southern Nuclear Operating Company will operate these units, which are permitted to use up to 74 mgd (GADNR 2018) (https://epd.georgia.gov/watershed-protection-branch-lists).

Numerous other large facilities positioned along the river also withdraw water for industrial uses. Up to 100 mgd of Savannah River water may be withdrawn to support the growth of South Carolina communities located outside of the Savannah River basin, such as Greenville and

Beaufort County (Spencer and Muzekari 2002). In 2011, the State of South Carolina established a system and rules for permitting and registering the withdrawal and use of surface water. The program requires permitting, registration, use, and reporting for surface water withdrawals in excess of 3,000,000 gallons during any 1 month (S.C. Code Sections 49-4-10 et seq.). The most recent statewide report on surface water use is from 2020 (SCDHEC 2021). A query of South Carolina's "Watershed Atlas" (https://gis.dhec.sc.gov/watersheds/) reveals nine permits for surface water withdrawals from the Savannah River below the ADD, in the state of South Carolina, active in 2022. That query also reports non-power-related surface water withdrawals by those permit holders was 33,657 million gallons per month. Permitted water withdrawals to support public water supplies accounted for 6,835 million gallons of the water per month. Edgefield and Aiken Counties in South Carolina are adjacent to the Savannah River where the Augusta Canal Project is located. Edgefield County permit holders located on the Savannah River are permitted to withdraw approximately 697.5 million gallons a month. Aiken County permit holders located on the Savannah River are permitted to withdraw approximately 39,560 million gallons a month. Of note, the US Department of Energy's – Savannah River Site accounts for 25,185 million gallons a month of the permitted water withdrawals in Aiken County.

In Georgia, permitted surface water withdrawals are limited by either a maximum daily withdrawal limit or a monthly average withdrawal limit (GADNR 2020). The largest non-municipal water user in Georgia is Richmond County, where the Augusta Canal Project is located, is the Graphic Packaging International, LLC - Augusta Mill (72 mgd of water) (GADNR 2020) (https://epd.georgia.gov/watershed-protection-branch-lists). Augusta-Richmond County is the largest municipal permittee in the Savannah basin, with surface water withdrawals coming from both the Augusta Canal (50 mgd) and the Savannah River (21 mgd) directly (GADNR 2020). Duncan et al. (2003) note that pre-dam low flows in the Augusta Shoals ranged from 2,840 cfs in September to 6,410 cfs in April. Based on 1984-2001 data, low flows over the Augusta Shoals below the ADD average 1,870 cfs and 3,431cfs for March and October, respectively. The Augusta Shoals are also subject to fluctuations in flow governed largely by the periodicity of upstream hydropower generation.

Climate Change

Large-scale factors affecting 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 to be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions.

Regionally, the Southeast has experienced an annual average increase in temperature of 0.46°F when comparing the present (1986-2016) to the first half of last century (1901-1960). This increase is the smallest of any region of the United States (Vose et al. 2017). The temperature of the hottest day in any given year has decreased by 1.49°F since 1900 in the Southeast (Vose et al. 2017). Long-term observations illustrate changes in temperature can occur at a rapid rate. From 1896-2024, the average annual temperature in the Southeast has risen 0.1°F per decade. From 1950-2024, the increase triples to 0.3°F per decade (NCDC 2024). Aside from observation, climate modeling also projects future increases in temperatures in the Southeast. Table 5 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).[9] The Southeast is also projected experience a greater frequency of both heat waves[10] and extreme heat waves[11] in the future (Vose et al. 2017).

Table 5. 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)

Annual precipitation in the Southeast has increased by 0.46 inches per decade since 1950 (NCDC 2022). The number of extreme rainfall events is increasing, with a large increase in the number of such events reported in the Southeast during the fall (Easterling et al. 2017). Mean precipitation in the Southeast is projected to increase between 0-20% relative to mean precipitation from 1976-2005 depending on the season (Easterling et al. 2017). However, even in locations where greater precipitation is projected, those increases are expected to be relatively small relative to natural variation already observed (Easterling et al. 2017).

Within the Southeast Region, higher resolution consideration of climate change on a state level has also been conducted. In the state of South Carolina temperatures have risen more than 1°F since the beginning of the 20th century (Runkle et al. 2022). Under a higher emission scenarios (RCP8.5), historically unprecedented warming is projected for South Carolina during this century (Runkle et al. 2022). Even under a lower emission scenarios (RCP4.5), the annual average temperatures are projected to most likely exceed historical record levels by the middle of this century. However, a large range of temperature increases is projected under both scenarios, and under the lower emissions scenario, a few projections are only slightly warmer than historical records (Runkle et al. 2022). Increases in the number of extremely hot days and decreases in the number of extremely cold days are projected to accompany the overall warming (Runkle et al. 2022).

In South Carolina, there is no overall trend in changes of annual precipitation in South Carolina since the beginning of the 20th century. However, the total annual precipitation has been below average during most years since 2000 (Runkle et al. 2022). Periods of notable drought occurred in 2000-2003, 2007-2008, and 2010-2013, where between 50-100% of the state experienced drought ranging in intensity from “abnormally dry” to “exceptional” (NDMC 2018). Yet, periods

[9] 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.

[10] *Heat waves* are 6-day periods with a maximum temperature above the 90th percentile.

[11] *Extreme heat waves* are 5-day periods experiencing 1-in-10 year high temperatures events

of high rainfall have also been observed. Runkle et al. (2022) reported above average rainfall during the 2015–2020 period, noting some recent years (notably 2015, 2018, and 2020) have been very wet. However, any increases in temperature will accelerate the loss of soil moisture during dry spells, increasing the intensity of naturally occurring droughts in the future. The resulting decreases in water availability, exacerbated by population growth, will continue to increase competition for water (Runkle et al. 2022).

For South Carolina, Runkle et al. (2022) also report the number of extreme precipitation events was below average from 2000-2015 but has been above average from 2015-2020. Of the last 21 years (2000-2020) in South Carolina, 15 have been characterized by warm-season drought conditions (Runkle et al. 2022). Regardless of the emission scenario, little change in total annual precipitation is projected over this century for the state of South Carolina (Runkle et al. 2022).

Temperatures Georgia have risen by 0.8°F, about half of the warming for the contiguous United States, since the beginning of the 20th century, but the warmest consecutive 5-year interval was 2016–2020 (Frankson et al. 2022). Georgia has recently experienced several warm years: 2016, 2017, and 2019 were the three hottest on record (Frankson et al. 2022). Under a higher emissions scenario (RCP8.5), historically unprecedented warming is projected during this century (Frankson et al. 2022). Even under a lower emissions scenario (RCP4.5), annual average temperatures are projected to most likely exceed historical record levels by the middle of the century (Frankson et al. 2022). However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records.

Georgia receives abundant precipitation throughout the year, with totals ranging from more than 70 inches in the mountainous northeastern corner of the state to around 45 inches in the southeastern and central portions (Frankson et al. 2022). The state has experienced periods of drought since 2000. Periods of notable drought occurred in 2000-2003, 2007-2008, and 2010-2013, where between 50-100% of the state experienced drought ranging in intensity from "abnormally dry" to "exceptional" (NDMC 2018). Another, shorter period of drought struck in 2016-2017, again with 50-100% of the state experiencing drought ranging in intensity from "abnormally dry" to "exceptional (NDMC 2021).

While Georgia has periodically undergone periods of drought, drought frequency appears to be increasing (Ruhl 2003). Future precipitation projections for Georgia are uncertain (Frankson et al. 2022). Even if annual precipitation remains constant, higher temperatures will increase evaporation rates and decrease soil moisture during dry spells, leading to greater drought intensity (Frankson et al. 2022). 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.

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).

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. Since 1900, global sea level has increased 7-8 inches, with an additional increase of 12-48 inches projected by 2100 (Frankson et al. 2022). 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

Directed harvest of sturgeon is currently prohibited; however, sturgeon are taken incidentally in fisheries occurring within Georgia and South Carolina, as well as offshore, and are likely targeted by poachers throughout their range (Collins et al. 1996; Dadswell 1979; Dovel et al. 1992). Impacts from poaching are unknown.

Overutilization of shortnose sturgeon from directed fishing caused initial severe declines in shortnose sturgeon populations in the Southeast, from which they have yet to rebound. Further, continued collection of shortnose sturgeon as bycatch in 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.

Entanglement of sturgeon in gillnets can result in injury and mortality, reduced fecundity, and delayed or aborted spawning migrations of sturgeon (Collins et al. 2000; Moser 2000; Moser and Ross 1993; Moser and Ross 1995; Weber and Jennings 1996). In the Savannah River from 1984-1992, adult sturgeon were common as bycatch from the lowest point in the river at which gillnet fishing was allowed (about river km 43) up to river km 278 (the uppermost location of several sturgeon spawning areas), as reported by Collins and Smith (1993). Immediate bycatch mortality of sturgeon in set gill nets was 16%, with another 20% of sturgeon having varying degrees of injuries (Collins et al. 1996). Bahn et al. (2012) reported that from 2007-2009, shortnose sturgeon mortality rates were less than 8% in gillnets targeting shad in the Altamaha River. No estimates of post-release mortality are available.

Mandatory reporting of sturgeon bycatch was initiated in 2000 by ASMFC; a summary of self-reported shortnose and Atlantic sturgeon bycatch via the South Carolina shad gillnet fishery is presented in Table 6. South Carolina's primary shad fishery areas include Winyah Bay, Santee River, Edisto River, Combahee River, and Savannah River. In most cases, shortnose sturgeon captured as bycatch of the shad gillnet fishery are returned to the river uninjured; survival is expected to be greater early in the shad season when waters are cooler. There are no data to separate total number of sturgeon into unique and recaptured individuals.

Table 6. Self-Reported Bycatch of Shortnose by South Carolina Commercial Shad Fishermen, by River System, with Estimated Catch-Per-Unit- Effort (CPUE) (Source: SCDNR)

Year	Winyah Bay System*	CPUE	Santee River	CPUE	Edisto River	CPUE	Combahee River	CPUE	Savannah River	CPUE	Annual Total
2000	6	0.00000656	10	0.0000073	3	0.0000078	0	0.0000000	4	0.0000296	23
2001	27	0.00001848	2	0.0000011	0	0.0000000	0	0.0000000	16	0.0001040	45
2002	41	0.00002343	9	0.0000036	0	0.0000000	0	0.0000000	26	0.0004258	76
2003	1	0.00000035	1	0.0000010	0	0.0000000	0	0.0000000	1	0.0000187	3
2004	0	0.00000000	3	0.0000023	0	0.0000000	0	0.0000000	23	0.0001406	26
2005	0	0.00000000	0	0.0000000	0	0.0000000	0	0.0000000	7	0.0000808	7
2006	3	0.00000078	6	0.0000022	0	0.0000000	0	0.0000000	3	0.0000662	12
2007	0	0.00000000	8	0.0000054	0	0.0000000	0	0.0000000	17	0.0001433	25
2008	6	0.00000286	25	0.0000127	0	0.0000000	0	0.0000000	12	0.0002979	43
2009	5	0.00000202	11	0.0000042	0	0.0000000	0	0.0000000	25	0.0002619	41
2010	4	0.00000221	2	0.0000013	0	0.0000000	0	0.0000000	8	0.0000963	14
2011	0	0.00000000	3	0.0000008	0	0.0000000	0	0.0000000	18	0.0001949	21
2012	7	0.00000296	12	0.0000037	0	0.0000000	0	0.0000000	16	0.0001291	35
2013	6	0.00000345	1	0.0000006	0	0.0000000	0	0.0000000	0	0.0000000	7
2014	2	0.00000256	1	0.0000005	0	0.0000000	0	0.0000000	0	0.0000000	3
2015	7	0.00000923	0	0.0000000	0	0.0000000	0	0.0000000	0	0.0000000	7
2016	0	0.00000000	8	0.0000065	0	0.0000000	0	0.0000000	0	0.0000000	8
2017	11	0.00001203	19	0.0000121	0	0.0000000	0	0.0000000	0	0.0000000	30
2018	2	0.00000233	4	0.0000025	3	0.0000519	0	0.0000000	0	0.0000000	9
2019	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0
2020	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0
2021	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0	0.00000000	0

*Winyah Bay includes the Waccamaw River, Pee Dee River, and Winyah Bay

NMFS (2013) issued the State of Georgia an ESA Section 10 permit for their commercial shad fishery in December 2012. Georgia amended their commercial shad fishing regulations to minimize incidental capture of shortnose sturgeon. Fishing is restricted to the lower portions of the Savannah River. Georgia's conservation plan also reduced the number of days per week that certain areas are open to shad fishing. The Section 10 permit issued to the State of Georgia estimates that incidental capture of shortnose sturgeon by commercial shad fisheries will not exceed 70 shortnose sturgeon and 35 Atlantic sturgeon per year in the Savannah River. NMFS (2013) estimated a mortality rate of 2.3% for incidentally captured shortnose sturgeon in Georgia's commercial shad fisheries based on an estimate provided in Bahn et al. (2012); Bahn et al. (2012) did not estimate Atlantic sturgeon mortality. NMFS (2013) estimated a 1% mortality rate for Atlantic sturgeon based on observed mortality in drift nets reported by shad fishermen and researchers.

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 fisheries bycatch.

<u>Stochastic Events</u>

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 because of them or indirectly if habitat is damaged because of these disturbances. Hurricane impacts are primarily caused by low DO, or hypoxia, in floodwaters caused by the entrainment and decomposition of organic matter transported into rivers from the floodplain, saturated soils, and wastewater and septic inputs (Mallin and Corbett 2006; USFWS and NMFS 2022). For example, in 2018, flooding from Hurricane Florence flushed significant amounts of organic matter into rivers supporting sturgeon in South Carolina and North Carolina. The DO levels in those rivers dropped so low (i.e., 0.2 mg/L) that thousands of fish suffocated, including multiple sturgeon. Also in 2018, Dula et al. (2022) estimated Hurricane Michael likely caused an approximately 33% reduction in the adult population of Gulf sturgeon in the Apalachicola River, Florida, due to anoxic conditions caused in its wake. Harm to benthic invertebrate communities by hurricanes has also been documented (Poirrier et al. 2008) and may lead to indirect effects on shortnose sturgeon populations through temporary loss of prey. The severity of impacts to shortnose sturgeon may be related to the strength of the hurricane and geographic aspects of its landfall.

4.2 Status of South Atlantic DPS of Atlantic Sturgeon

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

4.2.1 Species Description and South Atlantic DPS 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). Armor-like plates (called scutes) and a long protruding snout that has 4 barbels (slender, whisker-like feelers extending from the lower jaw used for touch and taste) make them distinguishable from other fish species. 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 South Atlantic DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers' basin (ACE Basin) southward along the South Carolina, Georgia, and Florida coastal areas to the Saint Johns River, Florida. The marine range of Atlantic sturgeon from the South Atlantic DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida (Figure 9).

While adult Atlantic sturgeon from all DPSs mix extensively in marine waters, virtually all Atlantic sturgeon return to their natal rivers to spawn. Genetic studies show that fewer than 2 adults per generation spawn in rivers other than their natal river (King et al. 2001; Waldman et al. 2002; Wirgin et al. 2000). The action area includes the ADD; the pool above the ADD (i.e., the Savannah River upstream of the ADD to the Stevens Creek Dam); the entire Augusta Canal; and the Savannah River downstream of the ADD to the NSBL&D. Given the action area is over 200 miles upstream within the Savannah River, any Atlantic sturgeon encountered in the action area are likely to be spawning (adult) or recently hatched (eggs, larvae, juvenile). Therefore, we expect only Atlantic sturgeon from the South Atlantic DPS to be found in the action area.

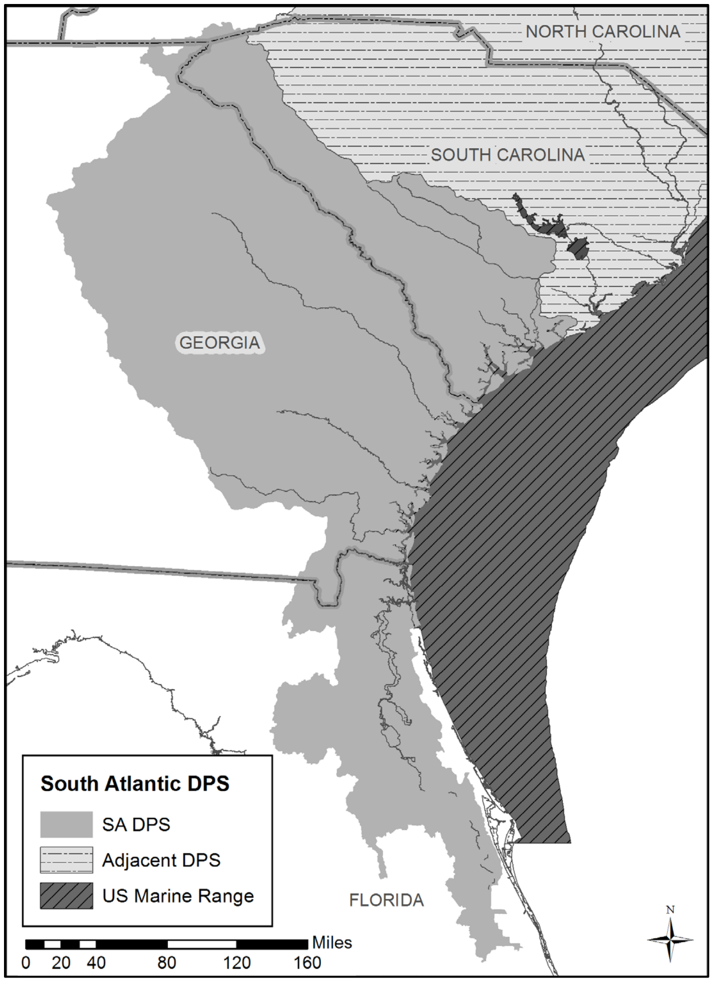

Figure 9. The South Atlantic DPS with Adjacent Portion of the Marine Range

4.2.2 Life History Information

Atlantic sturgeon are generally referred to as having 4 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. 1980). 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 less than 4 weeks old, with total lengths (TL) less than 30 millimeters (mm) (Van Eenennaam et al. 1996). Animals in this phase are in freshwater and are located 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 also frequently encountered in estuaries of non-natal rivers (Bahr and Peterson 2016).

The density of younger, less-developed juveniles may influence the outmigration of larger 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 habitats, 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 less 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 1963; 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 1973). 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. 2002b; Collins et al. 2000; Smith 1985) and 2 to 5 years for females (Stevenson and Secor 1999; Van Eenennaam et al.

1996; Vladykov and Greely 1963). 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 1997).

Traditionally, spawning for adult Atlantic sturgeon was generally considered to occur 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. 2002b; Murawski et al. 1977; Smith 1985; Smith and Clugston 1997). However, likely fall spawning runs have been identified in the Edisto River, South Carolina (Farrae et al. 2017) and the Altamaha River, Georgia (Ingram and Peterson 2016). Telemetry data collected in 2013 and 2015-2020 also show acoustically tagged fish making putative spawning runs to the areas near NSBL&D in April and May (B. Post, SCDNR, unpublished data) and also from July to November (Post et al. 2014; Post et al. 2016; Post et al. 2017a; Post et al. 2018; Post et al. 2019; Post et al. 2020). A fall spawning run has also been confirmed in the Roanoke River, North Carolina (Smith et al. 2015), in the Carolina DPS; however, they report a spring spawning run is also likely occurring. This suggests that a fall spawn is occurring in a number of southern rivers (Collins et al. 2000; 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.[12] Modeling suggests the optimal linear bottom water velocities for Atlantic sturgeon spawning range from 0.46-0.76 ~~cubic~~ meters per second (ASMFC 2017), but evidence of spawning has been found in a wider array of conditions. Eggs from fall spawn Roanoke River fish were collected during volumetric flows of 55-297 cubic meters per second (Smith et al. 2015). In the Cape Fear River, eggs were collected during the spring of 2023 during discharge flows of 68-72 cubic meters per second (J. Mathews, UNCW, pers. comm. to A. Herndon, NMFS, email, August 2023). Atlantic sturgeon have been documented spawning in water from 2.4-60 meters deep (ASMFC 2017; Bain et al. 2000; Borodin 1925; Caron et al. 2002a; Collins et al. 2000; Hatin et al. 2002; Scott and Crossman 1973). Spawning depth seems to vary greatly depending upon the available depth range. A Habitat Suitability Index (HSI) model developed by Brownell et al. (2001) estimated the optimal depth range for spawning and egg incubation of Atlantic sturgeon in the Southeast, ranged from 2.4-8 meters (ASMFC 2017). Eggs collected from the Cape Fear River in 2023 were at approximately 6 meters depth (J. Mathews, UNCW, pers. comm. to A. Herndon, NMFS, email, August 2023). It should be noted that depth in this HSI model had a maximum range of 8 meters because areas where spawning is likely to occur (areas above the fall zone) in the Southeast are not much deeper than 8 meters (P. Brownell, NOAA Fisheries, Southeast Regional Office, personal communication in ASMFC 2017).

Generally, 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. 2000; Dovel and Berggren 1983; Smith 1985). In the Savannah River, Atlantic sturgeon were detected making putative spawning runs when water temperatures were between 20° to 30°C (SCDNR 2020;

[12] River "flows" are commonly discussed as a volumetric measure (i.e., cubic feet per second [cfs]) but can also reference a linear velocity (i.e., meters per second).

SCDNR 2021a; SCDNR 2022). 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 1989; Smith and Clugston 1997).

4.2.3 Status and Population Dynamics

Secor (2002) estimates that 8,000 adult females were present in South Carolina prior to 1890. Prior to the collapse of the fishery in the late 1800s, the sturgeon fishery was the third largest fishery in Georgia. Secor (2002) estimated from U.S. Fish Commission landing reports that approximately 11,000 spawning females were likely present in Georgia prior to 1890.

The South Atlantic DPS historically supported 8 spawning subpopulations. At the time of listing only 6 spawning subpopulations were believed to have existed: the Combahee River, Edisto River, Savannah River, Ogeechee River, Altamaha River (including the Oconee and Ocmulgee tributaries), and Satilla River. We determined those rivers/river systems supported spawning if YOY were observed or mature adults were present in freshwater portions of a system. All riverine populations in the South Atlantic DPS are significantly reduced from their likely historical levels. However, three of the spawning subpopulations in the DPS are considered relatively large even when compared to the other spawning subpopulations across all 5 DPSs. The Hudson River spawning subpopulation (New York Bight DPS) is the considered the largest, but the Altamaha River and the Combahee/Edisto River subpopulations are considered the second and third largest, respectively. Peterson et al. (2008) estimated the number of spawning adults in the Altamaha River was 324 (95% CI: 143-667) in 2004 and 386 (95% CI: 216-787) in 2005. The Altamaha and Combahee/Edisto River spawning subpopulations are likely less than 6% of their historical abundance. For the remaining spawning rivers, less than 300 adults are estimated to be spawning annually (total of both sexes) (75 FR 61904; October 6, 2010). The abundance of the remaining 3 spawning subpopulations in the South Atlantic DPS is likely less than 1% of their historical abundance (ASSRT 2007).

For the Savannah River, Bahr and Peterson (2016) estimated the age-1 juvenile abundance in the Savannah River from 2013-2015 at 528 in 2013, 589 in 2014, and 597 in 2015. Based on those estimates, the authors concluded that the Savannah River population is likely the second largest within the South Atlantic distinct population segment (Bahr and Peterson 2016). Fox et al. (2020) used an updated Huggins closed-capture models in RMark to re-calculate the abundance of Age-1 individuals in the Savannah River from 2013-2019 (A. Fox, UGA, to A. Herndon, NMFS, pers. comm. email 10/19/2020). The mean estimates for Age-1 individuals during that period ranged from 353 in 2020 to 1,075 in 2014 (Fox et al. 2020). Atlantic sturgeon spawning is assumed to occur in the Savannah River based on the putative spawning runs detected via telemetry (SCDNR unpublished data) and the presence of young juveniles (Bahr and Peterson 2016). Atlantic sturgeon have been tracked from the lowest reaches of the Savannah River up to the NSBL&D (Post et al. 2014; Vine et al. 2019).

In addition to the known spawning subpopulations, two remaining historical spawning subpopulations in the Broad-Coosawatchie River and St. Marys River were believed to be extinct. However, new information provided from the capture of juvenile Atlantic sturgeon suggests the spawning subpopulation in the St. Marys River persists at very low levels. Regardless of river, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development.

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 South Atlantic DPS abundance is "depleted" relative to historical levels. The assessment concluded there was not enough information available to assess the abundance of the DPS since the implementation of the 1998 fishing moratorium. However, it did conclude there was 40% probability the South Atlantic 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 South Atlantic DPS, the assessment reported N_e for the Edisto, Savannah, Ogeechee, and Altamaha rivers (Table 7). Additional estimates of N_e have been conducted since the completion of the assessment, including for additional river systems; Table 7 reports those estimates.

Table 7. Estimates of Effective Population Size by Rivers

River	Effective Population Size (N_e) (95% CI)	Sample Size	Collection Years	Reference
Edisto	55.4 (36.8-90.6)	109	1996-2005	ASMFC (2017)
	Fall Run – 48.0 (44.7-51.5)	1,154	1996-2004	Farrae et al. (2017)
	Spring Run – 13.3 (12.1-14.6)	198	1998, 2003	Farrae et al. (2017)
	60.0 (51.9-69.0)	145	1996, 1998, 2005	Waldman et al. (2018)
Savannah	126.5 (88.1-205)	98	2000-2013	ASMFC (2017)
	123 (103.1-149.4)	161	2013, 2014, 2017	Waldman et al. (2018)
Ogeechee	32.2 (26.9-38.8)	115	2003-2015	ASMFC (2017)
	26 23.9–28.2	200	2007-2009, 2014-2017	Waldman et al. (2018)
	23.9 (22.2-25.7)	197	2007-2009, 2014-2017	Fox et al. (2019)
Altamaha	111.9 (67.5-216.3)	186	2005-2015	ASMFC (2017)
	149 (128.7–174.3)	245	2005, 2011, 2014, 2016-2017	Waldman et al. (2018)
	142.1 (124.2-164.0)	268	2005, 2011, 2014-2017	Fox et al. (2019)
Satilla	21 (18.7–23.2)	68	2015-2016	Waldman et al. (2018)
St. Marys	1 (1.3–2.0)	14	2014-2015	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). While not inclusive of all the spawning rivers in the South Atlantic DPS, the estimates reported in Table 3 suggest there is a risk for inbreeding depression ($N_e < 100$) in 4 of those rivers (Edisto, Ogeechee, Satilla, and St. Marys rivers) and loss of evolutionary potential

($N_e < 1000$) in all six. This information suggests there at least some inbreeding depression within the DPS and loss of evolutionary potential throughout all of it.

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 South Atlantic DPS put them in danger of extinction; none of the river populations are large or stable enough to provide any level of certainty for the continued existence of the South Atlantic DPS. Although the largest impact that caused the precipitous decline of the species has been restricted (directed fishing), the population sizes within the South Atlantic DPS have remained relatively constant at greatly reduced levels (approximately 6% of historical population sizes in the Altamaha River, and 1% of historical population sizes in the remainder of the DPS) 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 South Atlantic DPS can occur.

The viability of the South Atlantic 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 affect the persistence and viability of the DPS as a whole, as fewer than 2 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.

4.2.4 Threats

Atlantic sturgeon were once numerous along the East Coast until fisheries for their meat and caviar reduced the populations by over 90% in the late 1800s. Fishing for Atlantic sturgeon became illegal in state waters in 1998 and in remaining U.S. waters in 1999. Dams, dredging, poor water quality, and accidental catch (bycatch) by fishermen continue to threaten Atlantic sturgeon. The South Atlantic DPS was listed as endangered under the ESA in 2012 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.

Dams

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. Most existing 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. On the Savannah River, the NSBL&D currently obstructs Atlantic sturgeon access to 8% of its historically available habitat (ASSRT 2007). While the habitat between NSBL&D and ADD represents only 8% of historically available spawning habitat for Atlantic and shortnose sturgeon in the Savannah River (ASSRT 2007), it represents an estimated 90% to 95% of the suitable or marginally suitable spawning substrate in the river.

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 organisms; 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 estuarine habitats that support foraging, growth, and resting modifies the quality of the habitat and is further curtailing the extent of available habitat in the Cape Fear, Cooper, and Savannah rivers, 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 Savannah River and modeling indicates that the deepening of the navigation channel will result in reduced dissolved oxygen (DO) and upriver movement of the salt wedge, altering the juvenile rearing habitat. Dredging is also modifying nursery and foraging habitat in the Saint Johns River.

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 3 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; however, coverage relative to effort is not specified. Additional data provided by USACE indicate another 16 Atlantic sturgeon were killed by dredging from 2016-2018. To offset the adverse effects associated with dredging, relocation trawling is sometimes used. The USACE has used this technique during dredging at Brunswick Harbor, Savannah Harbor, Kings Bay, and in the Savannah River channel. Trawling in these area captured and relocated 215 Atlantic sturgeon from 2016-2018.

Seasonal restrictions on dredging operations have been imposed in some rivers for some species; for 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.

The Savannah Harbor Expansion Project (SHEP) was a port deepening project carried out by the Savannah District of the USACE. The project deepened the federal navigational channel of the Savannah Harbor from the existing depth of -42 feet mean lower low water (MLLW), to -47 ft MLLW. The harbor and deep-draft navigation channel comprise the lower 19.5 miles of the Savannah River and 16.1 miles of channel across the ocean bar to the Atlantic Ocean. The deepening also included the Kings Island Turning Basin and eight berths (Berths 2, 3, 4, 5, 6, 7, 8, and 9) at the Garden City Terminal. Approximately 23.6 million cubic yards of sediment was expected to be removed during the deepening. The deepening allows higher salinity water to travel further up the river. The salt water affects freshwater habitats found within the Savannah National Wildlife Refuge adjacent to the project area along the Middle and Back river. To address this project effect, the USACE developed a flow re-routing modification plan to re-direct freshwater to areas adjacent to (and found within) the refuge with the intent of minimizing the loss of the freshwater tidal marsh. The intent was to identify alterations to reduce salinity levels in critical areas of the estuary. The deepening also adversely impacted dissolved oxygen levels in the harbor. The USACE attempted to mitigate for this issue with the installation of several dissolved oxygen injection sites (i.e., Speece Cones).

Ultimately, NMFS (2011) determined that juvenile Atlantic sturgeon from the South Atlantic DPS within the Savannah River would be affected by the habitat changes caused by the deepening. NMFS (2011) concluded approximately 251 acres of foraging and resting habitat used by juvenile Atlantic sturgeon during the winter would be lost or approximately 7.6% of the total habitat available. After initially exceeding the ITS for Atlantic sturgeon takes via dredge equipment, consultation was reinitiated and an amendment to the biological opinion to was completed (i.e., (NMFS 2017a)). NMFS (2017a) determined up to 215 Atlantic sturgeon incidental takes (20 lethal takes), across all five DPSs combined, were likely as a result of direct interactions with dredge and relocation trawling equipment.[13]

Water Quality

Issues with water quality can affect how Atlantic sturgeon 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 (1995) 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 high occurrence of low DO coupled with high temperatures in the river systems throughout the range of the South Atlantic DPS in the

[13] Hopper dredging accounted for 17 lethal interactions; relocation trawling accounted for 198 interactions, 3 lethal and 195 nonlethal (NMFS 2017).

Southeast. Sturgeon are more highly 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 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 2009a; Niklitschek and Secor 2009b; Secor and Gunderson 1998). Secor and Gunderson (1998) established that the DO level required to avoid mortality was 5 mg/L. For sturgeon, DO levels below 5 mg/L can be physiologically stressful, impair animal growth, and the complete lack of oxygen (anoxia) will kill animals. Low DO is modifying sturgeon habitat in the Savannah due to dredging, and nonpoint source inputs are causing low DO in the Ogeechee River and in the Saint Marys River, which completely eliminates juvenile nursery habitat in summer. Low DO has also been observed in the Saint Johns River in the summer. The recent extirpations and severe population depressions of these species in the Southeast are probably not coincidental; mortalities related to the synergistic effects of low DO levels and high summer temperatures would tend to affect southern populations to a greater extent than those further north.

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 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).

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. 1981), 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. Atlantic sturgeon are in direct contact through water, diet, or dermal exposure with multiple contaminants throughout their marine, estuarine, and freshwater range (ASSRT 2007). Trace metals, trace elements, or inorganic contaminants (mercury, cadmium, selenium, lead, etc.) are another suite of contaminants occurring in fish. Post (1987) states that toxic metals may cause death or sub-lethal effects to fish in a variety of ways and that chronic toxicity of some metals may lead to the loss of reproductive capabilities, body malformation, inability to avoid predation, and susceptibility to infectious organisms.

Water Quantity

Threats from changes in water quantity to Atlantic sturgeon are the same as those described for shortnose sturgeon (Section 4.1.4).

Climate Change

Threats from climate change to Atlantic sturgeon are the same as those described for shortnose sturgeon (Section 4.1.4).

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 bycatch of Atlantic sturgeon in fisheries is an ongoing impact to the South Atlantic DPS (ASMFC 2017). Mandatory reporting of sturgeon bycatch was initiated in 2000 by ASMFC; a summary of self-reported Atlantic sturgeon bycatch via the South Carolina shad gillnet fishery is presented in Table 8. South Carolina's primary shad fishery areas include Waccamaw River, Pee Dee River, Winyah Bay, Santee River, Edisto River, Combahee River, Savannah River, and the Atlantic Ocean intercept fishery. In most cases, Atlantic sturgeon captured as bycatch of the shad gillnet fishery are returned to the river uninjured; survival is expected to be greater early in the shad season when waters are cooler. There are no data to separate total number of sturgeon into unique and recaptured individuals.

Table 8. Self-Reported Bycatch of Atlantic Sturgeon by South Carolina Commercial Shad Fishermen, by DPS, with Estimated Catch-Per-Unit- Effort (CPUE) (Source: SCDNR)

	Carolina DPS		**South Atlantic DPS**		
Year	Waccamaw River, Pee Dee River, Winyah Bay, and Santee River	CPUE	Edisto River, Combahee River, and Savannah River	CPUE	**Annual Total (Both DPSs)**
2000	40	0.0000175	5	0.0000089	45
2001	128	0.0000383	20	0.0000406	148
2002	74	0.0000175	5	0.0000166	79
2003	16	0.0000041	3	0.0000071	19
2004	11	0.0000027	0	0.0000000	11
2005	0	0.0000000	1	0.0000027	1
2006	226	0.0000342	2	0.0000051	228
2007	162	0.0000632	6	0.0000156	168
2008	76	0.0000187	0	0.0000000	76
2009	186	0.0000364	3	0.0000108	189
2010	12	0.0000036	3	0.0000135	15
2011	173	0.0000297	8	0.0000332	181
2012	194	0.0000345	11	0.0000422	205
2013	157	0.0000454	1	0.0000047	158
2014	14	0.0000049	0	0.0000000	14
2015	10	0.0000031	0	0.0000000	10
2016	15	0.0000084	0	0.0000000	15
2017	66	0.0000265	0	0.0000000	66
2018	138	0.0000566	0	0.0000000	138
2019	19	0.0000124	0	0.0000000	19
2020	2	0.0000011	0	0.0000000	2
2021	4	0.0000032	0	0.0000000	4

The commercial shad fisheries in Georgia incidentally capture Atlantic sturgeon. Georgia implemented regulations restricting fishing to the lower portions of the Savannah, Ogeechee, and Altamaha Rivers and close the fishery in the Satilla and St. Marys River to reduce sturgeon bycatch. The Georgia shad fishery is open from January 1 to March 31. Georgia applied for, and received, an Incidental Take Permit from NMFS in 2013. The biological opinion evaluating the permit request determined the continued operation of the fishery was likely to adversely affect Atlantic sturgeon but would not jeopardize its continued existence. NMFS determined that incidental capture by fisherman will not exceed 140 Atlantic sturgeon per year (no more than 420 in a 3-year period) in the Altamaha River, 35 Atlantic sturgeon per year (no more than 110 in a 3-year period) in the Savannah River, and 5 Atlantic sturgeon per year (no more than 20 in a 3-year period) in the Ogeechee River; the animals will be juveniles and subadults. The biological opinion anticipated the maximum intercept rate for each Atlantic sturgeon DPS to be: South Atlantic DPS 95%; Chesapeake Bay DPS 20%; Carolina DPS 15%; New York Bight DPS 10%; and Gulf of Maine DPS 2% of the total number of incidental capture, and a mortality rate of 1% (NMFS 2013e). Subsequent to the completion of the biological opinion, the Ogeechee River was closed to commercial shad fishing in 2014. Incidental Take Permits are typically issued for 10 years. GADNR has submitted an application and accompanying conservation plan for the incidental take Atlantic sturgeon associated with the otherwise lawful shad fishery in Georgia. The permit will be active for 10 years. Due to changes in the way the fishery operates since the last Incidental Take Permit was issued in 2013 (e.g., fewer dealers purchasing shad, fewer new shad fishermen entering the fishery) GADNR is expected to request fewer incidental captures of Atlantic sturgeon under its new permit.

Additionally, fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species. Because Atlantic sturgeon mix extensively in marine waters and may access multiple river systems, they are subject to being caught in multiple fisheries throughout their range.

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 (1997) calculated that Atlantic sturgeon can only withstand the annual loss of up to 5% 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% (ASMFC 2017), 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.

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

Threats from stochastic events to Atlantic sturgeon are the same as those described for shortnose sturgeon (Section 4.1.4).

5 ENVIRONMENTAL BASELINE

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

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

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

5.1 Status and Distribution of Sturgeon in the Action Area

Because the action area is located upstream of the currently impassible barrier at NSBL&D, sturgeon are not currently present in the action area. Once fish passage is established at NSBL&D sturgeon will gain access to the action area. The sturgeon occurring in the action area are anticipated to be the same individuals whose status and distribution are described in Section 4.1and 4.2.

5.2 Factors Affecting Sturgeon in the Action Area

5.2.1 Water Quantity and Quality

Water Quantity-Surface Water Withdrawals

The headwaters for the project area originate in the Blue Ridge Mountains of North Carolina, pass through Georgia, and drain into the Atlantic Ocean through the Savannah River. Water flows have been drastically changed through the construction of dams and reservoirs, and from the removal of water for industrial, agricultural, and municipal uses. Wrona et al. (2007) reports that under the dam management regime of the last 50 years, the 100-year flow is approximately the same size as the pre-dam 2-year flow, and that the current 2-year flow (approximately 35,000 cfs) is one-third the size of the pre-dam 2-year flow (approximately 90,000 cfs). Water flow is regulated by USACE through dams at Lake Hartwell, Lake Richard B. Russell and Clarks Hill Lake (known as J. Strom Thurmond Lake in South Carolina). Flow in the Savannah River is primarily controlled by releases from JST Dam. The gates at the NSBL&D are controlled remotely at the Thurmond Reservoir.

5.2.2 Other Federal Actions

Interagency Consultation (ESA Section 7)

In recent years, NMFS has undertaken a number of ESA Section 7 consultations to address the effects of federal actions on endangered sturgeon in the Savannah River system (Table 9). For most of the projects listed in Table 9, the primary source of potential impacts to shortnose and Atlantic sturgeon were from in-water construction activities and, based on the action agencies' willingness to adopt seasonal in-water construction moratoria or other special construction conditions, adverse effects were not likely. NMFS determined several projects were likely to adversely affect Atlantic and shortnose sturgeon. While none of these consultations considered projects within the current action area, the individual sturgeon potentially affected by these actions could occur within the action area of this project once fish passage is established at NSBL&D.

Table 9. ESA Section 7 Consultations for Sturgeon in the Savannah River the Last 10 Years.

Date	Project
04/08/2011	SCDOT - Road Widening and Bridge Widening on US 17 in Jasper County, South Carolina
05/19/2011	NRC - Vogtle Electric Generating Plant, Units 3 and 4 Combined Licenses Application
11/04/2011	Savannah Harbor Federal Navigation Project
02/15/2012	Continued Authorization South Atlantic Coral, Dolphin-Wahoo, Golden Crab, Snapper-Grouper, and Sargassum Fisheries and the Gulf of Mexico/South Atlantic Spiny Lobster Fishery FMPs (reinitiation for Atlantic sturgeon)
05/16/2012	King Mill Hydroelectric Project
08/01/2012	GADOT replacement of Back River bridge-Chatham County (reinitiation for Atlantic sturgeon)
11/27/2012	GADOT Fort Pulaski Bridge Project in Chatham County, Georgia
12/04/2012	Savannah District COE - Field Study of Bed Levelers with Hopper Dredges in Savannah and Brunswick Harbors, Chatham/Glynn Counties, Georgia
12/20/2012	Georgia Shad Fishery Section 10 Permit
02/22/2013	Georgia Department of Natural Resources' Request to Amend ESA Section 6 Cooperative Agreement
03/01/2013	Savannah River Berth Maintenance
04/23/2013	Southern LNG Berth Maintenance

Date	Project
05/17/2013	GADOT Replacement of the CR 787/Islands Expressway Bridges over the Wilmington River, Chatham County, Georgia
04/07/2015	SCDOT - Spanish Well Road (S-79) - Bridge Replacement Project (PIN 39102) - BA for Shortnose/Atlantic Sturgeon
07/01/2015	Army Permit No. SAS-2014-363 (201400363) - Biological Assessment for Shortnose and Atlantic Sturgeons - city of Savannah - Plant Riverside Riverwalk (Riverfront Plaza)
3/28/2017	Army Permit No. SAS-2001-12360 - Georgia Ports Authority - Dredging Project
03/29/2017	SCDOT & GDOT - U.S. Route 17 Widening and Bridge Over Back River Biological Assessment for the Atlantic and Shortnose Sturgeons And West Indian Manatee
8/2/2017	Army Application Number SAS-2005-855
12/15/2017	Reinitiation of SCDOT - U.S. Route 17 Widening and Bridge Over Back River Biological Assessment for the Atlantic and Shortnose Sturgeons And West Indian Manatee
1/16/2018	Em. Response - Army Corps - US Navy Munition Disposal Tybee Island, Georgia
3/27/2020	2020 South Atlantic Regional Biological Opinion (2020 SARBO)
2/19/2020	SR-25 Bridge Middle River Project
1/31/2020	Savannah River Drought Contingency Plan
4/16/2020	Georgia Kaolin Terminal Dock
3/23/2021	SeaPoint Marine Terminal
6/22/2021	SR 25 US Highway 17 Bridge (Houlihan Bridge) Replacement

Cooperation with States (ESA Section 6)

Through an ESA Section 6 cooperative agreement with Georgia and South Carolina, NMFS has supported numerous research projects within the project area to investigate the life history of the shortnose and Atlantic sturgeon. Since 2013, six multi-year projects looking at movement, migration, genetics, diet, habitat use, and population dynamics of Atlantic and shortnose sturgeon in North Carolina, South Carolina, and Georgia have been funded. ESA Section 10 research permits were issued to researchers studying shortnose and Atlantic sturgeon as part of their Section 6-funded work.

Research, Enhancement, and Incidental Take Permits (ESA Section 10)
Through issuance of ESA Section 10(a)(1)(A) permits, scientific and enhancement studies are conducted by researchers on captive shortnose sturgeon maintained at various quarantined research facilities. Currently, only researchers employed by USFWS are authorized to study captive shortnose sturgeon from stocks in the Southeast. These captive individuals are periodically conditioned and spawned and the resulting gametes and progeny are used for scientific studies, such as cryogenics, disease transmission, nutrition, genetics, toxicology, fish passage, and fish culture techniques.

Three Section 10(a)(1)(A) scientific research permits are currently issued to study shortnose sturgeon in the Southeast (Table 10). Three Section 10(a)(1)(A) scientific research permits are currently issued to study Atlantic sturgeon from the South Atlantic DPS (Table 11). Each permit approves sampling methodology and authorizes take. Permit 23096 authorizes mortalities of up to 3 adult and 3 juvenile shortnose sturgeon annually and up to 4 adult/subadult and 4 juvenile Atlantic sturgeon annually. Similarly, Permit 20528-04 authorizes up to 1 adult and 1 juvenile shortnose sturgeon annually, and 1 adult/subadult and 1 juvenile Atlantic sturgeon annually. The way the permit is structured, all of those authorized mortalities could occur in the Savannah River, some mortalities could occur in the Savannah while others occurred in different rivers, or all of the mortalities could occur in rivers other than the Savannah. The specific stressors to fish subject to NMFS-issued ESA permit conditions are capture in nets; handling and restraint during examinations; measuring and weighing; tagging using passive integrated transponder (PIT), internal, and external tags; tissue sampling; anesthetizing; laparoscopy; blood sampling; and gonad biopsy.

Table 10. Current Shortnose Sturgeon ESA Section 10 (a)(1)(A) Research Permits

Permit No.	Location	Authorized Take	Research Activity
23096 Expires: 1/1/2030	Savannah, Ogeechee, Canoochee, Altamaha, Oconee, Ocmulgee, Satilla, St. Marys, St. Johns, and Nassau rivers, and all Georgia/Florida rivers, estuaries, and coastal marine areas	970 adult/juv. (lethal – 3 juv. and 3 adult); 400 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag, collect ELS
20528-04 Expires: 3/31/2027	Santee, Cooper, Edisto, and Savannah rivers; Winyah Bay; Lake Moultrie and Lake Marion	535 adult/juv. (lethal – 1 juv. and 1 adult); 300 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag, collect ELS
23200-01 Expires: 1/31/2025	Cape Fear, Neuse, Tar/Pamlico, Roanoke/Chowan rivers	120 adult/sub-adult/juv.	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag

Early life stage (ELS) individuals

Table 11. Current Atlantic Sturgeon ESA Section 10 (a)(1)(A) Research Permits

Permit No.	Location	Authorized Take	Research Activity
23096 Expires: 1/1/2030	Savannah, Ogeechee, Canoochee, Altamaha, Oconee, Ocmulgee, Satilla, St. Marys, St. Johns, and Nassau rivers, and all Georgia/Florida rivers, estuaries, and coastal marine areas	2490 adult/sub-adult/juv. (lethal – 4 juv. and 4 adult); 400 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag, collect ELS
20528-04 Expires: 3/31/2027	Santee, Cooper, Edisto, and Savannah rivers; Winyah Bay, Intracoastal Waterways; Lake Moultrie and Lake Marion	1730 adult/juv. (lethal – 1 juv. and 1 adult); 200 ELS	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag, collect ELS
23200-01 Expires: 1/31/2025	Cape Fear, Neuse, Tar/Pamlico, Roanoke/Chowan rivers	1260 adult/sub-adult/juv.	Capture, handle, measure, weigh, PIT tag, tissue sample, fin-ray section, anesthetize, laparoscopy, gonad biopsy, blood collection, radio tag

Early life stage (ELS) individuals

5.2.3 Climate Change/Sea Level Rise

Threats to sturgeon from climate change and sea level rise in the action area are the same as those described previously in *Section 4: Status of Species*.

5.2.4 Drought

Threats to sturgeon from drought in the action area are the same as those described previously in *Section 4: Status of Species*.

5.2.5 Conservation and Recovery Actions Benefitting Sturgeon

Many measures have been implemented to protect the sturgeon in the Savannah River estuary. Overharvesting of sturgeon in directed fisheries has been eliminated as a causative factor in the decline of the Savannah River sturgeon populations. Since its ESA listing in 1967, it has been illegal to kill or possess shortnose sturgeon. In 1998, the Atlantic States Marine Fisheries Commission (ASMFC) instituted a coast-wide moratorium on the harvest of Atlantic sturgeon, which is to remain in effect until there are at 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. Sturgeon that are caught incidentally as bycatch in shrimp trawls are to be released alive. The phasing out of the traditional method of catching American shad (gillnets in a coastal intercept fishery) has greatly reduced the number of sturgeon inadvertently caught by shad fishermen. In turn, this has greatly reduced the interruption of sturgeon migrations in the late winter and early-fall.

As listed species, the ESA provides protections that lead to the conservation and recovery of Atlantic and shortnose sturgeon. Section 7(a)(1) of the ESA charges all federal agencies to utilize their authorities in furthering the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species. Under Section 7(a)(2) of the ESA, any action funded, authorized, or undertaken by a federal agency that may affect either species would require consultation with NMFS. During consultation, NMFS evaluates the anticipated level of take associated with the action, evaluates whether it would jeopardize the continued existence of the species, and determines RPMs that would reduce the anticipated effects of the incidental take on the species. Recovery may be facilitated through incorporating conservation measures into activities that potentially affect shortnose and Atlantic sturgeon through Section 7(a)(2) consultations and Section 10(a)(1)(B) permitting.

NMFS finalized the Recovery Plan for the shortnose sturgeon in 1998 with the following recovery objective "to recover shortnose sturgeon populations to levels of abundance at which they no longer require protection under the ESA, and for each population segment, the minimum population size will be large enough to maintain genetic diversity and avoid extinction." The Recovery Plan identified 19 discrete populations of shortnose sturgeon and determined the Savannah River population to be discrete (NMFS 1998). The 1998 shortnose sturgeon Recovery Plan also identified 4 main recovery actions: 1) establish listing criteria for shortnose sturgeon population segments, 2) protect shortnose sturgeon and their habitats, 3) rehabilitate shortnose sturgeon populations and habitats, and 4) implement recovery tasks. To rehabilitate shortnose sturgeon habitats and population segments, the Recovery Plan calls for actions to restore access to habitats, spawning habitat and conditions, and foraging habitat. In 2007, NMFS convened a team of experts on shortnose sturgeon biology, genetics, and life history to conduct a biological assessment of shortnose sturgeon. In 2013, NMFS released the "Biological Assessment of Shortnose Sturgeon," which represents the best available information regarding shortnose sturgeon throughout its range.

Through ESA Section 6 cooperative agreements, NMFS has supported numerous research projects within the South Atlantic to investigate the life history of the shortnose and Atlantic sturgeon. Researchers have worked to fill in knowledge gaps to better inform conservation and recovery of Atlantic and shortnose sturgeon. Studies include population dynamics and migration of Atlantic sturgeon captured in South Carolina rivers and coastal waters through mark-recapture and telemetry techniques; abundance, population dynamics, seasonal movement, diet, general ecology and environmental tolerance of Atlantic sturgeon captured in Georgia rivers and coastal waters; presence, population status, movement patterns, and habitat use of Atlantic sturgeon in Florida and Georgia coastal rivers.

Section 8 of the ESA permits the United States to cooperate internationally in conserving threatened and endangered species and implemented the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) protections in the United States. Shortnose sturgeon were listed in Appendix I by CITES in 1975. Appendix I species are considered threatened by extinction and trade is permitted only in exceptional circumstances. Atlantic sturgeon were listed in CITES Appendix I in 1975 and transferred to Appendix II in 1979. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. Both Atlantic and shortnose sturgeon were added to the International Union for Conservation of Nature and Natural Resources (IUCN) Red List in 1986 as vulnerable. Shortnose sturgeon continue to be classified by the IUCN as vulnerable, while Atlantic sturgeon were reclassified in 2006 as near threatened. However, the IUCN categories have no direct relationship to the listing status of either species under the ESA.

The GADNR Environmental Protection Division, in coordination with the EPA, regulates point source discharges in the Savannah River under the National Pollutant Discharge Elimination System (NPDES) program. The EPA published a draft revised TMDL for the Savannah River to improve DO conditions in the Savannah Harbor in 2010. If finalized, the TMDL would require a reduction in oxygen demanding substances over time as the various NPDES permits come up for renewal, in point source discharges. This TMDL would affect NPDES permit holders in the Augusta, Georgia, area as well, since their waste loads contribute to the DO deficiencies in Savannah Harbor.

5.2.6 Summary and Synthesis of Environmental Baseline for Sturgeon

In summary, several factors are presently adversely affecting shortnose and Atlantic sturgeon in the action area. These factors are ongoing and are expected to occur contemporaneously with the proposed action. These activities are expected to combine to adversely affect the recovery of shortnose and Atlantic sturgeon in the Savannah River. The legally required construction of fish passage at NSBL&D was first established via NMFS 2011 (NMFS 2011), and will support the recovery of shortnose and Atlantic sturgeon in the Savannah River. A design for the fish passage structure at NSBL&D was completed and its construction was slated to begin in 2020 before litigation halted construction. Construction remains suspended while the issue is resolved in court. We anticipate the nature-like fishway, specifically designed to pass sturgeon, will be implemented at NSBL&D within a reasonable time once the litigation is resolved.

6 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 but that are not part of the action. A consequence is caused by the proposed action if the effect would not occur but for the proposed action and the effect is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02).

The Final EA for the Augusta Canal Project acknowledges that the ADD and other dams in the Savannah River block access to spawning areas and limit usable habitat areas by reducing flows for resident fish species. In this section of our Opinion, we assess the effects of the action on the Savannah River populations of shortnose sturgeon and the South Atlantic DPS of Atlantic sturgeon that are likely to be adversely affected. The analysis in this section forms the foundation for our jeopardy analysis in Section 8. The quantitative and qualitative analyses in this section are based upon the best available commercial and scientific data on species biology and the effects of the action.[14]

[14] In some instances, the prior draft biological opinion stated we were employing a conservative approach to "err on the side of the species" or "give the benefit of the doubt" to listed species when addressing information gaps and uncertainty. In this final version, we have removed such stock language in order to better explain how we address information gaps and uncertainty.. When data is limited or equivocal, we have occasionally needed to make reasonable determinations based upon our best professional judgment to bridge the gap in the available data. The quantitative and qualitative analyses in this section are based upon the best available commercial and scientific data

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).

The routes of effects (sources of harm or other injury) of the Augusta Canal Project on Atlantic and shortnose sturgeon are: (1) obstruction of access to historical upstream spawning habitat, (2) the daily minimum aquatic base flow's impact on water quantity, (3) the daily minimum aquatic base flow's impact on water quality, and (4) injury or stress to individual sturgeon due to unsuccessful attempts to utilize the proposed fishway. The operation of other dams on the Savannah River also affect sturgeon habitat via changes in water quantity and water quality; therefore, it is important to understand the effects attributable to the Augusta Canal Project in the context of the effects of these other structures.

6.1 Effects from Continued Existence and Operation of the Augusta Diversion Dam

The Savannah River is segmented by a series of dams and reservoirs (USFWS et al. 2001). The construction of these dams, of which ADD is one, and reservoirs they create has converted or blocked access to approximately half of the 384 miles of habitat on the Savannah River. In total, the shoal habitat similar to that found around the city of Augusta extended above the ADD from RM 207 (333.1 RKM) to RM 313 (503.6 RKM) historically (Meyer et al. 2003). However, only the stretch below ADD remains as non-impounded riverine habitat. The ADD continues to block and inundate approximately 1 mile of historical shoal habit occurring between ADD and the Stevens Creek Project. The ADD continues to fragment, inundate, and block access to habitat historically used by Atlantic and shortnose sturgeon.

6.2 The Effects of Minimum Aquatic Base Flows

6.2.1 Spawning Habitat Availability at Augusta Shoals

Prior to the construction of dams on the Savannah River, there were approximately 110 miles of shoal habitat from the city of Augusta upstream to the mouth of the Tugaloo River (USFWS 2003). It is estimated that dams and their impoundments currently render 92% of historically available sturgeon spawning habitat in the Savannah River unusable (rapids complex: boulder, bedrock, cobble and gravel substrate) (ASSRT 2007). While some gravel bars below the NSBL&D are likely being used for spawning, the only remaining shoal habitat in the Savannah River is a 4.5 RM (7.2 RKM) reach extending downstream from the ADD. While the habitat between NSBL&D and ADD represents only 8% of historically available spawning habitat for

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on species biology, the primary biological features of critical habitat, and the effects of the action. In all instances, the approach to our analysis is explained, including how uncertainty, causation, and the choice among a range of values are evaluated and addressed.

Atlantic and shortnose sturgeon in the Savannah River (ASSRT 2007), it represents an estimated 90% to 95% of the suitable or marginally suitable spawning substrate.

Entrix (2002) and Dial-Cordy (2010) evaluated the habitats within that 4.5 RM stretch more closely. Via AutoCAD drawings, Entrix (2002) estimated the shoals contained 982 acres (3.9 km^2 or 42,768,000 ft^2) of surface area. Within that area, Entrix (2002) estimated 55% of the habitat was "run" habitat, 31% was "shoal" habitat, and 14% was "other" habitat. Generally, shoal habitats included large stretches of shallow bedrock and boulders, with some areas of large cobble. Entrix (2002) reported median depths in shoal habitats at 2,500 cfs of about 1.5 ft (0.4 m), with velocity about 1 ft per second (0.3 m per second). Run habitat includes deeper water upstream or downstream of these shoal habitats. Median depths at 2,500 cfs in these habitats ranged from 3-5 ft (0.9-1.5 m) and velocity about 0.5 ft per second (0.15 m per second) (Entrix 2002). Entrix (2002) reports "other" habitat consists of "open-run" habitat. We are unclear why the report did not include open-run habitat (14%) as part of the run habitat (55%).

Within the entire 4.5 RM stretch of the Augusta Shoals, we anticipate the "run" habitats described in Entrix (2002) are the most suitable for sturgeon spawning. These areas are deeper and with relatively slower velocities. These deeper habitats are more likely to remain accessible to adults even under lower flow conditions. Similarly, deeper habitats are more likely to provide thermal refuge and maintain suitable DO concentrations for longer than shallower shoal habitats during lower flows.

Entrix (2002) reported a wide range of flow conditions encountered at each transect during sampling. As a result, they selected a reference flow of 2,500 cfs, which they acknowledge is a relatively low flow for the Augusta Shoals. Entrix (2002) note that the 2,500 cfs reference flow is likely to be exceeded 75% of the time, annually. As flows increase, we anticipate some of the shoal habitat may become more suitable for spawning (i.e., more similar to the run habitat). We anticipate 55-69% of the habitat in the Augusta Shoals is run habitat with adequate depth and flow for spawning at the reference flow condition of 2,500 cfs (Entrix 2002).[15]

Dial-Cordy (2010) sampled sediments from 57 locations along 18 evenly spaced transects (perpendicular to shore) from ADD through Augusta Shoals (Figure 10). This sampling area covered 632 acres (2.6 km^2) of aquatic habitat after excluding exposed shoals and islands, of which they found 77% to be suitable or marginally suitable spawning substrate. Since the "substrate" parameter does not consider other hydraulic variables (e.g., depth or velocity), we combined the available information on suitable substrate from the Dial-Cordy (2010), with the available information on habitat categories likely suitable for spawning (i.e., run habitat) described in Entrix (2002). Using that approach, we estimated the maximum amount of habitat suitable for spawning is 416 acres and may be as much as 522 acres.[16] However, because Entrix (2002) chose a relatively low reference flow (i.e., 2,500 cfs) when estimating habitat proportions,

[15] The 69% estimate of run habitat assumes the additional 14% of "open run" habitat reported by Entrix (2002) is suitable for inclusion as run habitat potentially suitable for sturgeon spawning.
[16] 982 acres of aquatic habitat surface area in the Augusta Shoals x 55% of all habitat is run habitat x 77% of sites sampled were suitable- or marginally-suitable spawning substrate = 415.88 acres of run habitat with suitable- or marginally-suitable spawning substrate. 982 acres of aquatic habitat surface area in the Augusta Shoals x 69% of all habitat is run habitat ("run habitat" + "other habitat") x 77% of sites sampled were suitable - or marginally-suitable spawning substrate = 521.78 acres of run habitat with suitable- or marginally-suitable spawning substrate.

our estimate of 416–522 acres of suitable spawning habitat is a conservative estimate under the annual range of flow conditions at Augusta Shoals.

Dial-Cordy (2010) also evaluated potential spawning habitat downstream of the Augusta Shoals and NSBL&D. For the study area between NSBL&D and U.S. Highway 301, Dial-Cordy (2010) evaluated 3 (of 4) physical habitat elements considered primary determinants of sturgeon spawning success: (1) benthic substrate type, (2) river depth, and (3) water velocity (NMFS 2007). Dial-Cordy (2010) estimated approximately 127 acres of "suitable" and "marginally-suitable" spawning habitat exists within the 2,600-acre section of the river between the NSBL&D and the U.S. Highway 301 Bridge (near the city of Savannah). Thus, our conservative estimate of 416–522 acres of suitable- or marginally-suitable spawning substrate for sturgeon in the Augusta Shoals represents a 3- to 4-fold increase in acreage, relative to the amount of suitable- or marginally-suitable habitat that currently exists below NSBL&D. We note that neither sampling approach considered water temperatures, which are considered a critical element in the (NMFS 2007) habitat suitability index model. However, our review of the available water temperature data (Section 4.1.4) indicates that water temperatures will be suitable for spawning.

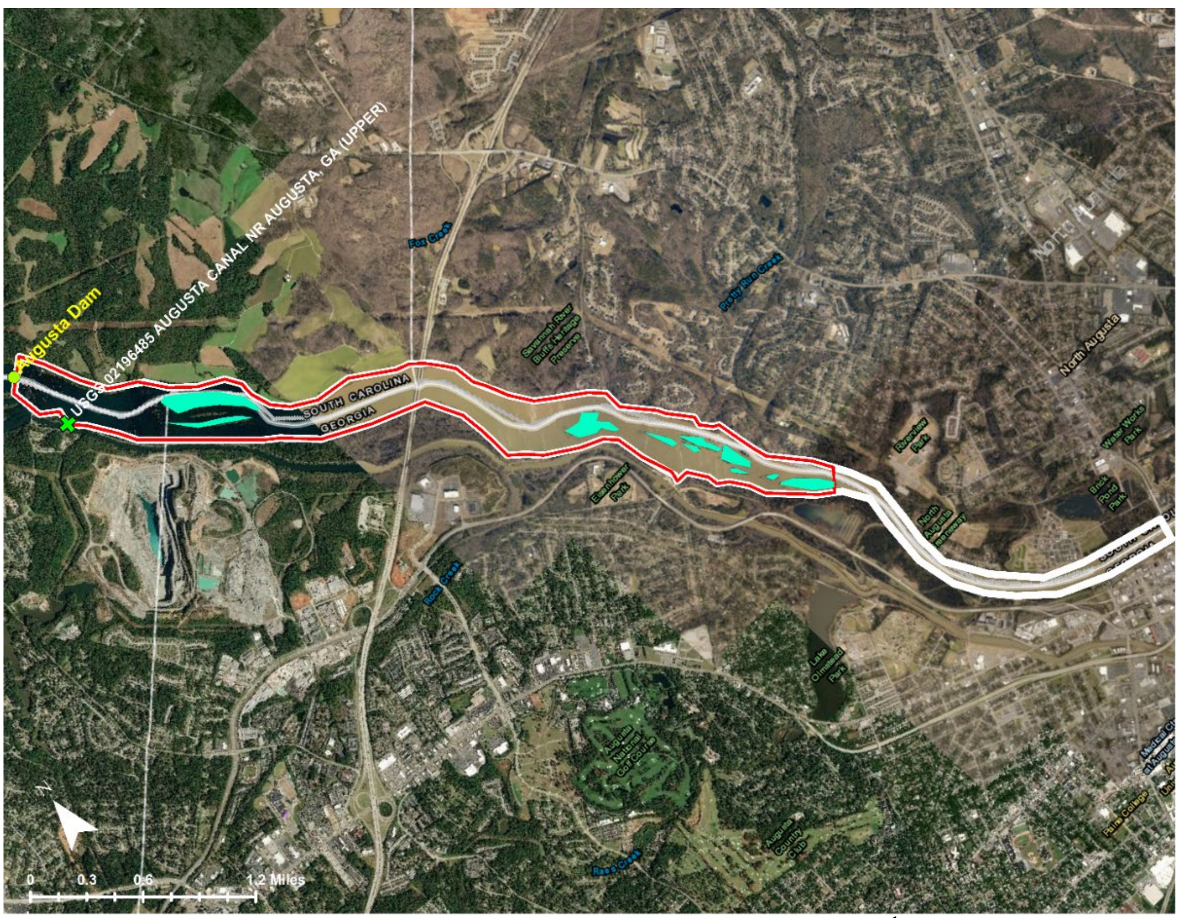

Figure 10. Map of Savannah River from Augusta Canal Project to 13th Street Bridge (white outline), showing Dial-Cordy (2010) sampling zone (red outline) and exposed Augusta Shoals and islands (green polygons). Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

6.2.2 Changes to Water Quantity

Both the Dial-Cordy (2010) and Entrix (2002) reports indicate moderate- to high-quality spawning habitat for sturgeon exist at the Augusta Shoals; the quantity and quality of that habitat is highly depend on the flow conditions at the Shoals. While the ADD has no storage capacity, it regulates flows over the Augusta Shoals via its diversion of a portion of the water from the Savannah River into the Augusta Canal. Water diversions for Augusta-Richmond County's municipal water supply are the only consumptive use of water from the Augusta Canal Project. The water use for the municipal water supply reduces the amount of water available in the river relative to no diversions occurring. Thus, the downstream effects from licensing and operation of the Augusta Canal Project are considered effects of the action.

Without minimum daily aquatic base flows in place, there are times when water is diverted into the Augusta Canal and very little water gets to the shoal habitat immediately below ADD, rendering much of the habitat unusable for spawning (Figure 11).

Figure 11. Shoal Habitat Below ADD During Low Flow Conditions (Photo Credit: E. Bettross, GADNR)

The minimum daily aquatic base flows proposed for the Augusta Shoals in the 2008 draft settlement agreement establish daily average flows between 1,500 and 3,300 cfs (Table 12), depending on the amount of flow reaching the ADD and the time of year. Within this flow range, portions of Augusta Shoals are accessible via wading and others require a boat (Entrix 2002 Appendix C). The higher flows established under the proposed license terms were applied to months (e.g., January, February, March, and April) when shortnose sturgeon were expected to be spawning based on the information available at the time. Atlantic sturgeon were not awarded federal protection under the ESA until 2012; thus, they were not expressly considered in the 2008 draft settlement agreement.

Table 12. Minimum Aquatic Base Flows Reserved for the Augusta Shoals

Incoming Flow Tier (cfs)		Feb-Mar	April	May 1-15	May 16-31	June-Jan
Tier 1	≥5,400	3,300	3,300	2,500	1,900	1,900
Tier 2	4,500-5,399	2,300	2,200	1,800	1,800	1,500
Tier 3	3,600-4,499	2,000	2,000	1,500	1,500	1,500
Tier 4	<3,600	1,800	1,800	1,500	1,500	1,500

Research concluded since 2008 indicates Atlantic sturgeon are likely making spawning runs to the areas near NSBL&D in April and May (B. Post, SCDNR, unpublished data) and also July, August, September, and October (Post et al. 2014; Post et al. 2016; Post et al. 2017a; Post et al. 2018; Post et al. 2019; Post et al. 2020). Based on this information, and for the purposes of this analysis, we anticipate spawning shortnose sturgeon will be near the NSBL&D in January, February, March and April, while we anticipate Atlantic sturgeon may be in the area in April and May, as well as July, August, September, and October.

We anticipate reservation of daily minimum aquatic base flows for the Augusta Shoals will improve conditions there relative to current conditions, because it ensures some minimum level of water will be reserved for the Shoals each day. However, the continued authorization of water diversions into the Augusta Canal will adversely affect sturgeon by restricting access to habitats at the Augusta Shoals once fish passage at NSBL&D is complete. Because the daily minimum aquatic base flows were negotiated without consideration of the flows needed for Atlantic sturgeon, there may not be sufficient water for spawning at all times when Atlantic sturgeon are expected to be present, after passage is implemented at NSBL&D. We considered the effects of the diversions by evaluating changes to the flow and habitat suitability at the Augusta Shoals.

Estimating Flow Conditions

To determine impacts of the daily minimum aquatic base flows, we began by estimating flows arriving at the ADD by following the procedure for calculating the "Augusta Declaration" as described in the 2008 draft settlement agreement. That procedure establishes that inflows will be calculated by summing the daily estimated flow releases from the JST Project (i.e., SEPA Declaration) with any additional inflow between the JST Project and the ADD for the same date as SEPA Declaration. The process for estimating the additional inflows occurring between the JST Project and the ADD is described in the 2008 draft settlement agreement.

Using the procedure described in the 2008 draft settlement agreement, we estimated the flow conditions arriving at the ADD from 1996–2019, using the historical SEPA Declaration data available from the JST Project and the best available information from 2 USGS gages (USGS gage 02196000 in Stevens Creek near Modoc, SC and USGS gage 02196485 Augusta Canal near Augusta, GA; Figure 12). We believe recent historical flow information is the best available information for determining likely future flow conditions. We acknowledge that future changes in climate could change future flow conditions in the river via either periods of drought or high rainfall. Information on future precipitation levels in the Southeast suggests more rain is expected on average going forward (see Section 4.1.4). However, precipitation projections for South Carolina and Georgia specifically, suggest less precipitation may occur on average during the winter, spring and fall, with heavier rainfall than average during the summer (Easterling et al. 2017). Trends in precipitation for South Carolina and Georgia, since 1950, indicate an increase of 0.23 inch/decade and 0.16 inch/decade, respectively, suggesting more water may be in the river in the future (NCDC 2021). Regardless, flows in the system are highly regulated by releases from the JST Project. The proposed action will have no influence over how the JST Project manages future flows within the system, so we believe historical flows represent the best available data for estimating future flows.

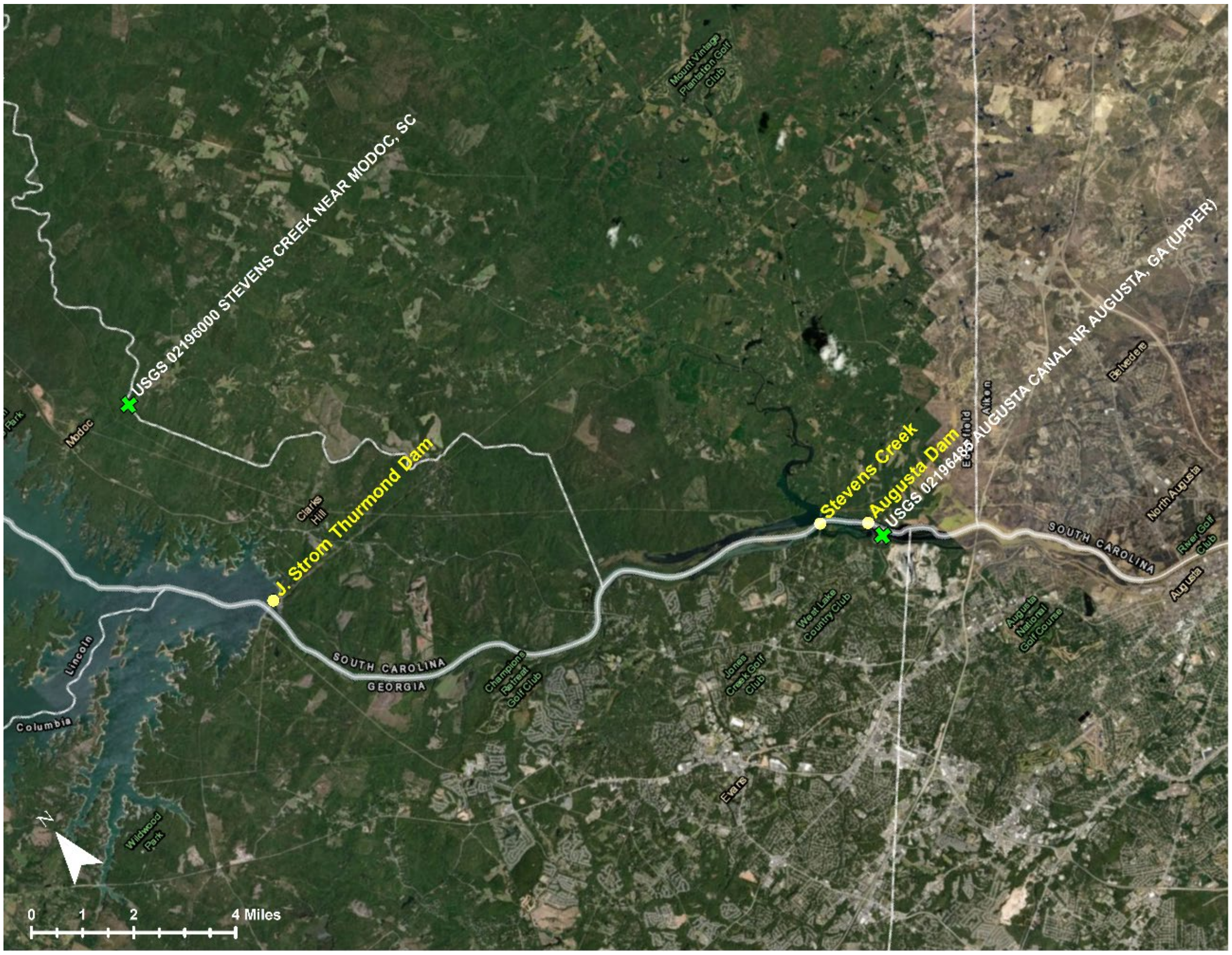

Figure 12. Map of Savannah River at Augusta Diversion Dam, showing USGS gage 02196000 in Stevens Creek near Modoc, SC and USGS gage 02196485 Augusta Canal near Augusta, GA.

Using the flow data from 1996–2019, we first estimated "*Undiverted Flow". Undiverted Flow* is the average amount of water that arrived at the ADD at a given time period. These flows could be diverted into the Augusta Canal, allowed to flow over the Augusta Shoals, or both. Because the ADD has no real storage capacity, when no flow is diverted into the Augusta Canal, all flows must go to the Augusta Shoals. Thus, under these conditions, all *Undiverted Flow* arriving at the ADD would flow to the Shoals. Our *Undiverted Flow* metric can also represent the flow conditions at the Shoals if continued diversions of water by the Augusta Canal project are not re-authorized.

We also estimated the "*Observed Flow*" at the Shoals. *Observed Flow* represents the actual conditions seen at Augusta Shoals from 1996–2019, after at least some of the *Undiverted Flows* arriving at the ADD were diverted into the Augusta Canal. We estimated *Observed Flow* by subtracting the flows diverted into the Augusta Canal from *Undiverted Flow*, as reported by USGS gauge 02196485 Augusta Canal near Augusta, Georgia.

To estimate the expected flows at the Augusta Shoals, if the daily minimum aquatic base flow ("MAB Flow") requirements had been in place, we used the same historical dataset to approximate "*MAB Flow*". We estimated *MAB Flow* through a simulated application of the daily minimum aquatic base flow requirements to *Undiverted Flow* arriving at ADD during that period. The *MAB Flow* was the water remaining to pass over Augusta Shoals after the ADD diverted water into the Augusta Canal. Our estimated *MAB Flow* was based upon compliance with the required daily minimum aquatic base flow in the 2008 draft settlement agreement (Table 12). Because the aquatic base flows in Table 12 are minimum flow requirements, it is possible that additional flow beyond those negotiated would reach Augusta Shoals under certain flow conditions.

We acknowledge that our estimates consider past water usage, which may differ from future water needs. However, when the representatives for the city of Augusta were asked what the current municipal water needs were during the September 2023 teleconference, no answer was provided. Instead, they referred to the projected water uses described in the 2006 EA (FERC 2006). FERC (2006) projected the minimum municipal water needs from the Canal would be 3,884 cfs by 2020. Our analysis of water inflows into the Canal indicates those minimum water needs are inaccurate. Our analysis assumed the total amount of water diverted into the Canal would meet or exceed the minimum flows required. For example, if the minimum municipal water needs were 3,884 cfs, we assume that at least 3,884 cfs would have been diverted into the Canal. Our review of the daily flows actually entering the Augusta Canal from 1996–2019 (USGS gage 02196485), indicate daily diversions have been around 2,700 cfs, reaching 3,500 cfs or greater on only 1% of days, with a maximum draw of 4,000 cfs. Thus, we believe the projections listed in the 2006 EA (FERC 2006) are an inaccurate reflection of current water needs and our estimates of likely water needs are based on best available information from flows directly measured in the Canal.

For the purposes of estimating *MAB Flow* and evaluating the potential consequences of continued flow diversion in the Augusta Canal on endangered sturgeon, we used historical flow data to simulate future conditions. In doing so, our analytical approach is based on historical water uses, including diversion of no more than 3,500 cfs into Augusta Canal. Using 3,500 cfs establishes an upper threshold on the expected future use, based on the best available information regarding past flow diversions, for our analysis of potential adverse effects to sturgeon. When *Undiverted Flow* arriving at ADD was sufficient to meet the daily minimum aquatic base flows for Augusta Shoals and the 3,500 cfs diversion into the Augusta Canal, we assumed any remaining flow would be allowed to flow over Augusta Shoals.

Estimating Weighted Usable Area (WUAs)

Once we estimated the expected historical flows arriving at, and flowing over the Shoals, we took those estimates further to understand how flow conditions affected the availability of the best spawning habitat conditions for sturgeon. Using our estimates of expected flow, we estimated the expected weighted usable area (WUA; expressed as ft^2/1,000 linear ft. of river) and percent maximum WUA (pWUA) associated with those flows.[17] WUA is not actually an estimate of area. WUA is best thought of as an index. WUA collectively considers a number of individual habitat parameters (e.g., depth, bottom type) that must be present for a given stretch of river to serve an ecologically useful function. WUA allows relative comparisons based on the presence of specific habitat suitability attributes (e.g., water depth, flow velocity, water temperature). Because each attribute is weighted (0.0–1.0), multiplying surface area by a unitless habitat suitability attribute results in a unitless habitat index (WUA) that can no longer be properly referred to as an area (Payne 2003).

Our consideration of WUA and pWUA focuses primarily on the relative comparisons across different flow scenarios. We anticipate areas with higher WUA values suggest more habitat is available to support an ecologically useful function. For example, if a hard bottom substrate that would otherwise be suitable for spawning is not under water, the substrate is functionally worthless and would have a WUA rating of zero. Conversely, if flows increased and that substrate becomes inundated, its WUA value would increase to greater than zero.

The city of Augusta considered WUA in Entrix (2002). The report used the Physical Habitat Simulation (PHABSIM) modeling technique to evaluate the potential impacts of the project operations during licensing in their application to FERC, including changes in WUA. The Final EA (FERC 2006) for relicensing states the city of Augusta's PHABSIM model did not specifically address Atlantic or shortnose sturgeon. However, Appendix I in Entrix (2002) is entirely devoted to the WUA and pWUA calculations for both shortnose and Atlantic sturgeon that considered depth, substrate, and flow.[18] Following a discussion with FERC, we determined it was most appropriate to use the species-specific information for this Opinion. Thus, our WUA estimates were interpolated from the PHABSIM model used in Appendix I of Entrix (2002).[19] The PHABSIM model in Entrix (2002) provided WUA and pWUA for a range of shoal flows, from 200 cfs to 8,000 cfs, at 200 cfs increments until reaching 6,000 cfs when increments moved to 500 cfs (bolded font in Table 13). While this information was useful, it was insufficient to fully consider the range of flows arriving at the ADD and Augusta Shoals from 1996–2019. We used stepwise imputation to take the existing WUA curves from Entrix (2002) to estimate expected WUAs and pWUAs for additional flows (non-bolded font in Table 13; Figure 13).[20]

Evaluating Flow, WUA, and pWUA under Different Scenarios

Once we estimated WUAs and pWUAs for a broader range of flows, we could evaluate the likely impacts of the proposed action on flows, WUAs, and pWUAs. We began by estimating the

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[17] WUA is defined as "the sum of stream surface area within a subreach, weighted by multiplying area by habitat suitability variables (most often velocity, depth, and substrate or cover) which range from 0.0 to 1.0 each, normalized to square units (either ft or m) per 1,000 linear units." Bovee, K. D., and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Information Paper 3. United States Fish and Wildlife Service FWS/OBS-77/63.

[18] Neither FERC nor NMFS could determine why the Final EA did not reference the sturgeon-specific analysis in Entrix (2002) Appendix I. FERC suggested the sturgeon-specific information should be the basis for our analysis in the Opinion (A. Creamer, FERC, pers. comm., to A. Herndon, NMFS; 7/31/2019)

[19] The PHABSIM model in Entrix (2002) provided WUA curves for a range of shoal flows, from 200 cfs to 8,000 cfs. The WUAs estimated were based on the stream habitat models that use flow velocity, water depth, substrate type and availability, and habitat preference curves for each species. NMFS provided the specific sturgeon parameters.

[20] We used stepwise imputation to estimate the expected WUAs and pWUAs for additional flows.

Undiverted Flow for each timeframe. Then, using the information in Table 13, we estimated the expected WUA and pWUA for that flow. We followed the same steps for the *Observed Flow.* We also estimated the expected WUA and pWUA under the daily minimum aquatic base flow (*MAB Flow*). We estimated this by determining the tier that would have been triggered based on the incoming flows to the ADD (*Undiverted Flow*).

For example, if *Undiverted Flow* arriving at ADD in March was 5,000 cfs, and all of that water had gone to the Shoals, Table 13 reports the maximum anticipated WUA and pWUA values for shortnose sturgeon were 71,462 and 79, respectively at that flow level. To estimate the *MAB Flow* under that scenario, we used Table 12 to determine flow reserved for the Shoals under that scenario. An incoming flow of 5,000 cfs in March is considered Tier 2 (Table 12). Flow partitioning for Tier 2 in March is 2,300 cfs for the Shoals, with the remainder (2,700 cfs) going to Augusta Canal. With 2,300 cfs set aside for the Shoals, we estimate the maximum WUA and pWUA values for shortnose sturgeon of 41,302 and 45.5, respectively, based on the values presented in Table 13.

Table 13. Reported (Bold) and Interpolated Weighted Usable Areas (WUA) and Percent Weighted Usable Areas (pWUA) for Atlantic Sturgeon and Shortnose Sturgeon

Flow (cfs)	**Atlantic sturgeon (eggs/spawning adults)**		**Shortnose sturgeon (eggs/spawning adults)**		**Flow (cfs)**	**Atlantic sturgeon (eggs/spawning adults)**		**Shortnose sturgeon (eggs/spawning adults)**	
	WUA	**pWUA**	**WUA**	**pWUA**		**WUA**	**pWUA**	**WUA**	**pWUA**
0	0	0	0	0	**4000**	**26213**	**74**	**64524**	**71**
100	0	0	0	0	4100	26572.5	75	65424.5	72
200	0	0	0	0	**4200**	**26932**	**76**	**66325**	**73**
300	264	0.5	142	0	4300	27234.5	76.5	66873	73.5
400	**528**	**1**	**284**	**0**	**4400**	**27537**	**77**	**67421**	**74**
500	1207	3	1095	1	4500	27767.5	78	68220.5	75
600	**1886**	**5**	**1906**	**2**	**4600**	**27998**	**79**	**69020**	**76**
700	2082.5	5.5	2674.5	3	4700	28110.5	79	69538	76.5
800	**2279**	**6**	**3443**	**4**	**4800**	**28223**	**79**	**70056**	**77**
900	2880.5	8	5708.5	6.5	4900	28333	79.5	70759	78
1000	**3482**	**10**	**7974**	**9**	**5000**	**28443**	**80**	**71462**	**79**
1100	4321	12	11231.5	12.5	5100	28555.5	80	72118	79.5
1200	**5160**	**14**	**14489**	**16**	**5200**	**28668**	**80**	**72774**	**80**
1300	6634.5	18.5	18280.5	20	5300	28728	80.5	73454	81
1400	**8109**	**23**	**22072**	**24**	**5400**	**28788**	**81**	**74134**	**82**
1500	8895	25	23983.5	26.5	5500	28898	81	74705	82.5
1600	**9681**	**27**	**25895**	**29**	**5600**	**29008**	**81**	**75276**	**83**
1700	12258	34.5	29519	33	5700	29286	81.75	76026.8	83.75
1800	**14835**	**42**	**33143**	**37**	5800	29564	82.5	76777.5	84.5
1900	15655.5	44	34949	38.5	5900	29842	83.25	77528.3	85.25
2000	**16476**	**46**	**36755**	**40**	**6000**	**30120**	**84**	**78279**	**86**
2100	16845	47	38198	42	6100	30557.8	85.4	79237.8	87.2
2200	**17214**	**48**	**39641**	**44**	6200	30995.6	86.8	80196.6	88.4
2300	17804	50	41302	45.5	6300	31433.4	88.2	81155.4	89.6
2400	**18394**	**52**	**42963**	**47**	6400	31871.2	89.6	82114.2	90.8
2500	19504.5	55	45665	50	**6500**	32309	**91**	83073	**92**
2600	**20615**	**58**	**48367**	**53**	6600	32512.2	91.4	83668.6	92.6
2700	20779.5	58.5	49470	54.5	6700	32715.4	91.8	84264.2	93.2
2800	**20944**	**59**	**50573**	**56**	6800	32918.6	92.2	84859.8	93.8
2900	21222.5	59.5	51947	57.5	6900	33121.8	92.6	85455.4	94.4
3000	**21501**	**60**	**53321**	**59**	**7000**	**33325**	**93**	**86051**	**95**
3100	21781	61	54874.5	60.5	7100	33561	93.8	86507.8	95.4
3200	**22061**	**62**	**56428**	**62**	7200	33797	94.6	86964.6	95.8
3300	22410.5	63	57459.5	63	7300	34033	95.4	87421.4	96.2
3400	**22760**	**64**	**58491**	**64**	7400	34269	96.2	87878.2	96.6
3500	23238.5	65.5	59384.5	65	**7500**	**34505**	**97**	**88335**	**97**
3600	**23717**	**67**	**60278**	**66**	7600	34733	97.6	88824.4	97.6
3700	24453	69	61360	67.5	7700	34961	98.2	89313.8	98.2
3800	**25189**	**71**	**62442**	**69**	7800	35189	98.8	89803.2	98.8
3900	25701	72.5	63483	70	7900	35417	99.4	90292.6	99.4
					≥8000	**35645**	**100**	**90782**	**100**

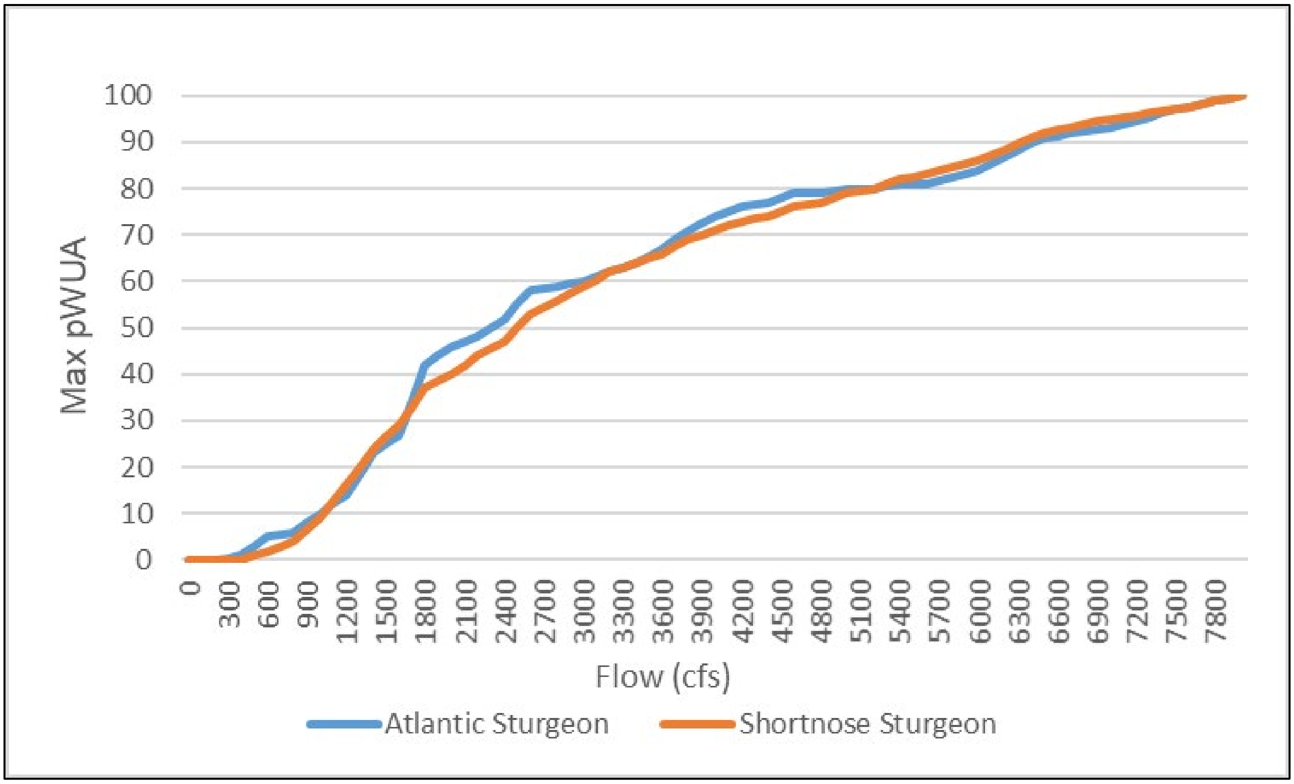

Figure 13. Interpolated Percent Maximum WUA (pWUA) by flow (cfs) for Atlantic (blue) and shortnose (orange) sturgeon based on the information reported in the PHABSIM model used in Entrix (2002).

Influence of Tiers and Timing on Benefits to Sturgeon from Flow Partitioning
As described above, this analysis assumes the Augusta Canal will take up to 3,500 cfs during periods of higher flow, even though historically it takes around 2,700 cfs, with the remaining water being allowed to flow over the shoals. Our review of the observed flow data from 1996–2019 determined that on 99.98% of days, flows diverted into Augusta Canal were less than 3,500 cfs, and only once during that period did flow into the Augusta Canal reach 4,000 cfs (0.02% of days). We also assume that because of minimum flow requirements established under the *MAB Flow*, the Augusta Canal will take less water during periods of lower flow than it would have historically. These assumptions are apparent in Figure 14. The top two panels (Tier 1 and Tier 2) illustrate that if the Augusta Canal takes up to 3,500 cfs, the amount of water remaining for the Shoals (*MAB Flow*; grey line) would be less than what it had received historically (*Observed Flow*; orange line). The bottom two panels (Tier 3 and Tier 4) illustrate how the Shoals would receive more water with *MAB Flow* (*MAB Flow*; grey line) in place than they received historically (*Observed Flow*; orange line) (Figure 14).

The benefits for sturgeon from the *MAB Flow* depends largely on the incoming flow (Figure 14, Table 14, Table 15). The higher the incoming flows, the less beneficial the base flow requirements are for the Shoals. At Tier 1 (≥5,400 cfs) and Tier 2 (4,500–5,399 cfs) the base flow requirements for the Shoals are easily met and generally do not require reallocation of flow away from the Augusta Canal to the Shoals. The Augusta Canal Project Final EA (FERC 2006) concluded as much, stating that because the *MAB Flow* represent minimum flow requirements they would often be exceeded by substantial amounts. We estimated the mean WUA and pWUA values were lower for *MAB Flow* than under *Observed Flow* for both Tier 1 and Tier 2 flows and regardless of spawning season (Table 14 and Table 15).

The benefits of the *MAB Flow* become apparent during lower flow scenarios. The *MAB Flow* establishes minimum flow "backstops" that are triggered during low flow conditions. For Tier 3 (3,600–4,499), the *MAB Flow* (Figure 14, grey line, bottom left panel) to the Shoals are higher than historically *Observed Flow* (Figure 14, orange line, bottom left panel) and would provide more water than had been available historically. Table 14 reports a mean increase in WUA of 2,274.9 ft^2/1,000 ft and pWUA +6.5% with Tier 3 flows occurring during Atlantic sturgeon spawning season and a mean increase in WUA of 12,726.8 ft^2/1,000 ft and pWUA +13.6% under that flow regime during shortnose sturgeon spawning season (Table 15)

Increases in flows to the Shoals under *MAB Flow* (Figure 14, grey line bottom right panel) are even more pronounced under Tier 4 (<3,600 cfs) flows, relative to the historically *Observed Flow* (Figure 14, orange line, bottom right panel). The *MAB Flow* reserved for the Shoals during Tier 4 flows would result in a mean increase in WUA during Atlantic sturgeon spawning season of 7,402.5 ft^2/1,000 ft and pWUA +21.0% (Table 14). *MAB Flow* reserved for the Shoals under Tier 4 flow during shortnose sturgeon spawning season would result in a mean increase in WUA of 19,076.0 ft^2/1,000 ft and pWUA +21.1% (Table 15).

Across Tiers 1–4 collectively, the *MAB Flow* are anticipated to increase the mean WUA during Atlantic sturgeon spawning season by 142.3.7 ft^2/1,000 ft and mean pWUA by +0.4%, relative to the conditions observed historically (Table 14; Figure 14, top panel). During shortnose spawning season, the *MAB Flow* is anticipated to increase the mean WUA by 4,569.7 ft^2/1,000 ft and mean pWUA by +4.9%, relative to the conditions observed historically (Table 15, Figure 14, top panel).

Of note across all tier levels, both individually and collectively, is how much additional water would have been available if all *Undiverted Flows* (green line; Figure 14) had gone to the Shoals. During Atlantic sturgeon spawning season, all WUA and pWUA values anticipated during *MAB Flow* were less than those expected under *Undiverted Flows*. WUA values expected under *MAB Flow* ranged from -7,098.0 to -16,624.0 ft^2/1,000 ft less than those expected under *Undiverted Flows.* The pWUA values under *MAB Flow* are expected to be -19.8% to -46.6% less than the values expected under *Undiverted Flows* (Table 14; Figure 14, bottom panel). A similar pattern is noted during shortnose sturgeon spawning season. WUA values expected under *MAB Flow* ranged from -10,801.8 to -32,846.1 ft^2/1,000 ft less than those expected under *Undiverted Flows.* The pWUA values under *MAB Flow* are expected to be -12.0% to -36.0% less than the values expected under *Undiverted Flows* (Table 15; Figure 14, bottom panel).

Across all tiers collectively, the estimated mean flows to the Augusta Shoals under the *MAB Flow* are estimated to be 155 and 124 cfs lower during spawning months for Atlantic and shortnose sturgeon, respectively relative to historically *Observed Flow* (Table 16). Relative to *Undiverted Flow*, *MAB Flow* is estimated to be 2,851 and 2,719 cfs lower during spawning months for Atlantic and shortnose sturgeon, respectively (Table 16). These decreases in flow due to reauthorizing diversions at ADD correspond to decreases in WUA of across all tiers collectively of approximately 13,254 ft^2/1,000 ft WUA (37.3% pWUA) and 23,246 ft^2/1,000 ft WUA (25.7% pWUA) during spawning months for Atlantic and shortnose sturgeon, respectively (Table 14, Table 15, Table 16; Figure 14 bottom panel).

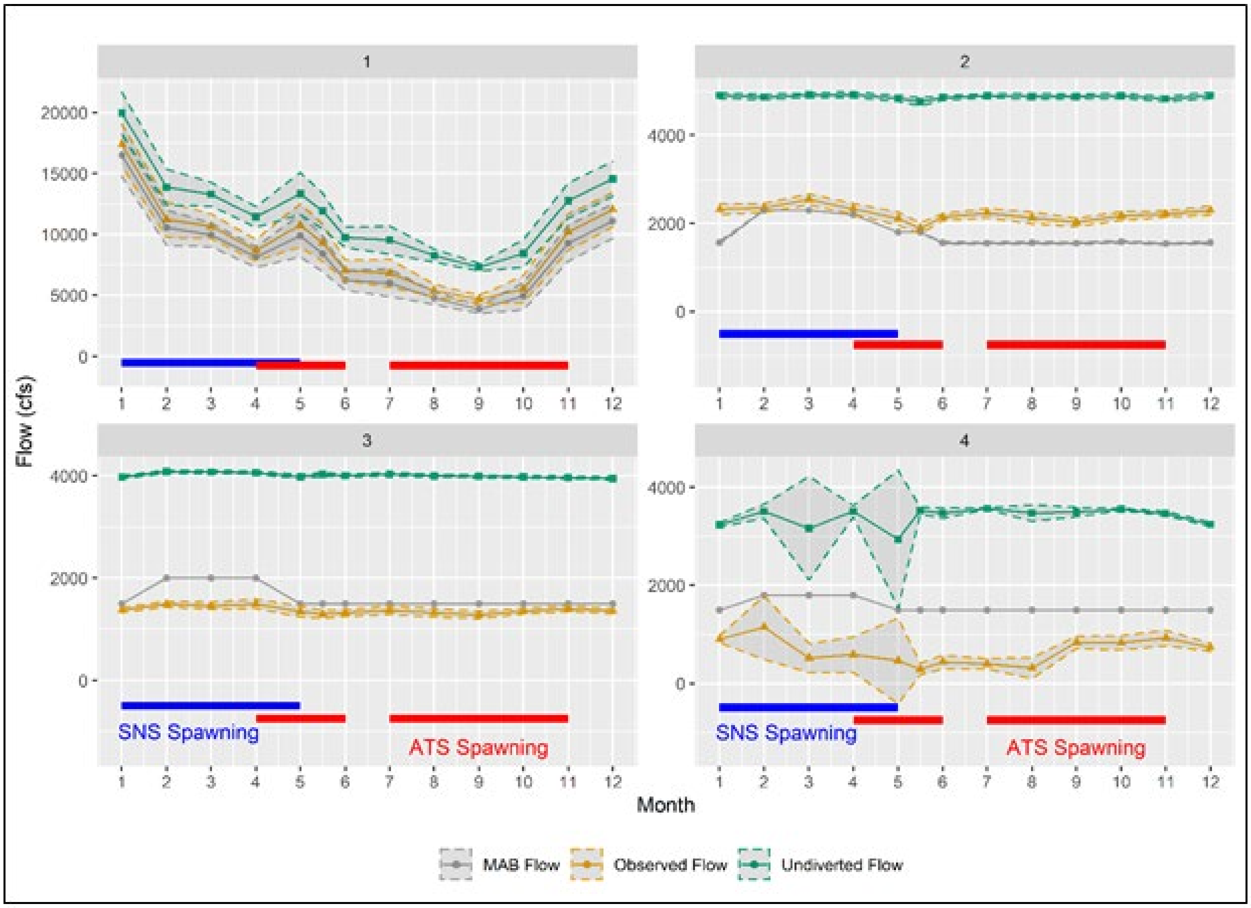

Figure 14. Mean monthly flows with 95% confidence bands by incoming flow Tier, based on USGS stream gauge data collected 1996-2019. Each panel depicts the flows arriving at Augusta Diversion Dam (green) (*Undiverted Flow*), flows allowed to pass to Augusta Shoals historically (orange) (*Observed Flow*), and flows that would have passed to Augusta Shoals under the daily minimum aquatic base flows (grey) (*MAB Flow*). The top panels depict Tier 1 and Tier 2 flow scenarios, respectively, the bottom panels depict Tier 3 and Tier 4 flow scenarios, respectively. Blue and red bars denote spawning season for shortnose sturgeon (SNS; January 1-April 30) and Atlantic sturgeon (ATS; April 1-May 31 and July 1-October 31), respectively.

Table 14. Comparison of Mean Monthly Weighted Usable Area (WUA) And Percent Maximum WUA (pWUA) During Atlantic Sturgeon Spawning Months (April 1-May 31 And July 1-October 31) for Historically Observed Flow to the Shoals (*Observed Flow*), the Projected Flow to Shoals Under the Minimum Aquatic Base Flows (*MAB Flow*), and the Projected Flow to Shoal if No Flows Were Diverted Into the Augusta Canal (*Undiverted Flow*).

Comparison	Flow Tier	Observed Flow (95% CI)	MAB Flow (95% CI)	Mean Difference MAB vs. Observed
Observed Flow vs. *MAB Flow* (WUA) (ft^2/1,000 ft)	1	27,892.7 (27,519.2 to 28,266.3)	26,013.4 (25,577.2 to 26,449.6)	-1,879.3 (-1,941.9 to -1,816.6)
	2	15,777.9 (15,381.7 to 16,174.2)	11,622.2 (11,324.7 to 11,919.6)	-4,155.8 (-4,254.6 to -4,056.9)
	3	7,604.5 (7,311.3 to 7,897.7)	9,879.4 (9,752.3 to 10,006.4)	2,274.9 (2,108.8 to 2441)
	4	1,818.9 (1,415.7 to 2,222)	9,221.4 (8,937.9 to 9,504.8)	7,402.5 (7282.9 to 7522.2)
	All Tiers	14,928.6 (14,548.4 to 15,308.9)	15,070.9 (14,769.1 to 15,372.8)	142.3 (63.9 to 220.7)
Comparison	**Flow Tier**	**Observed Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Observed**
Observed Flow vs. *MAB Flow* (pWUA)	1	78.3 (77.3 to 79.4)	73 (71.8 to 74.3)	-5.3 (-5.7 to -4.9)
	2	44.3 (43.2 to 45.4)	32.7 (31.8 to 33.5)	-11.7 (-12.9 to -10.4)
	3	21.3 (20.4 to 22.1)	27.7 (27.4 to 28.1)	6.5 (5.6 to 7.3)
	4	5 (3.8 to 6.1)	25.9 (25.1 to 26.7)	21.0 (19.5 to 22.4)
	All Tiers	41.9 (40.8 to 42.9)	42.3 (41.5 to 43.2)	0.4 (0.2 to 0.7)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Undiverted**
Undiverted Flow vs. *MAB Flow* (WUA) (ft^2/1,000 ft)	1	33,111.4 (32,945.6 to 33,277.3)	26,013.4 (25,577.2 to 26,449.6)	-7,098.0 (-6,827.6 to -7,368.3)
	2	28,246.1 (28,219.6 to 28,272.7)	11,622.2 (11,324.7 to 11,919.6)	-16,624.0 (-16,353.1 to -16,894.8)
	3	25,776.6 (25,721 to 25,832.2)	9,879.4 (9,752.3 to 10,006.4)	-15,897.2 (-15,825.7 to -15,968.7)
	4	22,914.3 (22,591.6 to 23,237)	9,221.4 (8,937.9 to 9,504.8)	-13,693.0 (-13,732.2 to -13,653.7)
	All Tiers	28,325.0 (28,192.6 to 28,457.4)	15,070.9 (14,769.1 to 15,372.8)	-13,254.0 (-13,084.6 to -13,423.5)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Undiverted**
Undiverted Flow vs. *MAB Flow* (pWUA)	1	92.8 (92.3 to 93.3)	73 (71.8 to 74.3)	-19.8 (-19.0 to -20.6)
	2	79.3 (79.2 to 79.4)	32.7 (31.8 to 33.5)	-46.6 (-45.8 to -47. 5)
	3	72.7 (72.5 to 72.8)	27.7 (27.4 to 28.1)	-45.0 (-44.6 to -45.3)
	4	64.5 (63.6 to 65.5)	25.9 (25.1 to 26.7)	-38.6 (-37.4 to -39.9)
	All Tiers	79.6 (79.3 to 80)	42.3 (41.5 to 43.2)	-37.3 (-36.8 to -37.8)

Table 15. Comparison of Mean Monthly Weighted Usable Area (WUA) and Percent Maximum WUA (pWUA) During Shortnose Sturgeon Spawning Months (January 1-April 30) for Historically Observed Flow to the Shoals (*Observed Flow*), the Projected Flow to Shoals Under the Minimum Aquatic Base Flows (*MAB Flow*), and the Projected Flow to Shoal if no Flows Were Diverted Into the Augusta Canal (*Undiverted Flow*).

Comparison	Flow Tier	Observed Flow (95% CI)	MAB Flow (95% CI)	Mean Difference MAB vs. Observed
Observed Flow vs. *MAB Flow* (WUA) (ft^2/1,000 ft)	1	78,984.7 (77,984.4 to 79,984.9)	76,789.2 (75,706.7 to 77,871.6)	-2,195.5 (-2,113.3 to -2,277.7)
	2	42,172.2 (41,102.2 to 43,242.2)	37,711.6 (36,977.9 to 38,445.3)	-4,460.6 (-4,796.8 to -4,124.3)
	3	20,429.1 (19,594 to 21,264.2)	33,155.9 (32,766.8 to 33,545)	12,726.8 (12,280.9 to 13,172.8)
	4	6,182.9 (4,642.1 to 7,723.8)	25,258.9 (24,544.1 to 25,973.7)	19,076.0 (18,249.9 to 19,902)
	All Tiers	46,299.8 (44,963.2 to 47,636.3)	50,869.5 (49,827.6 to 51,911.4)	4,569.7 (0 to 4,864.4)
Comparison	**Flow Tier**	**Observed Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Observed**
Observed Flow vs. *MAB Flow* (pWUA)	1	87 (85.9 to 88.1)	84.5 (83.3 to 85.7)	-2.5 (-2.1 to -2.8)
	2	46.4 (45.3 to 47.6)	41.7 (40.9 to 42.5)	-4.8 (-3. 5 to -6.1)
	3	22.6 (21.7 to 23.5)	36.2 (35.8 to 36.6)	13.6 (12.6 to 14.6)
	4	6.9 (5.2 to 8.6)	28 (27.1 to 28.8)	21.1 (19.2 to 23.0)
	All Tiers	51 (49.6 to 52.5)	55.9 (54.7 to 57.0)	4.9 (4.5 to 5.2)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Undiverted**
Undiverted Flow vs. *MAB Flow* (WUA) (ft^2/1,000 ft)	1	87,591 (87,222.8 to 87,959.2)	76,789.2 (75,706.7 to 77,871.6)	-10,801.8 (-10,087.6 to -11,516.1)
	2	70,557.7 (70,367.3 to 70,748.1)	37,711.6 (36,977.9 to 38,445.3)	-32,846.1 (-32,302.8 to -33,389.4)
	3	64,206.1 (64,065.7 to 64,346.6)	33,155.9 (32,766.8 to 33,545)	-31,050.2 (-30,801.5 to -31,298.9)
	4	56,285.2 (55,815.4 to 56,755)	25,258.9 (24,544.1 to 25,973.7)	-31,026.3 (-30,781.3 to -31,271.3)
	All Tiers	74,115.4 (73,594.9 to 74,635.9)	50,869.5 (49,827.6 to 51,911.4)	-23,246.0 (-22,724.6 to -23,767.3)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**MAB Flow (95% CI)**	**Mean Difference MAB vs. Undiverted**
Undiverted Flow vs. *MAB Flow* (pWUA)	1	96.5 (96.1 to 96.9)	84.5 (83.3 to 85.7)	-12.0 (-11.1 to -12.9)
	2	77.7 (77.5 to 77.9)	41.7 (40.9 to 42.5)	-36.0 (-35.2 to -36.9)
	3	70.7 (70.5 to 70.8)	36.2 (35.8 to 36.6)	-34.5 (-34.1 to -34. 9)
	4	61.9 (61.4 to 62.4)	28 (27.1 to 28.8)	-33.9 (-33.2 to -34.7)
	All Tiers	81.6 (81 to 82.2)	55.9 (54.7 to 57.0)	-25.7 (-25.2 to -26.3)

Table 16. Results of Paired T-Test Comparisons Between Flows, Weighted Usable Area (WUA), and Percent Maximum WUA (pWUA) Between Historical Water Use by Augusta Diversion Dam (ADD) and Projected Use Under the Minimum Aquatic Base Flows, and Between Projected Use Under the Minimum Aquatic Base Flows Relative to No Water Being Diverted by ADD. Comparisons Were Restricted to Spawning Months for Atlantic Sturgeon (Assumed April 1-May 31 And July 1-October 31) and Shortnose Sturgeon (Assumed January 1-April 30). Statistically Significant Differences are Shown in Bold.

Species (spawning months)	Comparison	Variable	Mean Difference (95% CI)	t	df	p
Atlantic Sturgeon (Apr-May & July-Oct)	*Observed Flow* vs. *MAB Flow*	Flow (cfs)	**-155 (-181 to -130)**	**-12.01**	**3055**	**<0.00001**
		WUA (ft^2/1,000 ft)	+142 (-61.86 to +346.49)	1.37	3055	0.17
		pWUA	+0.43% (-0.14 to +1.01%)	1.482	3055	0.14
	Undiverted Flow vs. *MAB Flow*	Flow (cfs)	**-2,851 (-2,870 to -2831)**	**-286.94**	**3055**	**<0.00001**
		WUA (ft^2/1,000 ft)	**-13,254 (-13,444 to -13,063)**	**-136.39**	**3055**	**<0.00001**
		pWUA	**-37.32% (-37.86 to -36.79%)**	**-136.08**	**3055**	**<0.00001**
Shortnose Sturgeon (Jan-Apr)	*Observed Flow* vs. *MAB Flow*	Flow (cfs)	**-124 (-156 to -92)**	**-7.55**	**2006**	**<0.00001**
		WUA (ft^2/1,000 ft)	**+4,570 (+4,008 to +5,131)**	**15.95**	**2006**	**<0.0001**
		pWUA	**+4.86% (4.25 to 5.47%)**	**15.58**	**2006**	**<0.00001**
	Undiverted Flow vs. *MAB Flow*	Flow (cfs)	**-2,719 (-2,747 to -2,690)**	**-186.95**	**2006**	**<0.00001**
		WUA (ft^2/1,000 ft)	**-23,246 (-23,827 to -22,665)**	**-78.52**	**2006**	**<0.00001**
		pWUA	**-25.7% (-26.4 to -25.1%)**	**-78.85**	**2006**	**<0.00001**

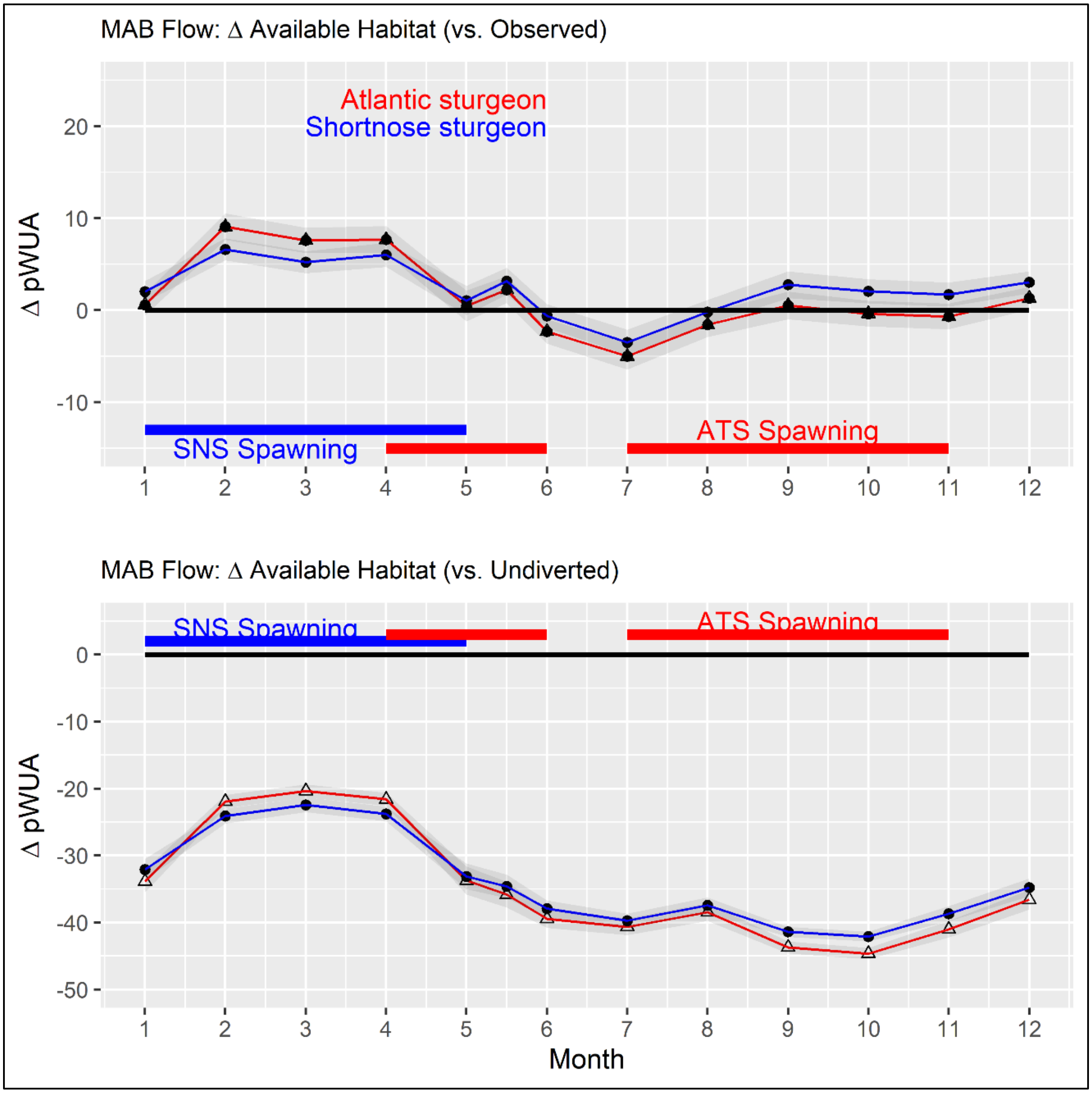

Figure 15. Mean and 95% confidence bands for changes in available spawning habitat (pWUA: percent weighted usable area) in Augusta Shoals under *MAB Flow* relative to historical use (top) and decreases in pWUA relative to undiverted flows (bottom) for Atlantic sturgeon (red lines, triangles) and shortnose sturgeon (blue lines, circles). Blue and red bars denote spawning seasons for shortnose sturgeon (SNS; January 1-April 30) and Atlantic sturgeon (ATS; April 1-May 31 and July 1-October 31) in the Savannah River, respectively.

Estimating Relative Changes in pWUA Under Different Scenarios

Entrix (2002) estimates 100% maximum percent WUA occurs around 7,800 cfs arriving at the Shoals. Flows in the Shoals are rarely 7,800 cfs or greater, meaning the maximum pWUA available is usually less than 100%. For example, during Atlantic sturgeon spawning months, we anticipate the greatest pWUA achieved on average is 92.8% (Table 14) and that occurs under a Tier 1 flow scenario with no diversions into Augusta Canal. Under the same scenario, we anticipate the mean pWUA available to Shoals will drop to 73% with *MAB Flow* in place (Table 14). That represents an *absolute* change of -19.8%. However, because the anticipated maximum pWUA is less than 100%, the *relative* change between the maximum pWUA available if no flow is diverted into the Augusta Canal (pWUA 92.8%) and what is expected maximum pWUA under *MAB Flow* (73%) is actually greater at -21.3% (Table 17).

The impact of considering a relative change is particularly noteworthy when considering Tier 4 flows (Table 17). For example, the absolute difference between the maximum pWUA anticipated under *MAB Flow* versus *Observed Flow* during Atlantic sturgeon spawning season is +21.0%. This is because the "backstop" established by the *MAB Flow* would ensure more water is reserved for the Shoals during future low flow conditions relative to flows arriving at the Shoals during past low flow conditions. The magnitude of this benefit is apparent when comparing the relative change between the maximum pWUA anticipated with the implementation of *MAB Flow* and maximum pWUA anticipated under *Observed Flow.* We anticipate *MAB Flow* will create a +339% relative increase in pWUA (Table 17). Similarly, the anticipated relative decreases in pWUA under *MAB Flow* versus *Undiverted Flows* are more (-59.8%) than the estimated absolute decreases (-38.6%) (Table 17).

Table 17. Mean Relative Difference in pWUA between *Undiverted Flow* and *MAB Flow* and *Observed Flow* and *MAB Flow*

Species (spawning months)	Flow Tier	Mean Absolute Difference in pWUA MAB vs. Undiverted	Mean Relative Difference in pWUA MAB vs. Undiverted	Mean Absolute Difference in pWUA MAB vs. Observed	Mean Relative Difference in pWUA MAB vs. Observed
Atlantic Sturgeon (Apr-May & July-Oct)	1	-19.8 (-19.0 to -20.6)	-21.3 (-20.4 to -22.2)	-5.3 (-5.7 to -4.9)	-6.5 (-7.1 to -6.9)
	2	-46.6 (-45.8 to -47. 5)	-58.8 (-57.8 to -59.8)	-11.7 (-12.9 to -10.4)	-26.3 (-26.3 to -3.2)
	3	-45.0 (-44.6 to -45.3)	-61.9 (-61.4 to -62.3)	6.5 (5.6 to 7.3)	27.1 (34.0 to 92.4)
	4	-38.6 (-37.4 to -39.9)	-59.8 (-59.2 to -60.5)	21.0 (19.5 to 22.4)	339.0 (559.7 to 714.9)
	All Tiers	-37.3 (-36.8 to -37.8)	-46.9 (-46.1 to -47.7)	0.4 (0.2 to 0.7)	21.8 (23.4 to 20.3)
Shortnose Sturgeon (Jan-Apr)	1	-12.0 (-11.1 to -12.9)	-12.4 (-14.3 to -16.7)	-2.5 (-2.1 to -2.8)	-2.8 (-2.7 to -3.0)
	2	-36.0 (-35.2 to -36.9)	-46.4 (-57.5 to -59.1)	-4.8 (-3. 5 to -6.1)	-10.3 (-10.8 to -9.8)
	3	-34.5 (-34.1 to -34. 9)	-48.8 (-63.4 to -64.2)	13.6 (12.6 to 14.6)	60.2 (55.7 to 65.2)
	4	-33.9 (-33.2 to -34.7)	-54.8 (-71. 2 to -72.9)	21.1 (19.2 to 23.0)	306.8 (235.8 to 424.4)
	All Tiers	-25.7 (-25.2 to -26.3)	-31.5 (-30.6 to -32.5)	4.9 (4.5 to 5.2)	8.4 (7.7 to 9.1)

Estimated Depth at Shoal Habitat
Although water depth is considered in WUA computations, we evaluated it individually as well, due to concerns that areas with eggs might become dewatered or adults might become stranded with rapid fluctuations in water depth. Under direction from resource agencies, Entrix (2002) evaluated hydraulic conditions within critical fish passage areas of the Augusta Shoals (Figure 16) (natural channel areas with shallow depths, bedrock ledges, and rapids) during differing flow conditions. The purpose was to determine the flow/depth threshold(s) at which passage of fish may become impaired, inhibiting their movement within and through the Augusta Shoals. The goal of evaluation was to determine the approximate range of low flows that will support upstream movement of migratory anadromous fishes through the Augusta Shoals (Entrix 2002).

The resource agencies specifically selected shallow areas and bedrock ledges they believed posed the greatest potential threat to fish passage for evaluation (Figure 16). Thus, these transects represent the shallowest areas of the shoals and do not purport to represent depths elsewhere in the shoals. Entrix (2002) outlined the water depth and channel width criteria that describe the passable conditions for anadromous fish and then used hydraulic data and stream channel structure measurements to model depth and width conditions within critical fish passage areas. They also reported the actual depths observed at different flows.

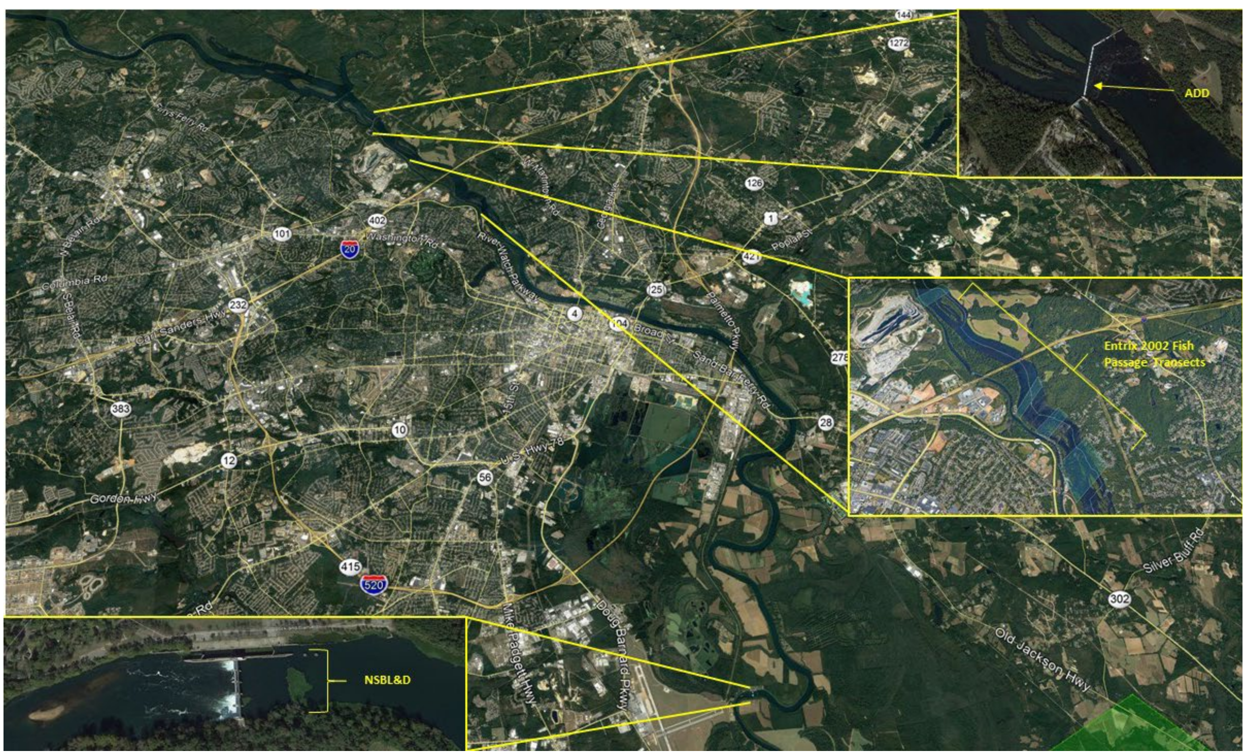

Figure 16. Locations of Entrix (2002) Fish Passage Transects, Augusta Diversion Dam, and New Savannah Bluff Lock and Dam

Stream channel and hydraulic measurements along the 5 fish passage transects were evaluated for flows ranging from 500–3,500 cfs and 7,500 cfs; transects are presented in full detail in Appendix D of Entrix (2002). Overall, the depths and velocities varied significantly depending on flow and the position along the transect (Entrix 2002). The average depth of the river at the fish passage transects generally increased with increasing flow. However, Entrix (2002) points out this generalization may oversimplify the changes in depth because, as water levels increase, areas that were previously dry become inundated but remain very shallow. If newly inundated areas are numerous, the addition of those shallow areas can make the mean depth decrease slightly with increasing flow. This explains why the change in depth is not a continuously increasing function of flow for all transects and flows (Entrix 2002).

Table 18 presents the depth estimates of Entrix (2002) for the five fish passage transects under different simulated flow conditions, as well as the maximum depths reported along each transect for a given flow. Maximum depths are more statistically robust and likely more biologically relevant, because even if water depths are shallow on average due to increasing fringing habitat, or low flow conditions, deeper runs/pools are often still available, as is the case in the Augusta Shoals. We anticipate sturgeon moving upstream will seek these deeper habitats. Figure number 3-7 from Entrix (2002) provides cross-sectional views at a fish passage transect location for flows around 2,500 cfs (Figure 17).[21] The figure shows the channel width along the horizontal access and the relative water depth along vertical access. The cross section clearly illustrates the channel depths vary. Some portions of the channel are very shallow, while others remain submerged with deeper portions available for passage. Thus, while the average depths of these transect locations may be relatively shallow, passable areas remain. Even Entrix (2002) suggests that fish passage routes are likely available, stating:

> "Critical fish passage areas 4 and 5 are considerably different than the other passage areas in that [they] are not located in the middle of extensive shoals. The shallow bedrock ledges at FP-4 and FP-5 are interspersed with deeper habitat types and, at low flow, water passes through a fewer number of area slots in the bedrock that are deeper and sometimes faster chutes. Fish passing these areas must follow a somewhat circuitous route, but in most cases fish probably easily negotiate these passage areas because the chutes are short and bounded on both sides by areas of suitable depth and slower velocities."

[21] Entrix (2002) stated flows of 2,500 cfs is a relatively low flow for the Augusta Shoals, noting on an annual basis, a flow of 2,500 cfs equaled or exceeded more than 75% of the time.

Table 18. Estimated Average and Reported Maximum Depths by Flow and Fish Passage Transect (Adapted from Entrix 2002)

	Average Depth (ft)					Maximum Depth (ft)				
Flow (cfs)	**Transect #1**	**Transect #2**	**Transect #3**	**Transect #4**	**Transect #5**	**Transect #1**	**Transect #2**	**Transect #3**	**Transect #4**	**Transect #5**
300	0.0	1.8	1.9	0.0	1.8	1.8	2.3	2.6	2.2	2.4
500	1.5	2.0	1.9	0.0	1.8	2.0	2.7	2.8	2.4	2.6
700	1.7	2.2	2.0	1.6	1.9	2.2	3.0	2.9	2.6	2.7
900	1.8	2.4	2.0	1.8	1.9	2.3	3.2	2.9	2.7	2.8
1,100	1.7	2.3	2.1	1.8	1.9	2.4	3.4	3.0	2.8	2.9
1,300	1.7	2.3	2.1	1.9	2.0	2.5	3.6	3.0	2.9	2.9
1,500	1.8	2.4	1.9	2.0	2.0	2.6	3.7	3.1	3.0	3.0
1,700	1.8	2.5	1.9	2.0	2.0	2.7	3.9	3.1	3.1	3.0
1,900	1.8	2.5	1.9	2.0	2.0	2.7	4.0	3.1	3.2	3.1
2,100	1.9	2.4	1.9	1.9	2.0	2.8	4.1	3.2	3.3	3.1
2,300	1.9	2.5	1.9	1.9	2.0	2.9	4.2	3.2	3.4	3.2
2,500	1.9	2.5	2.0	1.9	2.1	2.9	4.3	3.2	3.4	3.2
2,700	1.9	2.6	1.9	1.9	2.1	3.0	4.4	3.3	3.5	3.2
2,900	2.0	2.6	1.9	1.9	2.1	3.0	4.5	3.3	3.5	3.3
3,100	1.9	2.6	1.9	2.0	2.0	3.1	4.6	3.3	3.6	3.3
3,300	2.0	2.7	1.9	2.0	2.1	3.1	4.7	3.4	3.7	3.3
3,500	2.0	2.7	1.9	2.0	2.1	3.2	4.8	3.4	3.7	3.4
…	…	…	…	…	…	…	…	…	…	…
7,500	2.3	3.4	2.0	2.3	2.1	4.1	6.3	3.7	4.7	3.8

Figure 3-7. Example Cross-Section at Fish Passage FP-4 Showing River Bottom Profile and Water Depths

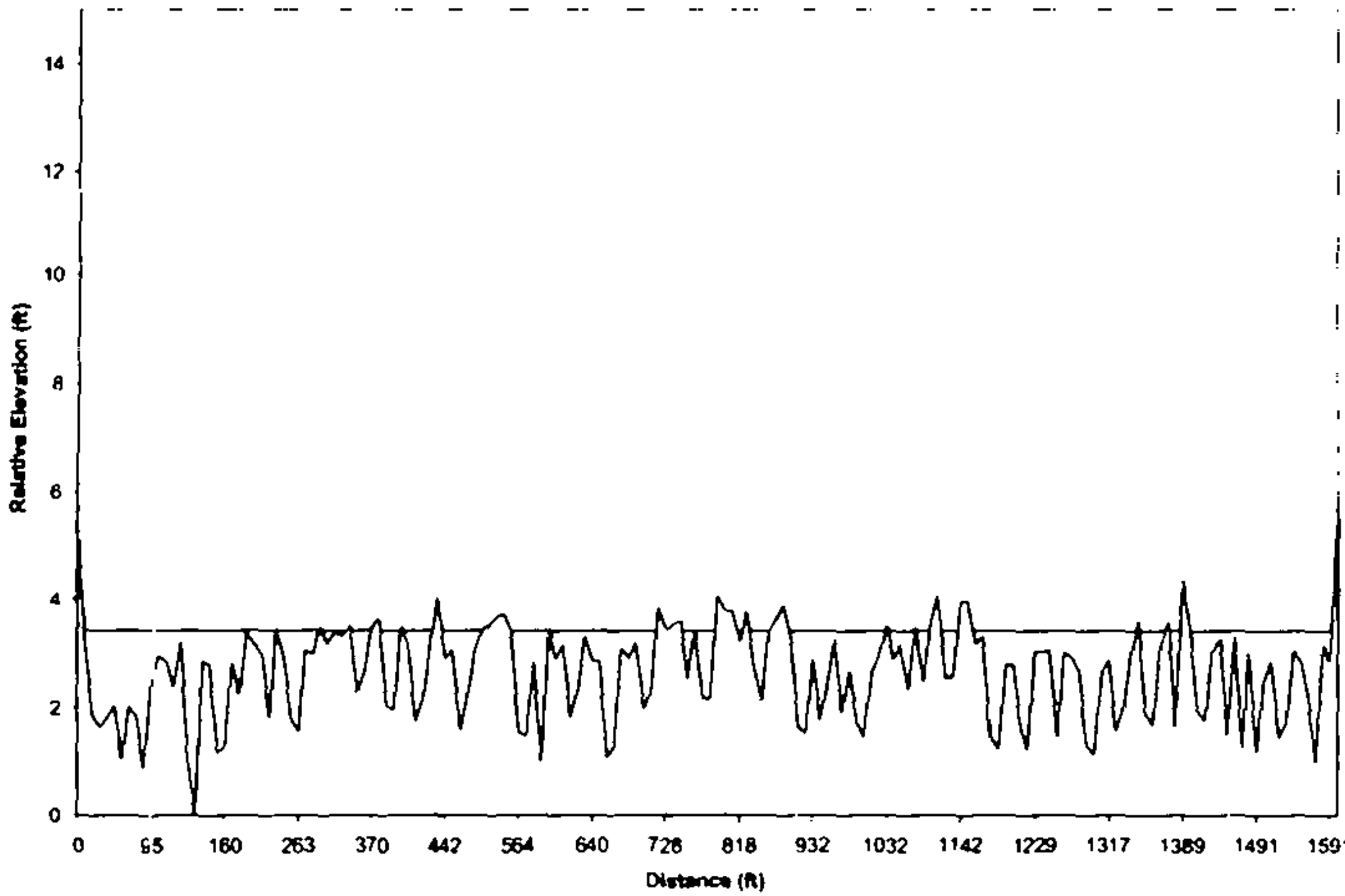

Figure 17. Example of Cross Section for Fish Passage Transect #4 (Entrix 2002).

Comparing the depths at the fish passage transect locations relative to sturgeon body depth can be instructive in determining the likelihood sturgeon would be able to effectively pass the shallow areas and bedrock ledges that had the greatest potential to impede fish passage. Sufficient depth at these locations ensures fish can swim normally (i.e., fully submerged, including dorsal fin, potentially avoid terrestrial predators) and may alleviate any adverse behavioral reaction to shallow water. Design criteria for constructing fish passage structures conservatively recommend water depth ranges from 2 times the largest fish's body depth (USFWS 2019) up to 3 times a fish's body depth (Turek et al. 2016). These recommendations are for designing a fish passage and do not represent absolute minimums through which fish cannot pass. For example, Haro et al. (2015) specifically selected a slightly less conservative minimum depth of 1.5 times the mean body depth of their target species, because the authors believed that value was more applicable to fish distribution in open river environments. Turek et al. (2016) report the average body depth of shortnose sturgeon as 8.35 in (21.2 cm) and 17.72 in (45 cm) for Atlantic sturgeon. Therefore, water depths ranging from 1.35 ft to 2.08 ft (0.4–0.6 m) for shortnose sturgeon and from 2.9 ft to 4.46 ft (0.88-1.35 m) for Atlantic sturgeon would achieve those conservatively identified passage depths for Atlantic sturgeon. Based on Table 18, shortnose sturgeon have sufficient maximum depth for passage at all five surveyed transects at all flow conditions. The larger Atlantic sturgeon require higher flows: 1,100 cfs to pass Transect 5; 1,300 cfs to pass Transect 4; and 2,300 cfs to pass Transect 5. Of course, passage of some highly motivated fish is possible at shallower depths, but greater passage depths at higher flow rates likely significantly increase the likelihood of successful passage for Atlantic sturgeon. Additionally, Dial-Cordy (2010) reported areas of suitable- and marginally-suitable spawning substrate throughout the shoals. This means sturgeon have multiple potential locations for spawning without the need to traverse the entire shoal complex.

Additionally, NMFS (2007) reports suitable water depths for sturgeon spawning range from a minimum depth of 1.6 ft (0.5 m) to optimal depths between 6.6 ft to 13.1 ft (2–4 m). Ideal water velocities for spawning range from 1.3 ft to 3.3 ft per second (fps) (0.4 to 1.0 mps; (NMFS 2007). Entrix (2002) report median depths at 2,500 cfs varied between about 1.5 ft in the shoal transects (0.5 m) to about 3-5 ft (0.9–1.5 m) in the run habitats. Median velocities at 2,500 cfs averaged about 1 fps (0.3 mps) in shoal areas and about 0.5 fps (0.15 mps) in run habitats. With implementation of the daily minimum aquatic base flows, water will not be diverted without maintaining at least 1,500–1,800 cfs over the Augusta Shoals, and the re-regulation of JST Project outflows by the Stevens Creek dam will reduce pulsing that would otherwise result in inconsistent flows and water depths on a daily basis over the Augusta Shoals.

Maintaining flows at a minimum level in the shallower river reaches is particularly important. Shallower reaches are more susceptible to fish stranding, egg desiccation, or drying out of habitat under low flow conditions. While we believe the environmental conditions (i.e., water temperature, DO concentration, depth) at the shoals are sufficient to support sturgeon overall, continued diversions into Augusta Canal may pose a risk to eggs/larvae at the Augusta Shoals relative to a no diversion scenario. Adults are mobile and we anticipate they will be able to respond to changing water conditions by finding areas of appropriate depth, even if river depths begin to shallow during periods of low flow. Eggs are attached to the benthos, and larvae with undeveloped fins lack mobility; neither stage can move if water conditions become detrimental.

Because of this lack in mobility and the regular fluctuations in river level, eggs/larvae mortality or injury may occur over the course of the license if the eggs/larvae are laid in sections of the river that dry out, are exposed to scouring, or water conditions deteriorate to the point of causing harm/mortality. As more spawners are added to the population, we anticipate more spawning adults will be using the spawning habitat in the Augusta Shoals. As the number of animals using those habitats increases, the likelihood that eggs will be laid in a stretch of habitat that may ultimately become dewatered is expected to increase. Thus, the likelihood of eggs/larvae being harmed may increase over time as the populations recover. However, we anticipate the implementation of the daily minimum aquatic base flows that will offset some of those harmful effects by preventing harmful ultra-low flow scenarios (e.g., less than 1,500 cfs). Increased minimum flow also reduces dewatering events, creates redundancy in egg-laying locations, and maintains higher overall depths for adult movement. While we anticipate eggs/larvae may be affected during the course of the license, the number of Atlantic and shortnose sturgeon eggs/larvae affected is currently unquantifiable given the lack of tools to measure take at that stage. Table 18 reinforces that even under the daily minimum aquatic base flows (1,500 cfs), an average depth of at least 1.8 ft will occur over the shoals. This average depth meets the recommended depth for shortnose sturgeon (1.04 ft to 2.08 ft), but larger Atlantic sturgeon may need deeper water and be limited to passage at fewer, maximum depth passage locations through the Shoals. Atlantic sturgeon spawning takes place during months with lower mean flows. Due to their greater depth requirements and the increased likelihood of lower flows during their spawning season, Atlantic sturgeon are more likely to be adversely affected by shallow waters resulting from the *MAB Flow*.

NMFS anticipates the daily minimum aquatic base flows will provide a backstop against dewatering events at Augusta Shoals, thereby reducing potential impacts to spawning adults as well as eggs/larvae. Every increase in flow to the Augusta Shoals increases the amount of spawning habitat available, thereby reducing adverse effects to spawning sturgeon (Table 13, Figure 13) (Entrix 2002). Therefore, the Proposed Action provides additional benefits to spawning adults and eggs/larvae relative to historical flows, but substantially reduces available spawning habitat for egg deposition and adult movements relative to *Undiverted Flows*.

6.2.3 Changes to Water Quality

Dissolved Oxygen
Sturgeon are highly sensitive to changes in DO (Niklitschek and Secor 2009a). Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a by-product of photosynthesis. In turn, fish take up the oxygen for respiration in the water using their gills. Reductions in flow rate and volume can affect temperature and DO concentrations in rivers. Niklitschek and Secor (2005) found that the value and extent of nursery habitat for juvenile Atlantic sturgeon was highly sensitive to anthropogenic interventions affecting freshwater inflow, water temperature, and DO concentrations. Different fish have specific requirements for particular DO levels, below which they will not reproduce, feed, or survive. Sturgeon species have greater oxygen requirements than most other fish species; in fact, sturgeons have been considered as indicator species due to their particularly low tolerance to hypoxia (Niklitschek and Secor 2009a). Secor and Gunderson (1998) established that the DO level required to avoid mortality was 5 mg/L. At levels below 5 mg/L, sturgeon become stressed. They will often move

to areas of higher DO if able. Low DO levels (hypoxia) can impair animal growth or reproduction, and the complete lack of oxygen (anoxia) will kill animals.

The Augusta Canal Project will also affect water quality (e.g., DO concentration, pollutant levels). The Instream Flow Study for the Augusta Canal Project, included as part of the Final EA for the project, determined water passing over the ADD and through the Augusta Shoals improves water quality in the Savannah River, since the turbulent flow of water increases the DO concentrations (Entrix 2002). Conversely, water diverted into the Canal bypasses the Shoals entirely and is not naturally aerated in the same way. There is no publicly available information regarding the water quality parameters of the water re-entering the mainstem Savannah River from Augusta Canal. However, because the Canal lacks the geological features (i.e., shoal habitat) that naturally aerates river flow, we anticipate the DO concentrations of re-entering water will at best, be similar to concentrations of the water already in the river, and more likely, DO concentrations in the water re-entering the river will be lower. While diversion into the Canal clearly makes less water available for the Shoals, Entrix (2002) determined that DO was unlikely to be a limiting factor that was considerably affected or altered within the Augusta Shoals by the proposed project. This conclusion appears supported by the data reported from the PCWS. Section 4.1.4 reports recorded DO concentrations 8 miles downstream of the base of the JST Dam, as well as the DO concentrations recorded just downstream of the Augusta Shoals. This information also suggests that DO concentrations at the Augusta Shoals never dropped below 5 mg/L regardless of the flow (PCWS 2014; PCWS 2015; PCWS 2016; PCWS 2017; PCWS 2019; PCWS 2020; PCWS 2022). Higher volumes of water and rates of flow over the Augusta Shoals will aerate the water and increase DO concentrations. In addition, higher flows over the Augusta Shoals will aid in diluting any toxins present.

Water Temperature
We also investigated how water temperatures at the Augusta Shoals compared to temperatures at the gravel bar just downstream from the NSBL&D where sturgeon are likely spawning. However, because temperature of the water arriving at the Augusta Shoals is largely dictated by the water released from the JST Project, and not the Augusta Canal Project, the effects of water temperatures are discussed in Section 4.1.4.

6.2.4 Summary of the Effects of Aquatic Base Flows on Sturgeon

Currently, there is no minimum flow requirement over the Augusta Shoals and the city of Augusta can divert water into the Augusta Canal, potentially causing the Augusta Shoals to run dry. Upon implementation of the daily minimum aquatic base flows, “backstops” of at least 1,500-1,800 cfs of water will be maintained over the Augusta Shoals before the city of Augusta can divert water into the Augusta Canal. Across all flow tiers, under *MAB Flow*, 42.3% and 55.9% of the WUA in the Augusta Shoals is expected to be usable for Atlantic and shortnose sturgeon, respectively. The *MAB Flow* is anticipated to increase pWUA by 0.4% relative to what was observed historically during Atlantic sturgeon spawning season and increase pWUA by 4.9% during shortnose sturgeon spawning season relative to what was observed historically.

However, relative to an environmental baseline with no flow diversions into the Augusta Canal, the daily minimum aquatic base flows will substantially decrease available spawning habitat, especially for Atlantic sturgeon. Appendix I in Entrix (2002) indicates that increases in flow to Augusta Canal decrease the area available as sturgeon spawning habitat below the ADD in the Augusta Shoals (Table 13, Figure 13). As a result, we estimate 100% of the sturgeon life stages (i.e., spawning adults, eggs and larvae) present in the Augusta Shoals will be adversely affected by reauthorization of flow diversions into the Augusta Canal, because flow diversions reduce the amount of spawning habitat available, causing harm to all life stages. Conversely, Appendix I in Entrix (2002) also indicates that increases in flow to the Augusta Shoals increase the amount of spawning habitat available, thereby reducing adverse effects to sturgeon (egg, larvae, and spawning adults) (Table 13, Figure 13).

We established a causal relationship between flow diversion into the Augusta Canal and pWUA/WUA for sturgeon. For every increase in flow to the shoals, there was a concomitant increase in pWUA/WUA values on the whole (Figure 13). Alternatively, as more water is diverted, less is available to go to the shoals, reducing pWUA/WUA values. It is worth acknowledging that increasing flows will change hydraulic conditions. For example, some areas that were previously inaccessible because of low water will now become accessible. Similarly, shallow areas with relatively low water velocities may see water velocities increase as more water flows across/through them. Conversely, existing shallow areas with relatively high flow velocities may become deeper, reducing flow velocities. Overall, the more water there is available in the shoals, the better conditions will be for spawning sturgeon. To reduce the adverse effects to sturgeon from flow diversions into the Canal, this Opinion will require a 3,500 cfs maximum flow into Augusta Canal (an intake threshold exceeded only 0.02% of the time from 1996–2019) and will require minor changes to the daily minimum aquatic base flows over Augusta Shoals as Reasonable and Prudent Measures (RPM). The first RPM formalizes the City's historic maximum use to avoid excess (unused) water being routed past Augusta Shoals back into the Savannah River. The second RPM protects Atlantic sturgeon from low flows during spawning periods that were not considered during the original development of the daily minimum aquatic base flows. This RPM will provide more water for passage of deeper-bodied Atlantic sturgeon adults as they spawn and will reduce the likelihood of eggs and larvae being exposed during low water events.

6.3 The Effects of Fish Passage at the Augusta Diversion Dam on Sturgeon

The terms of the FERC license will include a requirement that a vertical slot fishway with attraction flows be constructed on the South Carolina side of the ADD and be operational as soon as possible, but no later than 3 years, after the completion of the nature-like fishway, specifically designed to pass sturgeon at NSBL&D. The fishway at ADD is size-selective to pass American shad, Blueback herring, striped bass, and American eels, and behaviorally selective against sturgeon. The fishway must be self-regulating to accommodate varying flow conditions.

While shortnose sturgeon were originally included as a target species for passage above ADD in the 2008 draft settlement agreement (Atlantic sturgeon had not been listed in 2008), NMFS is not requiring passage of either species upstream of the ADD at this time. NMFS does not believe it is beneficial for sturgeon to be above the ADD at this time due to suspected limited availability of suitable upstream spawning habitat, which is drowned under the pool created by the ADD, and, more importantly, risk of injury during downstream passage. Additionally, this Opinion requires that efforts be made to ensure that sturgeon do not use the fishway to be built at ADD, which is the only way sturgeon could gain access above the ADD. Therefore, while there is downstream fish passage at the Raw Water Pumping Station within the Canal that is likely large enough to accommodate sturgeon species, we do not expect sturgeon will ever occur in the Canal. In the unlikely event a sturgeon did enter the canal, once past the pumping station, there is no downstream route back to the mainstem of the Savannah River without first passing through the turbines of the hydroelectric projects located along the canal.

While sturgeon are no longer a target species for the vertical slot fishway, Thiem et al. (2011) reported several lake sturgeon using a vertical slot fishway designed to help pass sturgeon in Quebec, Canada. To avoid sturgeon passing into the fishway, and potentially passing above the ADD, Dr. Brett Towler, a fishway engineer with USFWS, recommended placing a mid-water spoiler/baffle plate at the entrance of the fishway to exclude Atlantic and shortnose sturgeon from entering it. NMFS's Third Modified Fishway Prescription requires such a baffle. Because no studies are available to quantify the efficacy of a mid-water spoiler/baffle plate at prohibiting sturgeon entry into the fishway, we are evaluating the effects of sturgeon potentially entering the fishway, even with the spoiler/baffle plate.

While the vertical slot fishway is being prescribed to access habitat in the Savannah River above the ADD, it is possible that Atlantic and shortnose sturgeon may enter the fishway and be injured. In the only study quantifying voluntary sturgeon passage at a vertical slot fishway in the natural, non-laboratory environment, Parsley et al. (2007) found that 2% of tagged white sturgeon *(Acipenser transmontanus)* entered the vertical slot fishway, with no sturgeon passing upstream successfully. It is important to note that the Parsley et al. (2007) study involved a different sturgeon species (white sturgeon) in a much larger, faster moving riverine environment (the Columbia River, Oregon) than is found in the Savannah River. However, this represents the best available information on how many sturgeon may enter the vertical slot fishway in the ADD. Therefore, up to 38 shortnose sturgeon (2% of 1,865, the mean estimate of adult Savannah River shortnose sturgeon (Bahr and Peterson 2017) and up to 6 Atlantic sturgeon (2% of 300, the maximum estimate of adult Savannah River Atlantic sturgeon spawning annually) may enter the fishway per year. However, we expect the installation of the spoiler/baffle plate to deter sturgeon from entering the fishway, reducing this number.

In the study by Parsley et al. (2007), no injuries or mortalities were reported in the studies observing sturgeon utilizing fishways, even when the sturgeon navigated the fishway unsuccessfully. In "Diadromous Fish Passage: A Primer on Technology, Planning, and Design for the Atlantic and Gulf Coasts," NMFS and USGS (2011) note that if injury and mortality are going to occur, they most frequently happen at downstream passage structures, but are also possible at upstream passage structures as well (NMFS and USGS 2011). NMFS and USGS (2011) noted that the narrow slot widths used in vertical slot fishways designed for salmonids may result in increased fish contact, descaling, and increased mortality of American shad.

No studies of sturgeon injuries in vertical slot fishways are available. However, in a laboratory study of lake sturgeon in a prototype side-baffle ladder fishway, Kynard et al. (2011) observed that in 190 passes within the fishway, 9% of the lake sturgeon made no contact with the sides or baffles inside the fishway. Of the 91% of fish that made contact with baffles protruding in the fishway, 82.6% of sturgeon "glanced off" the baffle and made no hesitation in their movements.

The remaining 8.4% of the lake sturgeon halted after making a direct or glancing blow on the baffle and held position in the fishway for an average of 8.3 minutes before resuming swimming with no visible injuries or lingering effects. Sturgeon are covered in protective armored scutes (bony plates) (Findeis 1997) rather than scales like American shad, and it is unlikely that contact with the fishway would have more than minor effects on sturgeon that do enter the fishway. Lethal injuries to sturgeon from entering a vertical slot fishway have never been reported and are not anticipated.

If Kynard et al.'s (2011) observation of 8.4% of lake sturgeon experiencing potential minor and temporary injury from contacting baffles inside a fishway is applied to the potential number of fish entering the proposed fishway at the ADD, a maximum of 4 shortnose (8.4% of 38 fish potentially entering the ADD fishway, rounded up to the nearest whole number) and 1 Atlantic sturgeon (8.4% of 6 fish potentially entering the ADD fishway, rounded up to the nearest whole number) could experience minor and temporary injuries or stress from attempting to pass the proposed fishway at the ADD annually. While the hesitation Kynard et al. (2011) observed in the 8.4% of sturgeon contacting the fishway baffles is not an indication of an actual injury or even stress to the fish, these observations were made over 2-, 24-, and 72-hour periods in a controlled laboratory setting with a different sturgeon species (Lake sturgeon). In addition, the sturgeon used in the laboratory experiment were 3–4 ft in length, while adult Atlantic sturgeon can grow much larger than that. Over the course of the 50-year license issued for the Augusta Canal Project in a dynamic and unpredictable natural setting, it is possible that injuries and stress to shortnose and Atlantic sturgeon could be higher than that observed in the laboratory, though we would still expect the injuries or stress to be sublethal. Additionally, with the installation of the spoiler/baffle plate, the number of sturgeon entering the fishway and potentially being injured is expected to be reduced.

Sturgeon may experience stress during unsuccessful fishway attempts and potential negative consequences could include reduced spawning success or abandoning spawning activities altogether, though monitoring of post-passage behavior at fishways has rarely been considered (Roscoe et al. 2011). Cocherell et al. (2011) evaluated physiological responses of white sturgeon to stress in a laboratory experiment with a fishway. The study found mild stress markers in blood samples taken from white sturgeon, including increased plasma cortisol concentration, percentage of red blood cells by blood volume, and plasma lactate levels, and decreased plasma pH and glucose levels. These responses were similar to mild stress responses in other fish species, and Cocherell et al. (2011) found that all blood parameters returned to pre-activity levels within 24 hours of completing the laboratory fishway exercises. Roscoe et al. (2011) found little evidence that sockeye salmon utilizing a fishway or having previous experience in the tailrace of the dam resulted in physiological stress or exhaustion. Indices of stress in the sockeye salmon sampled immediately after dam passage were low compared to several previous reports of blood biochemistry in the same species.

Thus, once safe and effective passage for sturgeon is constructed at the NSBL&D, which is anticipated during the course of any license issued for the Augusta Canal Project, Atlantic and shortnose sturgeon will be able to utilize the reach of the Savannah River between the NSBL&D and the ADD. While access to the Augusta Shoals is expected to greatly improve the opportunities for successful sturgeon spawning, the ADD and other upstream dams will continue to fragment and block access to habitat historically used by Atlantic and shortnose sturgeon. Additionally, while sturgeon may enter the fishway prescribed at ADD, we do not believe they will enter in large numbers, or sustain serious injuries.

7 CUMULATIVE EFFECTS

Cumulative effects are the effects of future state, local, or private activities that are reasonably certain to occur within the action area considered in this Opinion. 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.

Within the action area, major future changes are not anticipated in ongoing human activities described in the environmental baseline. The present, major human uses of the action area are expected to continue approximately at the present levels of intensity in the near future. Human activities that affect water quality and quantity such as farming, and industrial and sewer discharges are also expected to continue approximately at current rates. As discussed in section 6.2.2, municipal water needs of the city of Augusta may increase in the future. To the extent that future increases are predictable based on available information, we have considered those potential increases in our analysis. Future cooperation between NMFS, GADNR, 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.

Our understanding of future changes in the climate are discussed in Sections 4 and 5. We generally expect climate change may affect Atlantic and shortnose sturgeon, and their habitats, in a variety of ways. These changes, however, are difficult to predict precisely and we expect environmental responses to these changes will take decades to manifest in measurable way. Because of this uncertainty we cannot conduct a meaningful analysis of measureable risk for either species.

8 JEOPARDY ANALYSIS

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

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

The analyses conducted in the previous chapters of this opinion provide a basis to determine whether the proposed action would be likely to jeopardize the continued existence of the endangered shortnose sturgeon and the endangered Atlantic sturgeon South Atlantic DPS by identifying the nature and extent of adverse effects ("take," as previously defined in Section 6) expected to impact each species. Next, we consider how sturgeon will be impacted by the proposed licensing of the Augusta Canal Project in terms of overall population effects and whether those effects of the proposed action will jeopardize the continued existence of the species when considered in the context of the status of the species and their habitat (Section 4), the environmental baseline (Section 5), and cumulative effects (Section 7).

In the following analysis, we evaluate the effects of continuing restriction of access to sturgeon habitat above the ADD, control of the flow regime in a portion of the Savannah River, and some non-lethal interactions of sturgeon with the proposed fish passage structure. Over the course of the 50-year license, we expect the proposed action to have some impacts on the distribution (due to blockage by the dam) and reproduction (through the reduction in the quantity and quality of spawning habitat) of the species.

8.1 Shortnose Sturgeon

We determined that once effective fish passage is operational at the NSBL&D, shortnose sturgeon will be present seasonally just below the ADD. Thus, the proposed action may result in nonlethal incidental take of up to 4 spawning shortnose sturgeon every year via interactions with the proposed fish passage structure at the ADD. We also anticipate additional nonlethal harm will occur to spawning shortnose sturgeon from blocked access to habitat above ADD. We also anticipate additional nonlethal incidental takes of spawning shortnose sturgeon via habitat degradation. The spawning shortnose sturgeon in the Savannah River migrating to the Augusta Shoals would be harmed by reduced spawning habitat suitability downstream of the ADD caused by flow diversions into the Augusta Canal. Table 19 summarizes the types of take, the species and life stages affected the extent of take and where these effects are anticipated to occur.

Whether the reductions in numbers and reproduction of this species would appreciably reduce its likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. In Section 4 (Status of Species), we presented the status of the species, outlined threats, and discussed information on estimates of the number of known river populations. In Section 5 (Environmental Baseline), we outlined the past and present impacts of all state, federal, or private actions and other human activities in or having effects in the action area that have affected and continue to affect this species. We also included a discussion of Climate Change in Section 4.1.4. In Section 7 (Cumulative Effects), we discussed the effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area. These effects are in addition to the other ongoing effects to the species described in Section 4.1.4. We also discussed the effects from other federal actions, and the potential effects of climate change, in detail in the preceding sections of this Opinion. It is important to note that virtually all of the effects we discussed, including the effects from the proposed action, have been occurring and affecting the species for decades. All of the previously discussed effects are part of the baseline upon which we founded our analysis, and the associated population level implications for the species are reflected in the species current population trends.

The nonlethal takes occurring via interactions with the proposed fish passage structure at the ADD are not expected to have any measurable impact on the reproduction, numbers, or distribution of the species. We anticipate these individuals will fully recover from the interactions such that no reductions in reproduction or numbers are anticipated.

We do anticipate the proposed action will affect the distribution (due to blockage by the dam), and reproduction (through potential impacts to eggs/larvae) of the species over the course of the 50-year license. Although the proposed action includes fish passage, NMFS does not believe it is beneficial for shortnose sturgeon to be above the ADD at this time. The existence of the ADD restricts the distribution of shortnose sturgeon in the Savannah River. In the absence of the ADD, one additional mile of riverine habitat would be available. However, once fish passage at NSBL&D is constructed, previously blocked habitat will be opened up and the Savannah River will be functionally unobstructed for approximately 205 miles. While the proposed action will prevent shortnose sturgeon in the Savannah River from accessing one additional mile of habitat, over 205 river miles will remain free of obstruction. Therefore, no functional restriction in the distribution of the Savannah River population of shortnose sturgeon or the species range wide is anticipated.

As discussed in Section 4.1, shortnose sturgeon in the Southeast comprise a single metapopulation, the "Carolinian Province." Each metapopulation is reproductively isolated from the other and constitutes an evolutionarily (and likely an adaptively) significant lineage. The loss of any metapopulation would result in the loss of evolutionarily significant biodiversity and would result in a gap(s) in the species' range. It would also increase the species' vulnerability to random events. Loss of the southern shortnose sturgeon metapopulation would result in the loss of the southern half of the species' range. Our determination of the likely impacts to shortnose sturgeon from the proposed action considers the impacts on the Savannah River population and ultimately how those impacts affect the metapopulation and the species range-wide.

The Savannah River population of shortnose sturgeon is a component of the Carolinian Province and has been experiencing the chronic effects of water control projects for over 100 years. Habitat fragmentation, low flows, and poor water quality have combined with other sources of human induced stress and mortality to greatly reduce this population from historical levels. The Savannah River population has managed to persist in the wild under the past operation of the Augusta Canal Project. Because other projects in the action area have dictated water quantity (i.e., the JST Project since the 1960s) and habitat access (NSBL&D since the 1930s), sturgeon in the Savannah River have not experienced direct effects from the Augusta Canal Project for most of that time. Individuals within this metapopulation show less reproductive isolation between rivers than the other two shortnose sturgeon metapopulations.

The range-wide status of the species is considered mixed as some populations are increasing and others are decreasing or unknown. The Savannah River shortnose sturgeon population has decreased dramatically from historical levels. While significantly depressed from a historical perspective, Bahr and Peterson (2017) report the Savannah River shortnose sturgeon population is possibly the second largest in the Southeast, with the highest point estimate of the total population (adults and juveniles) occurring in 2013 at 2,432. Those numbers declined in 2014 and 2015, reaching an estimated 1,390 total individuals in 2015; more recent estimates are not currently available. We determined the proposed fishway at ADD may adversely affect up to 4 shortnose sturgeon per year. We anticipate these animals could enter the fishway and suffer harm/injury during unsuccessful attempts to pass, although lethal injuries are not anticipated. The installation of an adjustable spoiler/baffle plate at the entrance of the fishway would further reduce the anticipated incidence of sturgeon attempting to enter the fishway. Because we do not anticipate any shortnose sturgeon deaths because of interactions with the fishway, and no other lethal routes of effect were identified, we do not believe the operation of the fishway associated with the proposed action will reduce the number of shortnose sturgeon in the Savannah River population, or the species range wide.

Considering flow, depth, and substrate, Dial-Cordy (2010) estimate approximately 127 acres of “suitable” and “marginally-suitable” spawning habitat exists below NSBL&D. Shortnose sturgeon populations have persisted in the Savannah River with only those 127 acres of potential spawning habitat. Our analysis indicates that the daily minimum aquatic base flows during the shortnose sturgeon spawning season should provide depths and water velocities in the ranges suggested by NMFS (2007) for shortnose sturgeon spawning. We estimated the continued authorization of diversions by ADD will lead to an absolute change of -25.7% pWUA, and a relative change of -31.5% in potentially available spawning habitat for shortnose sturgeon at the Augusta Shoals across all flow tiers collectively (see Table 17, *Undiverted vs. MAB Flow*), relative to no flow being diverted into the Augusta Canal. With passage at NSBL&D and 2,500 cfs of flow at Augusta Shoals, the available spawning habitat for sturgeon in the Savannah River is expected to increase to 416–522 acres; approximately quadruple the estimated 127 acres of “suitable” and “marginally-suitable” spawning habitat below NSBL&D. Although the daily minimum aquatic base flows decrease available shortnose sturgeon spawning habitat relative to undiverted flows (-25.7% absolute pWUA change; -31.5% relative pWUA change), when coupled with fish passage at NSBL&D, they still represent a significant improvement in access and quality of available spawning habitat over current conditions. We anticipate the net effect of the improvement to the environmental baseline from fish passage at NSBL&D along with the impacts of the proposed diversions will be to increase survival and recruitment relative to the status quo.

The relicensing of the Augusta Canal Project will reduce shortnose sturgeon reproduction by adversely affecting spawning habitat. We estimate a -31.5% relative change in pWUA (Table 17) because of the proposed action relative to the absence of the ADD and its water diversion.

However, the impacts to the species from that habitat loss will be offset to some extent by the benefits realized through changes in the environmental baseline (construction of fish passage at NSBL&D) and the implementation of the daily minimum aquatic base flows that will prevent harmful ultra-low flow scenarios (e.g., less than 1,500 cfs). During Tier 4 (<3,600 cfs) flow events, we estimate the *MAB Flow* requirements will cause an absolute change in pWUA of +21.1%, representing a relative change of +306.8% pWUA (Table 17), compared to historically observed conditions. Additionally, first time access to suitable and marginally suitable spawning habitat and minimum flow reservations will improve spawning conditions for, and the survival rate of, shortnose sturgeon offspring in the Savannah River. Therefore, while the proposed action will adversely affect reproduction of the Savannah River population of shortnose sturgeon, via reduction in spawning habitat relative to no diversions into the Augusta Canal, we do not anticipate that change, taken together with changes in the environmental baseline, will appreciably reduce the likelihood of the population's survival in the wild. With no anticipated reduction in the likelihood of Savannah River population's survival in the wild, we also conclude the proposed action's effects to reproduction will not appreciably reduce the likelihood of survival of shortnose sturgeon range wide.

Some currently unquantifiable amount of shortnose sturgeon eggs/larvae will be adversely affected by the proposed action. This reduction is not inconsequential given that a single female shortnose sturgeon may produce between 30,000–200,000 eggs annually (Gilbert 1989). Reducing the success of a single shortnose sturgeon reproductive event results in long-term impacts on both the population and the species overall. Because shortnose sturgeon reproduce annually over many years, impacts from decreased fecundity and recruitment accrue geometrically and therefore impacts to reproductive success can become very large with apparently small annual impacts when they are compounded over subsequent generations. The elasticity profile for population growth of shortnose sturgeon was found to be most sensitive (i.e., had the highest potential gains in recovery) for YOY and juvenile ages as compared with mature individuals (Gross et al. 2002). Thus, the anticipated loss of eggs/larvae would also affect their potential reproductive contributions to future generations. Undoubtedly, the loss of eggs/larvae has the potential to have cascading effects on the population. However, the natural mortality rate of shortnose sturgeon eggs/larvae is high, and we expect a large proportion of the eggs/larvae that may ultimately be adversely affected by the proposed action would be unlikely to survive in the absence of the ADD and its water diversions. Therefore, we do not believe the action will appreciably reduce reproduction of the shortnose sturgeon in the Savannah River, nor the species range wide.

We analyze the likelihood of shortnose sturgeon recovery in the wild by considering effects resulting from the proposed action relative to accomplishing the conservation goals described in the Shortnose Sturgeon 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 that are partially addressed by the proposed action include:

1. Restore flows in regulated rivers during spawning periods to promote spawning success and rehabilitate degraded spawning substrate.
2. Ensure that all fish passageways permit adequate passage of shortnose sturgeon and do not alter migration or spawning behavior.

The continued authorization of diversions by ADD under the proposed action will lead to an absolute reduction of -25.7% pWUA, and a relative reduction of -31.5% in potentially available spawning habitat for shortnose sturgeon at the Augusta Shoals (see Table 17, *Undiverted vs. MAB Flow*), relative to no flow being diverted into the Augusta Canal. These continued diversions, and resulting reductions in the potential spawning habitat, clearly interfere with the first of the recovery goals listed previously and will likely slow the overall recovery of the Savannah River population of shortnose sturgeon. However, while continued diversions into the Augusta Canal will likely slow the overall recovery, the implementation of the *MAB flow* does provide some incremental support for the first recovery goal. The minimum flow reservations will restore flows and slightly increase the overall spawning habitat available for shortnose sturgeon (absolute change pWUA +4.9%; relative change pWUA +8.4%, Table 17) in a stretch of regulated river during spawning periods, relative to historically observed conditions. Coupled with fish passage at NSBL&D reestablishing access to suitable and marginally suitable spawning habitats for the first time in generations of sturgeon, we anticipate the implementation of the minimum flow reservations will improve spawning conditions for, and the survival rate of, shortnose sturgeon offspring in the Savannah River. We expect increased spawning success will in turn increase recruitment success rates once sturgeon can access the habitat. Nursery habitat for early life stages of larval sturgeon will also be improved through increased flow and water quality. Eggs/larvae will have additional time to grow and develop physiological tolerances prior to reaching the saltwater interface. Access to additional spawning habitats may also decrease the likelihood of egg predation, increasing annual recruitment. Therefore, while the proposed action will interfere with the first recovery goal for the Savannah River population of shortnose sturgeon, slowing recovery overall, we do not anticipate it will appreciably reduce the likelihood of its recovery in the wild or the species range wide.

Although the proposed action includes fish passage for other species, NMFS does not believe it is beneficial for shortnose sturgeon to be above the ADD at this time. In the future, if we determine it is beneficial for sturgeon to be above the ADD, the spoiler/baffle plate in the vertical slot fishway can be removed, allowing shortnose sturgeon access to the additional 1 mi of spawning habitat above the dam. Thus, while the proposed action is not entirely consistent with this specific long-term recovery goal, the requisite minimum base flows represent the best option for protecting sturgeon given the current conditions.

8.2 South Atlantic DPS Atlantic Sturgeon

We determined that once effective fish passage is operational at the NSBL&D, and Atlantic sturgeon from the South Atlantic DPS can access the habitat up to the ADD. Thus, the proposed action may result in nonlethal incidental take of up to 1 spawning Atlantic sturgeon from the South Atlantic DPS every year via interactions with the proposed fish passage structure at the ADD. Further, those individuals will experience nonlethal harm from blocked access to habitat caused by the continued existence and operation of the ADD. Similarly, spawning Atlantic sturgeon from the South Atlantic DPS using the Augusta Shoals will suffer nonlethal harm from reduced spawning habitat suitability downstream of the ADD, caused by flow diversions into the Augusta Canal. Table 19 summarizes the types of take, the species and life stages affected, the extent of the take, and where we anticipate these effects will occur.

Whether the reductions in numbers and reproduction of this DPS would appreciably reduce its likelihood of survival depends on the probable effect the changes in numbers and reproduction would have relative to current population sizes and trends. In Section 4 (Status of Species), we presented the status of the DPS, outlined threats, and discussed information on estimates of the number of known river populations. In Section 5 (Environmental Baseline), we outlined the past and present impacts of all state, federal, or private actions and other human activities in or having effects in the action area that have affected and continue to affect this DPS. We also included a discussion of Climate Change in Section 4.2.4. In Section 7 (Cumulative Effects), we discussed the effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area. These effects are in addition to the other ongoing effects to the DPS described in Section 4.2.4. We also discussed the effects from other federal actions, and the potential effects of climate change, in detail in the preceding sections of this Opinion. It is important to note that virtually all of the effects we discussed, including the effects from the proposed action, have been occurring and affecting the DPS for decades. All of the previously discussed effects are part of the baseline upon which we founded our analysis, and the associated population level implications for the DPS are reflected in the species current population trends.

The nonlethal take occurring via interactions with the proposed fish passage structure at the ADD are not expected to have any measurable impact on the reproduction, numbers, or distribution of the species. We anticipate these individuals will fully recover these interactions such that no reductions in reproduction or numbers are anticipated.

We do anticipate the proposed action will affect the distribution (due to blockage by the dam), and reproduction (through potential impacts to eggs/larvae) of the species over the course of the 50-year license. Although the proposed action includes fish passage, NMFS does not believe it is beneficial for Atlantic sturgeon to be above the ADD at this time. The existence of the ADD restricts the distribution of Atlantic sturgeon in the Savannah River. In the absence of the ADD, one additional mile of riverine habitat would be available. However, once fish passage at NSBL&D is constructed, previously blocked habitat will be opened up and the Savannah River will be functionally unobstructed for approximately 205 miles. While Atlantic sturgeon in the Savannah River will be prevented from accessing one additional mile of habitat because of the proposed action, over 205 river miles will remain free of obstruction. Therefore, we do not believe the proposed action is appreciably reducing the distribution of the Savannah River population of Atlantic sturgeon or the DPS.

The South Atlantic DPS of Atlantic sturgeon is listed as endangered throughout its range. The range-wide status of the species is considered mixed, as some populations are increasing and others are decreasing or unknown. The ASMFC's 2017 assessment concluded there was not enough information available to assess the abundance of the DPS since the implementation of the fishing moratorium in 1998. However, it did conclude there was a 40% probability the South Atlantic DPS is still subjected to mortality levels higher than determined acceptable in the assessment.

The Savannah River Atlantic sturgeon population has decreased dramatically from historical levels. While information is not available to know the historical abundance of Atlantic sturgeon in the Savannah River, using state-wide landings data, Secor (2002) estimated that 8,000 adult female Atlantic sturgeon were present in South Carolina prior to 1890. The Savannah River is estimated to have less than 300 spawning Atlantic sturgeon adults (total of both sexes) per year. Bahr and Peterson (2016) estimated a relatively stable age-1 juvenile abundance in the Savannah River from 2013–2015 at 528 in 2013, 589 in 2014, and 597 in 2015 (Figure 18). More recent estimates show a decline in age-1 juvenile abundance since 2017 (Fox et al. 2020) with an increase noted from 2020 to 2021. Regardless, clear evidence of an overall Savannah River Atlantic sturgeon population trend is currently unavailable.

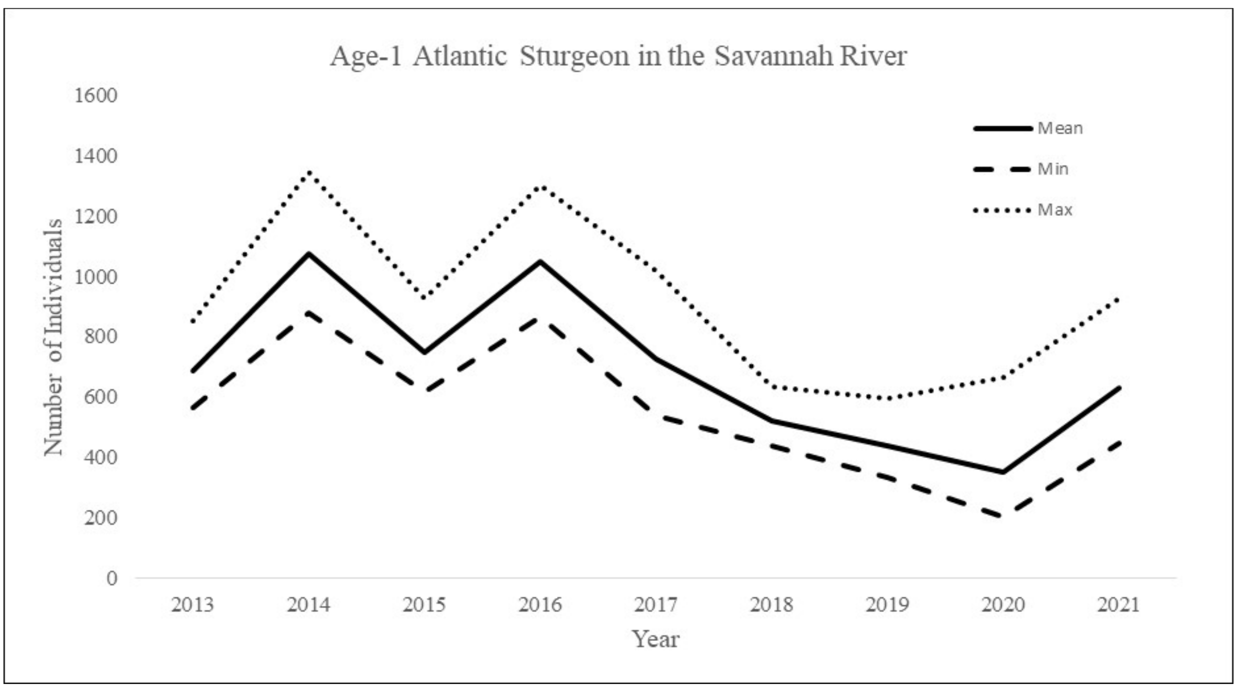

Figure 18. Estimated Abundance of Age-1 Atlantic Sturgeon in the Savannah River, 2013–2020 (Bahr and Peterson 2016; Fox et al. 2020)

Considering flow, depth, and substrate, Dial-Cordy (2010) estimate approximately 127 acres of "suitable" and "marginally-suitable" spawning habitat exists below NSBL&D. The South Atlantic DPS of Atlantic sturgeon has persisted in the Savannah River with only those 127 acres of "suitable" and "marginally-suitable" spawning habitat. We estimate the continued authorization of diversions by ADD under the proposed action will lead to absolute change of -

37.3% pWUA, and a relative change of -46.9% in potentially available spawning habitat for Atlantic sturgeon at the Augusta Shoals across all flow tiers collectively (see Table 17, *Undiverted vs. MAB Flow)*. Relative to historic flows at Augusta Shoals, the daily minimum aquatic base flows in the proposed action provide only a 0.4% increase in available spawning habitat at Augusta Shoals. With passage at NSBL&D and 2,500 cfs of flow at Augusta Shoals, the available spawning habitat for sturgeon in the Savannah River is expected to increase to 416–522 acres; approximately quadruple the estimated 127 acres of "suitable" and "marginally-suitable" spawning habitat below NSBL&D. Although the daily minimum aquatic base flows decrease available Atlantic sturgeon spawning habitat relative to undiverted flows (-37.3% absolute pWUA change; -46.9% relative pWUA change), when coupled with fish passage at NSBL&D, they still represent a significant improvement in access and quality of available spawning habitat over current conditions. We anticipate the net effect of the improvement to the environmental baseline from fish passage at NSBL&D along with the impacts of the proposed diversions will be to increase survival and recruitment relative to the status quo.

The relicensing of the Augusta Canal Project will reduce reproduction of Atlantic sturgeon from the South Atlantic DPS by adversely affecting spawning habitat. We estimate a 46.9% relative reduction in WUA (Table 17) because of the proposed action relative to the absence of the ADD's water diversions. However, the impacts to the species from that habitat loss will be offset to some extent by the benefits realized through changes in the environmental baseline (construction of fish passage at NSBL&D) and the implementation of the daily minimum aquatic base flows that will prevent harmful ultra-low flow scenarios (e.g., less than 1,500 cfs). During Tier 4 (<3,600 cfs) flow events, we estimate the *MAB Flow* requirements will cause an absolute change in pWUA of +21.0%, representing a relative change of +339% pWUA (Table 17), compared to historically observed conditions. Additionally, reestablishing access to suitable and marginally suitable spawning habitat for the first time in generations of sturgeon and establishing minimum flow reservations will improve spawning conditions for, and the survival rate of, Atlantic sturgeon offspring in the Savannah River. Therefore, while the proposed action will adversely affect reproduction of the Savannah River population of Atlantic sturgeon, via reduction in spawning habitat, we do not anticipate that reduction will appreciably reduce the likelihood of the population's survival in the wild. With no anticipated reduction in the likelihood of Savannah River population's survival in the wild, we also conclude the proposed action's effects to reproduction will not appreciably reduce the likelihood of survival for the South Atlantic DPS.

Some currently unquantifiable amount of Atlantic sturgeon eggs/larvae will be adversely affected by the proposed action. This reduction is not inconsequential given that a single female Atlantic sturgeon may produce between 400,000 to 8,000,000 eggs per year (Dadswell 2006; Smith et al. 1982; Van Eenennaam and Doroshov 1998). Reducing the success of a single Atlantic sturgeon from the South Atlantic DPS reproductive event results in long-term impacts on both the population and the DPS overall. Because Atlantic sturgeon from the South Atlantic DPS reproduce annually over many years, impacts from decreased fecundity and recruitment accrue geometrically and therefore impacts to reproductive success can become very large with apparently small annual impacts when they are compounded over subsequent generations. Thus, the anticipated loss of eggs/larvae would also affect their potential reproductive contributions to future generations. Undoubtedly, the loss of eggs/larvae has the potential to have cascading effects on the population. However, the natural mortality rate of Atlantic sturgeon eggs/larvae is high and we expect a large proportion of the eggs/larvae that may ultimately be adversely affected by the proposed action would be unlikely to survive in the absence of the ADD and its water diversions. Therefore, we do not believe the action will appreciably reduce reproduction of Atlantic sturgeon in the Savannah River population, or the South Atlantic DPS.

We analyze the likelihood of recovery for the South Atlantic 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 (NMFS 2017b). The recovery outline discusses the implications of the major threats facing each DPS with respect to their impacts on overall recovery. Specific to the South Atlantic DPS and the proposed action, the outline notes that impeded access to historical spawning habitat, particularly in the Savannah River as a threat hindering recovery (NMFS 2017b). The outline also mentions that even where spawning habitat is available, accessibility does not necessarily equate to functionality. In particular, water quality, while showing signs of improvement, continues to rate only fair to poor in areas of the South Atlantic DPSs.

The Augusta Canal Project potentially contributes to these threats via:

1. Habitat alterations due to dams including:
    a. Curtailment of available habitat;
    b. Impeded access to spawning, developmental, and foraging habitat;
    c. Modification of a free-flowing river to reservoirs;
2. Reduced water quantity by modifying flows over the Augusta Shoals, which likely curtails the extent of available habitat for spawning and nursery areas.

Although the proposed action curtails potential habitat, impedes access to potential spawning grounds, and modifies a free-flowing river, we do not believe it will impede recovery. We do not believe it is beneficial for sturgeon to be above the ADD at this time. In the future, if we determine it is beneficial for sturgeon to be above the ADD, the spoiler/baffle plate in the vertical slot fishway can be removed, allowing shortnose sturgeon access the additional one mi of spawning habitat above the dam. Thus, while the project is blocking an additional one mile of upstream habitat, it represents the best solution for protecting sturgeon given the current conditions, provides the potential for future sturgeon passage, and does not impede recovery.

The continued authorization of diversions by ADD under the proposed action will lead to a 46.9% relative change in potentially available spawning habitat for Savannah River population of Atlantic sturgeon at the Augusta Shoals (see Table 17, *Undiverted vs. MAB Flow*), relative to no flow being diverted into the Augusta Canal. These continued diversions, and resulting reductions in the potential spawning habitat, will perpetuate both threats to recovery listed previously and will likely slow the overall recovery of the Savannah River population of Atlantic sturgeon. However, while continued diversions into the Augusta Canal will likely slow the overall recovery, the implementation of the *MAB flow* does provide some incremental support to alleviate threats 1(a) and 2. The minimum flow reservations will restore flows and make slightly more spawning habitat available for Atlantic sturgeon (absolute change pWUA +0.4%; relative change pWUA +21.8%, Table 17) overall, relative to existing conditions. Their implementation will also increase water quantity (i.e., flows) to Augusta Shoals, which will prevent harmful ultra-low flow scenarios and increase the availability of spawning and nursery habitat.

Coupled with fish passage at NSBL&D providing first-time access in generations to suitable and marginally suitable spawning habitats, we anticipate the implementation of the minimum flow reservations will improve spawning conditions for, and the survival rate of, Atlantic sturgeon offspring in the Savannah River. We expect increased spawning success will in turn increase recruitment success rates once sturgeon can access the habitat. Nursery habitat for early life stages of larval sturgeon will also be improved through increased flow and water quality. Eggs/larvae will have additional time to grow and develop physiological tolerances prior to reaching the saltwater interface. Access to additional spawning habitats may also decrease the likelihood of egg predation, increasing annual recruitment. Therefore, while the proposed action will perpetuate some of the existing threats to recovery of the Savannah River population of Atlantic sturgeon, slowing recovery overall, we do not anticipate it will appreciably reduce the likelihood of its recovery in the wild or the larger South Atlantic DPS.

Although the proposed action includes fish passage, NMFS does not believe it is beneficial for Atlantic sturgeon to be above the ADD at this time. In the future, if we determine it is beneficial for sturgeon to be above the ADD, the spoiler/baffle plate in the vertical slot fishway can be removed, allowing Atlantic sturgeon access the additional 1 mi of spawning habitat above the dam. Thus, while the proposed action perpetuates the first threat listed previously, the requisite minimum base flows represent the best option for protecting sturgeon given the current conditions.

9 CONCLUSION

We reviewed the Status of the Species, the Environmental Baseline, the Effects of the Action, and the Cumulative Effects using the best available data. The proposed action will result in the take of shortnose sturgeon and the South Atlantic DPS of Atlantic sturgeon. Given the nature of the proposed action and the information provided above, we conclude that the action, as proposed, is not likely to jeopardize the continued existence of shortnose sturgeon and or the South Atlantic DPS of Atlantic sturgeon, based on the impacts to the populations of these species in the Savannah River.

10 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 (ESA Section 2(19)). *Incidental take* refers to takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that would otherwise be considered prohibited under Section 9 or Section 4(d) but which is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the Reasonable and Prudent Measures (RPM) and the Terms and Conditions of the Incidental Take Statement of the Opinion.

As soon as the FERC or the city of Augusta becomes aware of any take of an ESA-listed species under NMFS's purview that occurs during the proposed action, they shall report the take to NMFS SERO PRD via the NMFS SERO Endangered Species Take Report Form (https://forms.gle/85fP2da4Ds9jEL829). This form shall be completed for each individual known reported capture, entanglement, stranding, or other take incident. Information provided via this form shall include the title, Licensing of the Augusta Canal Project, the issuance date, and ECO tracking number, (SERO-2012-00004), for this Opinion; the species name; the date and time of the incident; the general location and activity resulting in capture; condition of the species (i.e., alive, dead, sent to rehabilitation); size of the individual, behavior, identifying features (i.e., presence of tags, scars, or distinguishing marks), and any photos that may have been taken.

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

10.1 Extent of Anticipated Take

Despite conservation measures aimed at reducing the negative impacts of this project to shortnose and Atlantic sturgeon, NMFS anticipates that the proposed action could potentially result in incidental take of adults of these listed species in the form of harm through reduced habitat availability and suitability, as well as non-lethal injury. We also anticipate some unquantifiable amount of takes for eggs/larvae may occur over the course of the license. Table 19 summarizes the types of take, the species and life stages affected, the extent of take, and where we anticipate these effects will occur. Per our assessment, once effective fish passage is operational at the NSBL&D and sturgeon can access the habitat up to the ADD, 100% of the adult spawning Atlantic and shortnose sturgeon in the Savannah River may be harmed by blocked access to upstream spawning habitat and reduced spawning habitat suitability downstream. While the actual flow over the Augusta Shoals is expected to be higher than the daily minimum aquatic base flows a majority of the time, even at the minimum flows of 1,500–3,300 cfs, the available spawning habitat in the Augusta Shoals is expected to be 25% and 26.5% suitable for Atlantic and shortnose sturgeon, respectively. We anticipate a potential 26% and 37% reduction in spawning habitat suitability for shortnose and Atlantic sturgeon, respectively, relative to undiverted flows.

Further, up to 2% of the estimated adult spawning population of shortnose and Atlantic sturgeon may enter the proposed ADD fishway annually. Of the fish entering the fishway, 8.4% may experience temporary and minor stress or injury by contacting the fishway structure or other fish in the fishway during the term of the new license, which shall not exceed 50 years. Therefore, 0.168% (8.4% of 2%) of the estimated adult spawning population of shortnose and Atlantic sturgeon may enter the proposed ADD fishway annually and experience harm from contacting the structure or other fish in the fishway over the course of the 50-year license. No lethal take of any shortnose sturgeon or Atlantic sturgeon in the ADD fishway is authorized during this project.

NMFS assumes the population of shortnose sturgeon in the Savannah River on an annual basis is 1,865 adults (Bahr and Peterson 2017). We assume there are 300 adult Atlantic sturgeon spawning in the Savannah River annually (75 FR 61904; October 6, 2010). Therefore, a maximum of 38 shortnose sturgeon (2% of 1,865, rounded up to the nearest whole number) and 6 Atlantic sturgeon (2% of 300) may enter the fishway per year. Of those fish, 4 shortnose (8.4% of 38 fish potentially entering the ADD fishway, rounded up to the nearest whole number) and 1 Atlantic sturgeon (8.4% of 6 fish potentially entering the ADD fishway, rounded up to the nearest whole number) could experience minor and temporary injuries or stress from attempting to pass the proposed fishway at the ADD. The extent of take will initially be set at 4 shortnose sturgeon and 1 Atlantic sturgeon to be non-lethally taken each year in the fish passage facility (once operational) unless and until additional information becomes available indicating a change in the assumed populations of shortnose or Atlantic sturgeon present in the Action Area, as shown in Table 19.

Beyond the takes anticipated for adult Atlantic and shortnose sturgeon noted previously, we also anticipate an unquantifiable number of takes of eggs/larvae may occur during the course of the license. While we are able to anticipate the types of habitat sturgeon are likely to use for spawning, we are not currently able to estimate the numbers of individuals likely to use the area for spawning or to predict the discrete locations where sturgeon lay their eggs. Thus, we cannot quantitatively determine how many eggs/larvae will be affected. However, we are able to monitor those adverse effects via a take proxy (i.e., WUA), prescribe RPMs that are necessary or appropriate to minimize such impact, and sets forth the Terms and Conditions (including, but not limited to, reporting requirements).

The effects we anticipate are primarily caused when habitat where eggs have been laid or larvae hatched becomes unsuitable (e.g., dewatered). Since the death of individual eggs or larvae cannot be monitored directly, monitoring the factors that affect the habitat's suitability is appropriate. We believe WUA is the most appropriate metric for measuring habitat suitability. Table 13 allows us to estimate WUA based on the flows at the Augusta Shoals. Therefore, we believe monitoring the flows at the Augusta Shoals will allow us to directly determine relative changes in the amount of suitable habitat (via WUA).

The RPMs and Terms and Conditions of this Opinion require proper gauging equipment to be installed that will allow us to monitoring flows, and ultimately WUA, at the Augusta Shoals. If we determine flows are falling below those prescribed in the biological Opinion, aside from the instances for deviation allowed via the 2008 draft settlement agreement, we believe that will also be a reflection that suitable habitat is not being maintained. We believe this is an indication that the anticipated impacts to eggs/larvae at the Augusta Shoals is greater than previously considered and reinitiation of consultation will be required.

Table 19. Anticipated Annual Take of Shortnose and Atlantic Sturgeon (Once fish passage is operational at NSBL&D)

Species	Life Stage	Take Activity	Amount or Extent of Take	Location
Shortnose sturgeon	Adult	Minor and temporary injury as a result of unsuccessfully attempting to pass upstream in the ADD fishway	Annually, 0.168% of the annual number of spawners, rounded up to the nearest whole number i.e., 4 shortnose sturgeon (0.168% x 1,865 fish = 3.13 fish)	ADD fishway
Atlantic sturgeon	Adult	Minor and temporary injury as a result of unsuccessfully attempting to pass upstream in the ADD fishway	Annually, 0.168% of the annual number of spawners, rounded up to the nearest whole number i.e., 1 Atlantic sturgeon (0.168% x 300 fish = 0.504 fish)	ADD fishway
Shortnose sturgeon AND Atlantic sturgeon	Adult	Blocked access to upstream spawning habitat within the Savannah River	Annually, 100% of the spawning adults	1-mile segment of the Savannah River above the ADD and below the Stevens Creek Dam
Shortnose sturgeon	Adult	Reduction in availability and suitability of downstream spawning habitat due to diversion of water into the Augusta Canal	Annually, 100% of the spawning adults experience a maximum of 32% reduction in spawning habitat suitability when flows are greater than 1,800 cfs between February and April, and greater than 1,500 cfs during the rest of the year	5.75-mile segment of the Savannah River below the ADD to the tailrace of the Enterprise Mill
Atlantic sturgeon	Adult	Reduction in availability and suitability of downstream spawning habitat due to diversion of water into the Augusta Canal	Annually, 100% of the spawning adults experience a maximum of 47% reduction in spawning habitat suitability when flows are greater than 1,800 cfs between February and April, and greater than 1,500 cfs during the rest of the year	5.75-mile segment of the Savannah River below the ADD to the tailrace of the Enterprise Mill
Shortnose sturgeon AND Atlantic sturgeon	Eggs/Larvae	Reduced survival of early life stages	Not directly quantifiable– Extent of take assessed through surrogate monitoring in RPM #2	5.75-mile segment of the Savannah River below the ADD to the tailrace of the Enterprise Mill

10.2 Effect of Take

NMFS has determined that the anticipated incidental take specified in Section 10.1 is not likely to jeopardize the continued existence of shortnose sturgeon or the South Atlantic DPS of Atlantic sturgeon, if the project is developed as proposed and follows the RPM and Terms and Conditions described herein.

10.3 Reasonable and Prudent Measures

Section 7(b)(4) of the ESA requires NMFS to issue to any federal agency whose proposed action is found to comply with Section 7(a)(2) of the ESA, but may incidentally take individuals of listed species, a statement specifying the impact of that taking. The Incidental Take Statement must specify the RPMs necessary or appropriate to minimize the impacts of the incidental taking from the proposed action on the species, and Terms and Conditions to implement those measures. RPMs refers to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species" (50 CFR 402.02). Per Section 7(o)(2), any incidental taking that complies with the specified Terms and Conditions is not considered to be a prohibited taking of the species concerned.

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

NMFS has determined that the following RPMs are necessary and appropriate to minimize impacts of the incidental take of ESA-listed species related to the proposed action. RPMs and implementing Terms and Conditions cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes (50 CFR 402.14(i)(v)(2)). The daily minimum aquatic base flows were established prior to the listing of the South Atlantic DPS of Atlantic sturgeon. As a result, potential effects of the continued operation of the Augusta Canal on the South Atlantic DPS of Atlantic sturgeon were never considered. That omission is clearly visible in the daily minimum aquatic base flows. While those flows provide some assurance that Augusta Shoals will receive ecologically functional flows during the time of year when shortnose sturgeon may be spawning (i.e., January 1 – April 30), the same is not true for Atlantic sturgeon (i.e., April 1 – May 31; July 1 – October 31).

As noted in Section 10.1, we anticipate 100% of spawning adult Atlantic sturgeon will be adversely affected by continued water diversion into the Augusta Canal, relative to if the project was not reauthorized. To reduce the impacts from those adverse effects, this Opinion will require a minor change to the daily minimum aquatic base flows as an RPM. The RPM will yield measurable benefit to listed sturgeon, while not altering the basic design, scope, duration, or timing of the proposed action.

NMFS has determined the following RPMs are necessary or appropriate to minimize the impacts of the amount or extent of incidental take of shortnose and Atlantic sturgeon and to monitor levels of incidental take as FERC licenses the Augusta Canal Project for the next 50 years.

As described in Section 3.4.2, fish passage at NSBL&D is required to comply with the requirements of WIIN Act of 2016. With its construction, NMFS anticipates sturgeon will have access to the shoal habitat near ADD during the 30-year to 50-year authorization period of the FERC license issued for the Augusta Canal Project. Thus, the following RPMs and implementing Terms and Conditions are required. However, because these actions are intended to minimize potential adverse effects to sturgeon occurring upstream of NSBL&D, the RPMs and their implementing Terms and Conditions do not need to be implemented until fish passage at NSBL&D is operationally able to pass sturgeon. NMFS will monitor construction of the fish passage and notify FERC and applicant when it is operational.

10.3.1 RPM #1 – Maximum Water Diversion into Augusta Canal not to Exceed 3,500 cfs

In Section 6.2, we established a causal relationship between flow diversion into the Augusta Canal and pWUA/WUA for sturgeon. For every increase in flow to the shoals, there was a concomitant increase in pWUA/WUA values (Figure 13). Conversely, as more water is diverted, less is available to go to the shoals, reducing pWUA/WUA values. As described in Section 10.1, we anticipated adverse effects are likely to occur to sturgeon because the water diversions reduce habitat availability. We believe the magnitude of these adverse effects can be diminished by reserving more water for the shoals, increasing pWUA/WUA values. Based on our analysis, we could eliminate the anticipated adverse effects to sturgeon caused by flow diversion by requiring all diversions into the Augusta Canal be stopped, reserving all flow for the Augusta Shoals. However, our regulations do not require that adverse effects be eliminated only minimized and requiring the cessation of flow diversions would clearly alter the basic design, location, scope, duration, or timing of the proposed action. Thus, we sought a way to maximize flow to the shoals while simultaneously preserving flows necessary for the Augusta Canal.

Our review of the observed flow data from 1996–2019 determined that on 99.98% of days, flows diverted into Augusta Canal were less than 3,500 cfs; only once during that period did flow into the Augusta Canal reach 4,000 cfs (0.02% of days). Based on this historical data, we believe that even though the technical capacity of the Canal is 6,900 cfs, its functional capacity is significantly less. Thus, we conclude that even under the action as proposed, the Augusta Canal would not receive over 3,500 cfs 99.98% of the time. By establishing a 3,500 cfs cap, we ensure more flow to shoals, which reduces the adverse effects to sturgeon. Neither the proposed action, nor the RPMs, and implementing Terms and Conditions of this Opinion, require any physical modifications (e.g., dredging, shoreline hardening, or other construction activities) to the Augusta Canal that would alter its hydraulic capacity.

Based on this information, we establish an RPM and implementing Terms and Conditions in this Opinion to set a cap of 3,500 cfs for the Augusta Canal inflow. This provides the Augusta Canal with its maximum (99.98-th percentile) historical flow requirements for normal operations. This approach also more formally establishes the Augusta Shoals as the recipient of flows exceeding the Augusta Canal's functional capacity, consistent with observed historical maximal use. For example, when an incoming flow of 11,000 cfs arrives at the ADD, this RPM would cap flow diversion into the Augusta Canal at no more than 3,500, with the remaining 7,500 cfs set aside for the shoals. While we expect that this allocation is what would functionally occur under the minimum daily aquatic base flows, requiring it via the RPMs and implementing Terms and Conditions of this Opinion ensures the risk to sturgeon from diverted flows is further minimized.

10.3.2 RPM #2 – Determining, Allocating, and Monitoring Water Flows into Augusta Canal and Over the ADD

While establishing the 3,500 cfs cap will reduce adverse effects to sturgeon by ensuring more water is routed to the shoals, coupling that action with flow allocation protocols will further reduce adverse effects by ensuring excess water is specifically allocated to the shoals.

Determining Future Flow Arriving at ADD

The first step in allocating flows for the shoals is to determine likely flows arriving at the ADD, a process described as the "Augusta Declaration" in the 2008 draft settlement agreement. The Augusta Declaration is the sum of the daily flow declaration from JST and the daily tributary inflow. Daily tributary inflows are calculated by using available data from the USGS gage at Modoc (USGS No. 02196000)[22] and applying a scaling factor. Because the Augusta Declaration only considers daily flows, the daily minimum aquatic base flows required in these RPMs are also daily averages, not instantaneous flows. As described below, flow estimates are required to be set only once daily, based on the protocols described in the 2008 draft settlement agreement.

For illustrative purposes, this is how the Augusta Declaration would have been calculated for October 20, 2023. First, the daily average flow release projected from JST must be identified. Figure 19 reports the flow "declaration" of the actual past and anticipated future average daily flow releases from the three reservoirs USACE manages on the Savannah River, including JST, from October 4 to October 20, 2023. The anticipated flow to be released from JST on October 20, 2023 was 4,020 cfs (blue number) (Figure 20).

Next, the flow reported at the USGS gage at Modoc for the day in question (in this example Oct 20, 2023) must be determined (Figure 21); in this example, that is 17.9 cfs. Then a scaler (1.85) is applied to the flows recorded by the USGS gage at Modoc to account for additional inflows. Together, the JST flows and scaled Modoc flows establish the flows anticipated to arrive at ADD. In this example, Augusta Declaration for October 20, 2023, would have been 4,053[23], a Tier 3 Flow.

[22] USGS gage 02196000 at Modoc - http://waterdata.usgs.gov/sc/nwis/dv/?site_no=02196000&PARAmeter_cd=00060,00065

[23] 4,020 cfs releases from JST + 33.115 cfs adjust Modoc contributions (17.9 cfs reported by USGS gage 02196000 at Modoc*1.85 scaler) = 4,053 cfs

To: SEPA
To: CESAD
From: (CESAS-EN-H)

1 Week Declaration
SAVANNAH RIVER SYSTEM
Revised 10/11/2023 13:48

1 Reset=0	0:00	
Usable Pump Window(HRS)		10.00
Iteration Increment		10.00
TGen (Sched/Observed)		0.982
Allowed Imbalance		0.00

Project	Date	0:00 SOP POOL (FT-MSL)	RULE CURVE (FT-MSL)	STARTING STORAGE (AC-FT)	NET TOTAL INFLOW (CFS)	LOCAL IN (CFS)	NATURAL IN (CFS)	GEN TOTAL OUT (CFS)	TOTAL SPILL (CFS)	EST GEN (MWH)	DAILY TOTAL MIN GEN (MWH)	DAILY TOTAL MAX GEN (MWH)	EST PUMP (AC-FT)	ENDING STORAGE (AC-FT)	COMP ENDING POOL (FT-MSL)	RAINFALL (INCHES)	Hart Inf / HART	RBR Inf / RBR	JST Inf / JST
HARTWELL	Wed 04-Oct-2023	655.23	660.00	2294222	1289	1289	1289	1454	0	451			n/a	2293895	655.22	0.00	660.00	472.50	329.00
	Thu 05-Oct-2023	655.23	660.00	2294222	268	268	268	1472	0	457			n/a	2291832	655.18	0.00	500	-250	300
	Fri 06-Oct-2023	655.21	660.00	2293194	-763	-763	-763	1479	0	462			n/a	2288742	655.12	0.00			
	Sat 07-Oct-2023	655.15	660.00	2290110	-427	-427	-427	0	0	0			n/a	2289261	655.13	0.00	0.00	0.00	0.00
	Sun 08-Oct-2023	655.16	660.00	2290624	-947	-947	-947	0	0	0			n/a	2288743	655.12	0.00	0.6	0.6	0.6
	Mon 09-Oct-2023	655.15	660.00	2290110	-328	-328	-328	2954	0	930			n/a	2283591	655.02	0.00		7250	
	Tue 10-Oct-2023	655.05	660.00	2284970	564	564	564	2798	0	877	25	25	n/a	2280534	654.96	0.00		0	
	Wed 11-Oct-2023	654.99	660.00	2281894	1131	500	1131	2800	0	873	848	898	n/a	2278579	654.92	0.20			
	Thu 12-Oct-2023	654.92	660.00	2278579	1131	500	1131	3500	0	1091	1066	1116	n/a	2273875	654.83				
	Fri 13-Oct-2023	654.83	660.00	2273875	1203	572	1203	3500	0	1091	1066	1116	n/a	2269314	654.74	0.10			
	Sat 14-Oct-2023	654.74	660.00	2269314	1131	500	1131	0	0	0	0	25	n/a	2271560	654.78				
	Sun 15-Oct-2023	654.78	660.00	2271560	1131	500	1131	0	0	0	0	25	n/a	2273806	654.83				
	Mon 16-Oct-2023	654.83	660.00	2273806	1131	500	1131	3700	0	1153	1128	1178	n/a	2268704	654.72				
	Tue 17-Oct-2023	654.72	659.93	2268704	1131	500	1131	3700	0	1153	1128	1178	n/a	2263602	654.63				
	Wed 18-Oct-2023	654.63	659.87	2263602	1131	500	1131	3700	0	1153	1128	1178	n/a	2258500	654.53				
	Thu 19-Oct-2023	654.53	659.80	2258500	1131	500	1131	3700	0	1153	1128	1178	n/a	2253398	654.43				
	Fri 20-Oct-2023	654.43	659.74	2253398	1131	500	1131	3700	0	1153	1128	1178	n/a	2248296	654.33				
					NET	LOC	NAT			GEN	MIN	MAX					PUMP HR	PUMP CFS	AVL UNITS
RUSSELL	Wed 04-Oct-2023	473.58	475.00	0988920	1166	-288	1001	4041	0	1114			0	983209	473.36		0	0	1
	Thu 05-Oct-2023	473.36	475.00	0983231	1342	-130	139	4075	0	1120			0	977804	473.15		0	0	1
	Fri 06-Oct-2023	473.15	475.00	0977823	983	-496	-1259	4091	0	1125			0	971650	472.91		0	0	1
	Sat 07-Oct-2023	472.91	475.00	0971670	0	0	-427	0	0	0			0	971670	472.91		0	0	1
	Sun 08-Oct-2023	472.91	475.00	0971670	-258	-258	-1205	0	0	0			0	971157	472.89		0	0	1
	Mon 09-Oct-2023	472.89	475.00	0971159	2707	-247	-575	4128	0	1140			0	968338	472.78		0	0	1
	Tue 10-Oct-2023	472.78	475.00	0968350	2492	-306	258	4168	0	1151	50	50	0	965023	472.65		0	0	1
	Wed 11-Oct-2023	472.65	475.00	0965038	3050	250	1381	3880	0	1085	1035	1135	0	963390	472.59	0.10	0	0	1
	Thu 12-Oct-2023	472.59	475.00	0963390	3750	250	1381	6705	0	1875	1825	1925	0	957521	472.35		0	0	1
	Fri 13-Oct-2023	472.35	475.00	0957521	3500	0	1203	6705	0	1875	1825	1925	0	951156	472.10	0.10	0	0	1
	Sat 14-Oct-2023	472.10	475.00	0951156	-100	-100	1031	0	0	0	0	50	0	950957	472.09		0	0	1
	Sun 15-Oct-2023	472.09	475.00	0950957	-200	-200	931	0	0	0	0	50	0	950560	472.08		0	0	1
	Mon 16-Oct-2023	472.08	475.00	0950560	3450	-250	881	0	0	0	0	50	0	957412	472.35		0	0	0
	Tue 17-Oct-2023	472.35	475.00	0957412	3450	-250	881	0	0	0	0	50	0	964263	472.62		0	0	0
	Wed 18-Oct-2023	472.62	475.00	0964263	3450	-250	881	0	0	0	0	50	0	971115	472.89		0	0	0
	Thu 19-Oct-2023	472.89	475.00	0971115	3450	-250	881	0	0	0	0	50	0	977967	473.16		0	0	0
	Fri 20-Oct-2023	473.16	475.00	0977967	3450	-250	881	0	0	0	0	50	0	984818	473.42		0	0	0
					NET	LOC	NAT			GEN	MIN	MAX					0		
THURMOND	Wed 04-Oct-2023	325.20	330.00	2174000	4558	517	1518	4256	0	1054			0	2174601	325.21		0.31	0.28	0.25
	Thu 05-Oct-2023	325.21	330.00	2174700	3690	-385	3690	3690	0	910			0	2174700	325.21		0.31	0.27	0.25
	Fri 06-Oct-2023	325.22	330.00	2175400	4195	104	4195	4800	0	1194			0	2174198	325.20		0.31	0.28	0.25
	Sat 07-Oct-2023	325.24	330.00	2176800	-644	-644	-644	4196	0	1030			0	2167188	325.10		0.31	0.29	0.25
	Sun 08-Oct-2023	325.09	330.00	2166300	-546	-546	-546	4294	0	1043			0	2156668	324.94		0.31	0.29	0.24
	Mon 09-Oct-2023	324.92	330.00	2155200	2810	-1318	2810	4322	0	1050			0	2152196	324.87		0.31	0.28	0.24
	Tue 10-Oct-2023	324.87	330.00	2152200	5449	1281	5449	4239	0	1048	3600	30000	0	2154603	324.91		0.31	0.28	0.25
	Wed 11-Oct-2023	324.87	330.00	2152200	4230	350	4230	4200	0	1015	1015	1015	0	2152260	324.87	0.25	0.31	0.28	0.24
	Thu 12-Oct-2023	324.87	330.00	2152260	7005	300	7005	4200	0	1015	1015	1015	0	2157830	324.96		0.31	0.28	0.24
	Fri 13-Oct-2023	324.96	330.00	2157830	7048	343	7048	4200	0	1015	1015	1015	0	2163487	325.05	0.10	0.31	0.28	0.24
	Sat 14-Oct-2023	325.05	330.00	2163487	300	300	300	4020	0	971	971	971	0	2156099	324.93		0.31	0.28	0.24
	Sun 15-Oct-2023	324.93	330.00	2156099	300	300	300	4020	0	971	971	971	0	2148712	324.81		0.31	0.28	0.24
	Mon 16-Oct-2023	324.81	330.00	2148712	300	300	300	4020	0	971	971	971	0	2141324	324.69		0.31	0.28	0.24
	Tue 17-Oct-2023	324.69	329.93	2141324	300	300	300	4020	0	971	971	971	0	2133936	324.57		0.31	0.28	0.24
	Wed 18-Oct-2023	324.57	329.87	2133936	300	300	300	4020	0	971	971	971	0	2126548	324.44		0.31	0.28	0.24
	Thu 19-Oct-2023	324.44	329.80	2126548	300	300	300	4020	0	971	971	971	0	2119160	324.32		0.31	0.28	0.24
	Fri 20-Oct-2023	324.32	329.74	2119160	300	300	300	4020	0	971	971	971	0	2111772	324.20		0.31	0.28	0.24
		SOP POOL (FT-MSL)	RULE CURVE (FT-MSL)	STARTING STORAGE (AC-FT)		LOCAL IN (CFS)	NATURAL IN (CFS)	TOTAL OUT (CFS)	TOTAL SPILL (CFS)	EST GEN (MWH)	MIN GEN (MWH)	MAX GEN (MWH)	EST PUMP (AC-FT)	ENDING STORAGE (AC-FT)	ENDING POOL (FT-MSL)		HART Gen/Q	0.28 Gen/Q	THUR Gen/Q
				Local this week =>		-49	-246	-142	4257	1047							0.31	0.28	0.25
																		0.00	

		Hartwell	Russell	Thurmond
Weekly Generation Totals --->		5765	0	6797
for week beginning	Sat 14-Oct	Hartwell	Russell	Thurmond
Weekly Average Discharge		2643	0	4020
Previous Week Gen Total Targets		4420	5305	7147
for week beginning	Sat 7-Oct	4862	7126	7216
Weekly Average Discharge		2222	3655	4236
Delta Gen this week =>		442	1821	69
Local next week =>		500	-221	300

Week ending Fri 13-Oct-23

27304 (MW-HR) Contracted
16872 Originally Declared
19204 Generated
-8100 (MW-HR) Short of Contract
0 (unit-hours) Pumping

Week ending Fri 20-Oct-2023

27304 (MW-HR) Contracted
12562 (MW-HR) Declared
-14742 (MW-HR Short of Contract

Ending Pool Babance 0.13 ft
80 unit-hours Contracted next week
0 unit-hours Pumping next Week
5200(MW-HR) contracted from pumping
0.982 Schedule/Gen Ratio

REMARKS

SEPA - Please target a minimum of 4 hour pumptime for each pump unit used
SEPA - Please stay between daily max and min generation targets for each project
Santee Line Outage RBR 9/11 - 10/19, Reduced Pumping
GPC Line Outage RBR 10/2 - 11/10, No Pumping
Complete Plant outage RBR, Cable Replacement Draft Tube 10/16 - 10/27

(Sunset/Sunrise Calculation) http://aa.usno.navy.mil/data/docs/RS_OneYear.html

Hourly Pumping Schedule

Start		End		Unit-Hours
Wed 10/11 20:00	CDT	Thu 10/12 05:00	CDT	0
Thu 10/12 20:00	CDT	Fri 10/13 05:00	CDT	0
Fri 10/13 19:00	CDT	Sat 10/14 05:00	CDT	0
Sat 10/14 19:00	CDT	Sun 10/15 05:00	CDT	0
Sun 10/15 19:00	CDT	Mon 10/16 05:00	CDT	0
Mon 10/16 19:00	CDT	Tue 10/17 05:00	CDT	0
Tue 10/17 19:00	CDT	Wed 10/18 05:00	CDT	0
Wed 10/18 19:00	CDT	Thu 10/19 05:00	CDT	0
Thu 10/19 19:00	CDT	Fri 10/20 05:00	CDT	0
Fri 10/20 19:00	CDT	Sat 10/21 05:00	CDT	0

Figure 19. Example of reported past and anticipated future, flow releases from the three reservoirs managed by the USACE on the Savannah River, from October 4 to October 20, 2023 (Available from https://water.sas.usace.army.mil/gmap/; data queried 10/20/2023)

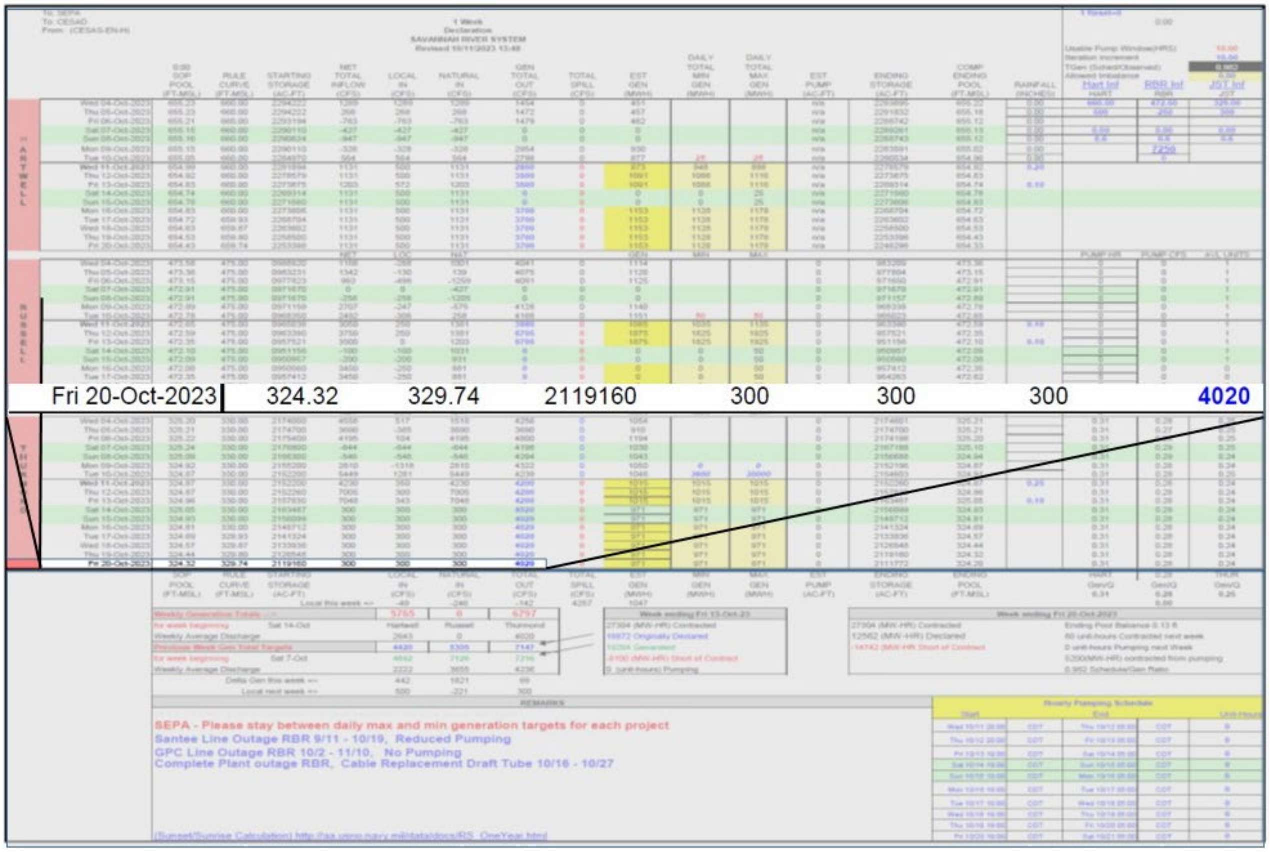

Figure 20. Example of the anticipated average daily flow release from JST for October 20, 2023 (Available from https://water.sas.usace.army.mil/gmap/; data queried 10/20/2023)

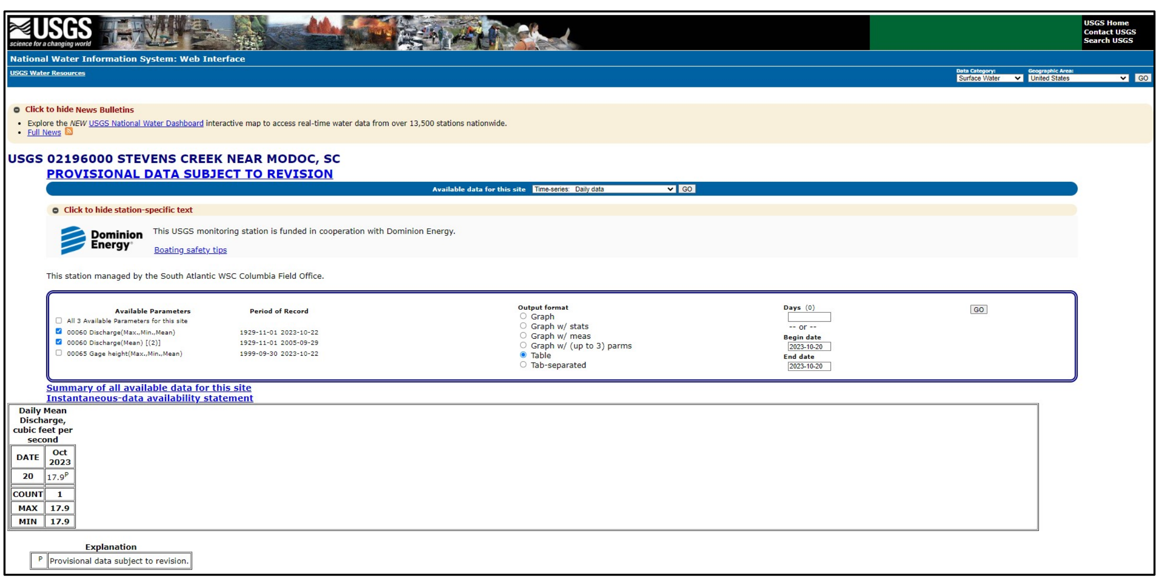

Figure 21. Example of flows reported by the USGS gage 02196000 at Modoc for October 20, 2023 (Available from http://waterdata.usgs.gov/sc/nwis/dv/?site_no=02196000&PARAmeter_cd=00060,00065; data queried 10/23/2023)

Allocating Flows to the Shoals and Augusta Canal
With anticipated flow arriving at ADD established, flows could be allocated in accordance with the *MABs*. To minimize adverse effects to sturgeon, flow allocation prioritization should mirror the process described in (Entrix 2003), where meeting the obligations of the flows set aside for the Augusta Shoals under the *MABs* (Table 20) are prioritized first, with all remaining flows (up to 3,500 cfs) available for the Augusta Canal. When flow arriving at the ADD exceed the sum of *MAB*s and canal needs (up to 3,500 cfs), no further management action would be required; we expect excess flows would go to the Shoals. For much the year, the flows arriving at the ADD should be sufficient to meet the flow needs in the Augusta Canal and the minimum flow requirements for the Augusta Shoals. While we expect this allocation is what would functionally occur under the *MAB* flows, requiring it via the RPMs and implementing Terms and Conditions of this Opinion ensures the risk to sturgeon from diverted flows is further minimized.

Monitoring Flow
To ensure the 3,500 cfs cap established via RPM #1 is not exceeded, water quantities passing over the ADD within the Savannah River and diverted into the Augusta Canal must be monitored. Monitoring will ensure compliance with the 3,500 cfs cap and the reserved aquatic base flows and other terms of the new license to ensure the protection of sturgeon and their habitat in the Augusta Shoals.

10.3.3 RPM #3 – Minor Change to Minimum Aquatic Base Flows to Protect Atlantic Sturgeon

The minimum daily aquatic base flows establish a tiered flow allocation system based on the amount of undiverted flow arriving at the ADD. The minimum daily aquatic base flows set aside specific flow amounts for the Augusta Shoals depending upon arriving flow and time of year. While some effort was made to ensure adequate flows to the Augusta Shoals are maintained during the time of year when shortnose sturgeon may be spawning, the same is not true for Atlantic sturgeon. As a result, we estimate 100% of Atlantic sturgeon (i.e., spawning adults, eggs and larvae) present in the Augusta Shoals will be adversely affected by flow diversions into the Augusta Canal, because flow diversions reduce the amount of spawning habitat available and overall conditions of that habitat, causing harm.

There is a strong biological/ecological basis for diverting all flows to Shoals, bypassing the canal completely. Figure 13 clearly illustrates that it would be most beneficial to shortnose and Atlantic sturgeon if all flows went to the Shoals. The WUA for both species continues to increase as flow increases up to 7,800 cfs, with some incremental increases providing greater increases in WUA. After evaluating the competing water needs (e.g., municipal water supply, hydroelectric power generation, biological/ecological needs), our required change ensures flows are available for all these needs, including flows for Augusta Shoals during the Atlantic sturgeon spawning season (i.e., April 1 – May 31; July 1 – October 31). As noted previously, our regulations do not require that adverse effects be eliminated only minimized. Thus, we sought a way to maximize flow to the shoals while simultaneously preserving flows necessary for the Augusta Canal.

This change will confer substantial additional protection to spawning adult Atlantic sturgeon and their eggs/larvae. Ultimately, we determined increasing the minimum flow for the Augusta Shoals to 1,800 cfs (up from 1,500 cfs) during spawning months for Atlantic sturgeon (April 1 – May 31; July 1 – October 31), for Tiers 2–4, was appropriate. Figure 22 clearly illustrates the largest increase in pWUA occurs between 1,500 to 1,800 cfs. This 1,800 cfs minimum is consistent with the previously agreed upon minimum reservation of 1,800 cfs during shortnose sturgeon spawning months from the daily minimum aquatic base flows. The daily minimum aquatic base flows under this RPM, following implementation of this change, are reported in Table 20 (changes highlighted in blue).

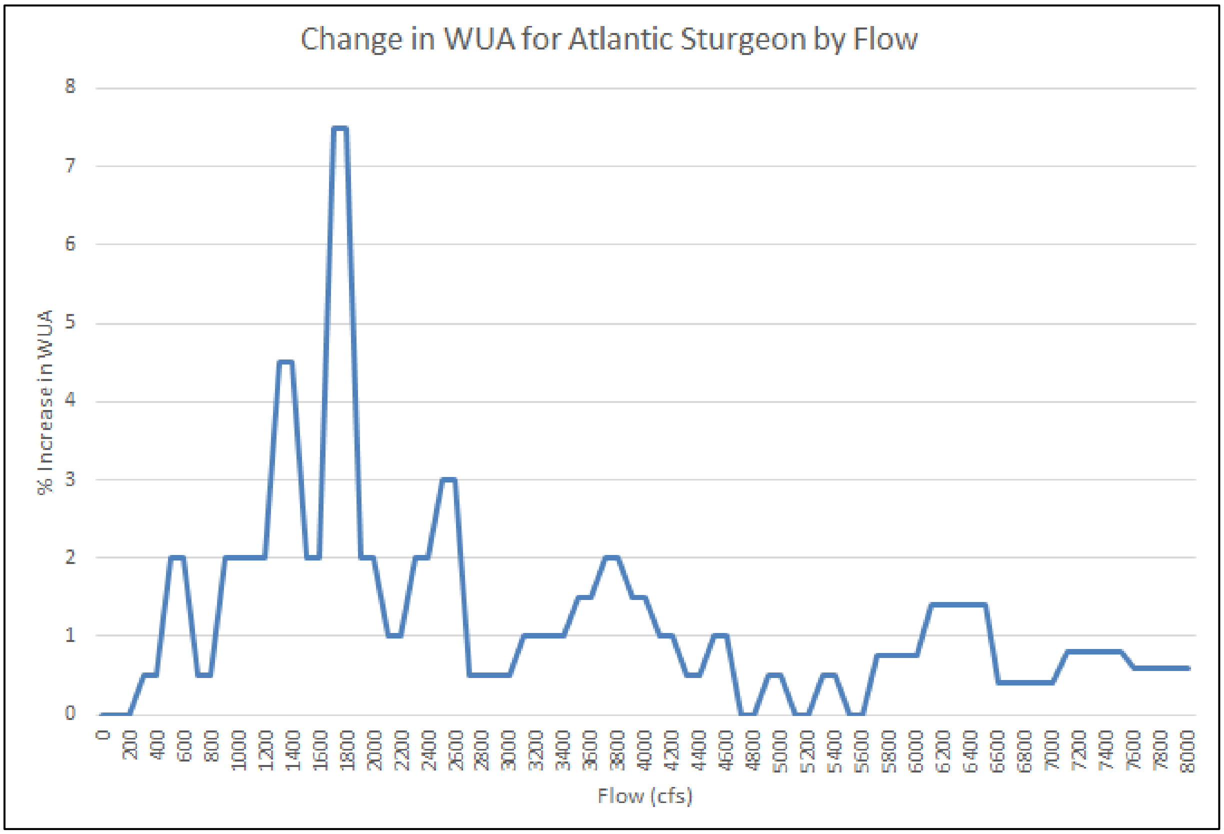

Figure 22. Changes in pWUA for Atlantic Sturgeon by Flow

Table 20. Minimum Daily Aquatic Base Flows by Tier and Month under RPM #3 (Changes from Original Minimum Aquatic Base Flows Denoted in Blue)

Incoming Flow Tier (cfs)		**Feb-Mar**	**April**	**May 1-15**	**May 16-31**	**June**	**July-Oct**	**Nov-Jan**
Tier 1	≥5,400	3,300	3,300	2,500	1,900	1,900	1,900	1,900
Tier 2	4,500–5,399	2,300	2,200	1,800	1,800	1,500	1,800	1,500
Tier 3	3,600–4,499	2,000	2,000	1,800	1,800	1,500	1,800	1,500
Tier 4	<3,600	1,800	1,800	1,800	1,800	1,500	1,800	1,500

Increasing the minimum flow from 1,500 to 1,800 cfs during spawning months for Atlantic sturgeon (denoted in blue in Table 20) would increase the overall pWUA across all 4 flow tiers from 42% under *MAB Flow* to 51% under our minor change (*"NMFS RPM Flow"*). This is a statistically significant increase of approximately 9% (t = 56.6, df = 3055, p < 0.0001) (Table 21, Figure 23). While the increases in WUA are statistically significant for all tier flows, the greatest benefits occur during the lower flow conditions. For Tier 3, the *NMFS RPM Flow* would increase the pWUA from 27.7% under *MAB Flow* to 40.9% pWUA, an absolute change of +13.2% and a relative change of +47.5% (Table 22). We estimate these changes will also increase spawning habitat from 9,879.4 ft^2/1,000 ft under *MAB Flow* to 14,484 ft^2/1,000 ft (Table 21). Under Tier 4 flows, *NMFS RPM Flow* would increase pWUA from 25.9% under *MAB Flow* to 40.3% pWUA (Table 21), an absolute change of +14.4% and a relative change of +55.6% (Table 22).

Under the daily minimum aquatic base flows, we estimated an absolute change of -37.3% of habitat available to Atlantic sturgeon, on average, across all 4 flow tiers relative to *Undiverted Flows* (i.e., no flow diversion into Augusta Canal) (Table 14), which corresponds to a relative change of -46.9% (Table 17). Under *NMFS RPM Flow*, we estimate both the absolute and relative losses in habitat availability will be lower. We anticipate an absolute change of -28.6% of available habitat, on average, across all 4 flow tiers relative to *Undiverted Flow* conditions (Figure 24, Table 21), which corresponds to a relative change of -36.0% (Table 22). Thus, this minor change in the flows is effective at minimizing the amount of harm from this action's habitat impacts.

Table 21. Comparison of Mean Monthly Weighted Usable Area (WUA) and Percent Maximum WUA (pWUA) During Atlantic Sturgeon Spawning Months (April 1–May 31 And July 1–October 31) for *MAB Flow*, the Projected Flow to Shoals Under *MAB Flow With NMFS RPM Flows*, and the Projected Flow to Shoal if no Flows Were Diverted Into the Augusta Canal (*Undiverted Flow*).

Comparison	Flow Tier	MAB Flow (95% CI)	NMFS RPM Flow (95% CI)	Mean Difference NMFS RPM vs. MAB (95% CI)
MAB Flow vs. *NMFS RPM Flow* (WUA) (ft^2/1,000 ft)	1	26,013.4 (25,577.2 to 26,449.6)	25,987.3 (25,549.1 to 26,425.5)	-26.1 (-24.1 to -28.1)
	2	11,622.2 (11,324.7 to 11,919.6)	15,185.4 (15,109.9 to 15,261)	3,563.3 (3,341.4 to 3,785.1)
	3	9,879.4 (9,752.3 to 10,006.4)	14,484 (14,389.7 to 14,578.3)	4,604.7 (4,571.9 to 4,637.4)
	4	9,221.4 (8,937.9 to 9,504.8)	14,256.2 (13,889.9 to 14,622.4)	5,034.8 (5,117.6 to 4,952)
	All Tiers	15,070.9 (14,769.1 to 15,372.8)	18,107.4 (17,872.9 to 18,341.9)	3,036.4 (2,969.1 to 3,103.7)
Comparison	**Flow Tier**	**MAB Flow (95% CI)**	**NMFS RPM Flow (95% CI)**	**Mean Difference NMFS RPM vs. MAB (95% CI)**
MAB Flow vs. *NMFS RPM Flow* (pWUA)	1	73 (71.8 to 74.3)	73.0 (71.7 to 74.2)	-0.1 (-0.1 to -0.1)
	2	32.7 (31.8 to 33.5)	42.9 (42.7 to 43.1)	10.2 (9.6 to 10.9)
	3	27.7 (27.4 to 28.1)	40.9 (40.6 to 41.2)	13.2 (13.3 to 13.1)
	4	25.9 (25.1 to 26.7)	40.3 (39.3 to 41.4)	14.4 (14.2 to 14.7)
	All Tiers	42.3 (41.5 to 43.2)	51.0 (50.4 to 51.7)	8.7 (8.5 to 8.9)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**NMFS RPM Flow (95% CI)**	**Mean Difference NMFS RPM vs. Undiverted (95% CI)**
Undiverted Flow vs. *NMFS RPM Flow* (WUA) (ft^2/1,000 ft)	1	33,111.4 (32,945.6 to 33,277.3)	25,987.3 (25,549.1 to 26,425.5)	-7,124.1 (-6,851.7 to -7,396.4)
	2	28,246.1 (28,219.6 to 28,272.7)	15,185.4 (15,109.9 to 15,261)	-13,060.7 (-13,011.7 to -13,109.7)
	3	25,776.6 (25,721 to 25,832.2)	14,484 (14,389.7 to 14,578.3)	-11,292.6 (-11,253.9 to -11,331.3)
	4	22,914.3 (22,591.6 to 23,237)	14,256.2 (13,889.9 to 14,622.4)	-8,658.2 (-8,614.6 to -8,701.7)
	All Tiers	28,325.0 (28,192.6 to 28,457.4)	18,107.4 (17,872.9 to 18,341.9)	-10,217.6 (-10,115.5 to -10,319.7)
Comparison	**Flow Tier**	**Undiverted Flow (95% CI)**	**NMFS RPM Flow (95% CI)**	**Mean Difference NMFS RPM vs. Undiverted (95% CI)**
Undiverted Flow vs. *NMFS RPM Flow* (pWUA)	1	92.8 (92.3 to 93.3)	73.0 (71.7 to 74.2)	-19.9 (-19.0 to -20.7)
	2	79.3 (79.2 to 79.4)	42.9 (42.7 to 43.1)	-36.4 (-36.2 to -36.6)
	3	72.7 (72.5 to 72.8)	40.9 (40.6 to 41.2)	-31.8 (-31.5 to -32.1)
	4	64.5 (63.6 to 65.5)	40.3 (39.3 to 41.4)	-24.2 (-23.0 to -25.4)
	All Tiers	79.6 (79.3 to 80)	51.0 (50.4 to 51.7)	-28.6 (-28.3 to -28.9)

Table 22. Mean Absolute and Mean Relative Difference in pWUA between *MAB Flow* and *NMFS RPM Flow* and *Undiverted Flow*

Species (spawning months)	Flow Tier	Mean Absolute Difference in pWUA NMFS RPM vs. MAB (95% CI)	Mean Relative Difference in pWUA NMFS RPM vs. MAB (95% CI)	Mean Absolute Difference in pWUA NMFS RPM vs. Undiverted (95% CI)	Mean Relative Difference in pWUA NMFS RPM vs. Undiverted (95% CI)
Atlantic Sturgeon (Apr-May & July-Oct)	1	-0.1 (-0.1 to -0.1)	-0.1 (-0.1 to -0.1)	-19.9 (-19.0 to -20.7)	-21.4 (-20.5 to -22.3)
	2	10.2 (9.6 to 10.9)	31.3 (28.6 to 34.1)	-36.4 (-36.2 to -36.6)	-45.9 (-45.7 to -46.1)
	3	13.2 (13.3 to 13.1)	47.5 (46.6 to 48.5)	-31.8 (-31.5 to -32.1)	-43.7 (-43.5 to -44)
	4	14.4 (14.2 to 14.7)	55.6 (54.8 to 56.4)	-24.2 (-23.0 to -25.4)	-37.5 (-36.8 to -38.2)
	All Tiers	8.7 (8.5 to 8.9)	20.5 (19.7 to 21.4)	-28.6 (-28.3 to -28.9)	-36 (-35.4 to -36.5)

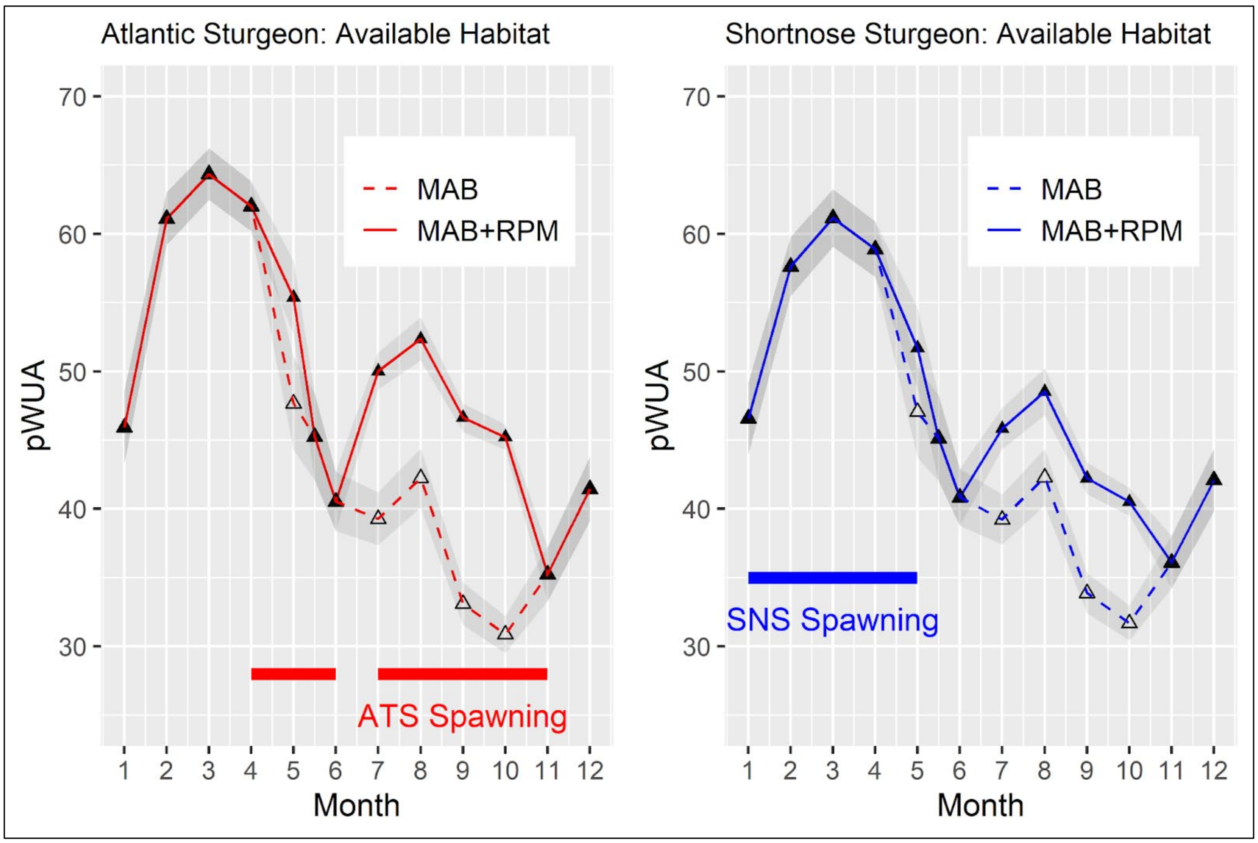

Figure 23. Mean available spawning habitat (pWUA) for shortnose (blue) and Atlantic sturgeon (red) with 95% confidence bands under *MAB Flow* (dashed) and *MAB Flow* with *NMFS RPM Flows* (solid). Blue and red bars denote spawning seasons for shortnose sturgeon (SNS; January 1-April 30) and Atlantic sturgeon (ATS; April 1-May 31 and July 1-October 31), respectively. Note significant increase in available spawning habitat during Atlantic sturgeon spawning season under NMFS RPM.

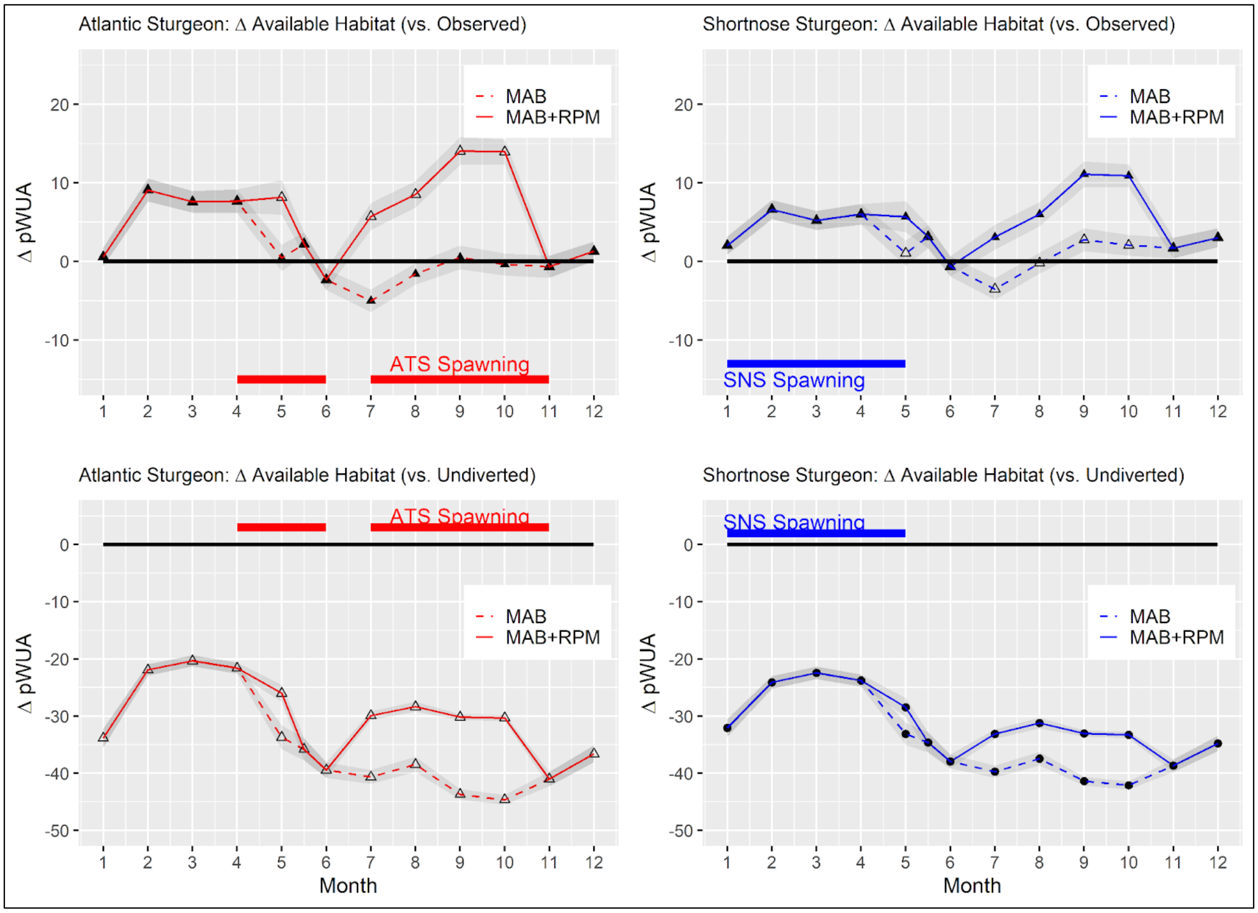

Figure 24. Mean change in available spawning habitat (pWUA) for shortnose (blue) and Atlantic sturgeon (red) under *MAB Flow* (dashed) and *MAB Flow with NMFS RPM Flows* (solid) with 95% confidence bands, relative to observed and undiverted flows 1996–2019. Blue and red bars denote spawning seasons for shortnose sturgeon (SNS; January 1–April 30) and Atlantic sturgeon (ATS; April 1–May 31 and July 1–October 31), respectively.

We note that RPMs, along with the Terms and Conditions that implement them, cannot alter the basic design, location, scope, duration, or timing of the proposed action and may involve only minor changes. 50 CFR §402.14 (i)(2). We believe increasing the base flow reservation to the Augusta Shoals from 1,500 to 1,800 cfs in Tiers 2–4 during Atlantic sturgeon spawning season, represents a minor change to the proposed action, because it does not alter the action's basic design, location, scope, duration, or timing.

The minimum daily aquatic base flows are a 'malleable conservation measure,' already dependent on tier levels of flow that may change on a daily or weekly basis. Under the draft settlement agreement, required flow reservations must only be met 95% of the time under normal flow conditions; this requirement will remain the same.

Using the historical flow (1996–2019) arriving at the ADD, we estimated how flows would change under the RPM versus the daily minimum aquatic base flows. While the *NMFS RPM Flow* would increase the minimum flow reserved for the Augusta Shoals during Atlantic sturgeon spawning months by 300 cfs relative to *MAB Flow*, historical flows suggest implementation of the RPM would only reduce the flows into Augusta Canal by 8%, on average, during Atlantic sturgeon spawning months.

We consider the 8% average change in flow during Atlantic sturgeon spawning months to be within the range of the inherent variability in the Savannah River system above the ADD. Some variability in flows is already inherent in the action as proposed, due to natural fluctuations and the re-regulation of JST Project flows by the Stevens Creek Project. The operating plan for the Stevens Creek Project states they should target an hourly discharge of ±15% of what is released by JST Project during normal conditions/operation. Given that FERC has established a 15% fluctuation in hourly flows as a target for "normal" operating conditions at all times of year, we believe an 8% change is well within the variability already seen in the system. Additionally, when Stevens Creek's flow variances are outside that 15% buffer, they generally release more water than less. Under these circumstances, we believe applying a minimum flow reservation during Atlantic sturgeon spawning season that alters flows an average of 8% during 5 months relative to the current daily minimum aquatic base flows is well within the range of anticipated deviations inherent in the project as proposed. Thus, we would not expect the modification of the base flows during Atlantic sturgeon spawning season to alter the basic design of the proposed action.

Other than changing the minimum flow reservation, the RPM would not impose any changes on the operation of the ADD or any of the canal water users. That is, the frequency of operation of the headgate to control flows will not increase and no physical changes are required to the ADD and supporting structures. All other provisions of the draft settlement agreement (included by FERC as part of the proposed action) would remain unchanged. Specifically, provisions in the draft settlement agreement providing for flexibility when the City is unable to meet flow requirements would remain in place. NMFS expects the provisions relating to drought conditions would still be applied to address these circumstances. To that end, the city of Augusta has previously acknowledged:

> "*During times when total flow of the Savannah River at the ADD is less than the sum of the Canal need and the aquatic base flow (typically dry to drought periods), the City could curtail Canal diversions to ensure that the protective aquatic base flows would be maintained. During such times, the average daily flows in the Shoals would vary around the daily aquatic base flow target. Actual flows in the Shoals may be higher or lower than the aquatic base flow target, by an amount roughly equal to variations in the ratio of SEPA's declared versus actual USACE flow release from Thurmond Dam as re-regulated by the Steven's Creek Project." (Entrix 2003)*

Finally, NMFS expects the RPM flows for Tiers 2–4 would be triggered only occasionally, based on historical flows. The draft settlement agreement supports this conclusion that the minimum flows backstop requirements are unlikely to be triggered frequently, stating:

> "*The flows stated in Section 4.3 are not minimum flows but base flows. This means that based on a 40 year historical average and as projected over the expected FERC license term, the flows will be greater than stated, especially at the Tier 1 Level, a majority of the time. This is because total flow in the Savannah River will often exceed the sum of*

the allocations for the Canal and Shoals, and any surplus water will flow into the Shoals."

Because flows are expected to be greater than the needs of Canal and the actual change in flows if the RPM is triggered would be an average of 8% during Atlantic sturgeon spawning months, and a median change of 0% annually, the RPM is expected to have only a minor change on how the project is operated. Additionally, existing flexibility incorporated into the base flow provisions will be retained. Thus, even with increased water usage over the course of the license, the RPM should not significantly interfere with the operation of the action as proposed.

The RPM will have no effect on location of the proposed action, as no activities outside of the action area would be implemented via the proposed RPM. It will also have no effect on the scope of the proposed action. Modifying the daily minimum aquatic base flows would not require any change in activities beyond those contemplated in the proposed action. Establishing minimum base flows, and then managing those flows, is already proposed. Managing those flows requires setting the headgates at the ADD based on the projected releases from JST Dam. The RPM would not require a change in how frequently those gates need to be adjusted. The RPM establishes a minimum base flow (1,800 cfs) for endangered Atlantic sturgeon spawning consistent with agreed upon minimum base flows for endangered shortnose sturgeon spawning, and is already considered in the suite of flow management thresholds. The RPM does not modify the duration of the proposed action.

The RPM will not affect the overall timing of the proposed action. The aquatic base flows as modified by the RPM would shift the flow reserved to the Augusta Shoals in April and May and July to November, when Atlantic sturgeon are expected to be present. The RPM would only require that different minimum reserved flows be used during those times of year but would not fundamentally change the timing of the overall action.

10.3.4 RPM #4 – Minimize Impacts to Sturgeon During Fishway Construction and Operation

All potential adverse impacts to sturgeon during the construction and operations of fishways are to be minimized to the greatest extent practicable.

10.4 Terms and Conditions

To be exempt from the prohibitions of Section 9 of the ESA, FERC and the city of Augusta (or any subsequent operator or licensee) must comply (or must ensure that any applicant complies) with the following Terms and Conditions, which implement the RPMs described above.

1. To implement RPM#1, FERC will incorporate into the license for the Augusta Canal Project and enforce the following conditions:
    a. The amount of water diverted into the Augusta Canal is the difference between the Augusta Declaration (calculated as described in Section 4.2 and Attachment 2 of the 2008 draft settlement agreement (Appendix 1) and the minimum daily aquatic base flows reserved for the Augusta Shoals described in Table 20. The maximum inflow into the Augusta Canal may not exceed 3,500 cfs.

2. To implement RPM #2, and guarantee the water arriving at ADD is properly apportioned, per the requirements of this Opinion and the 2008 draft settlement agreement, between the Augusta Canal and the Augusta Shoals, FERC will incorporate into the license for the Augusta Canal Project and enforce the following conditions:
    a. Per Section 4.12 of the 2008 draft settlement agreement, the city of Augusta will install appropriate gauging equipment in the Augusta Canal to record the amount of water being diverted into it. This equipment will provide a means of monitoring compliance with Sections 4.1–4.10 of the draft settlement agreement.

       If the city of Augusta exercises Option 4.11(a) of the 2008 draft settlement agreement to verify the procedure for determining the Augusta Declaration, NMFS must approve the selection of the hydrologist and be provided with the results of the hydrologist's evaluation.
    b. In addition to the gauging equipment installed for the Augusta Canal, the city of Augusta will install and maintain appropriate gauging equipment to record the daily flows to the Augusta Shoals as a means to monitor the daily minimum aquatic base flows reserved for the Augusta Shoals. Gauging equipment monitoring the flows to the Augusta Shoals must also record dissolved oxygen and water temperature on an hourly basis. Gauging equipment will be installed no less than 8 months after fish passage is operational at NSBL&D. Flow, dissolved oxygen, and water temperature reported by those gages must be made publicly available as soon as they are operational. This will allow real-time monitoring to establish a reliable environmental baseline and confirm that the action is having the predicted effect on the habitat of shortnose and Atlantic sturgeon.

3. To implement RPM #3, FERC will incorporate into the license for the Augusta Canal Project and enforce the following conditions
    a. The city of Augusta must map and quantify the available spawning habitat at the 5 fish passage transect locations identified in Entrix (2002). General substrate type must be mapped and reported and weighted usable area (WUA) must be calculated using a two-dimensional (2D) model. Model runs must estimate WUA at the 5 fish passage transect under daily average flows in the river mainstem of 1,500 cfs, 1,800 cfs, 2,500 cfs, 3,300 cfs and 8,000 cfs. NMFS recommends using a HEC-RAS (or equivalent) model for this exercise. Regardless of which model is used, NMFS must be informed of which is selected, and be allowed to reviewed the proposed work, and approve it before work can begin. Following review and approval by NMFS of the study and modeling approach, collection of necessary data must begin such that the entire effort can be completed no later than 1 year after fish passage is operational at NSBL&D.
    b. The city of Augusta will work with the NMFS to develop and finalize a flow and operations monitoring plan, including a gauging plan, as advised by FERC in the staff recommended alternative in the Final EA for the Augusta Canal Project no later than 1 year after fish passage is operational at NSBL&D. The City will provide the final plan to FERC no later than 6 months after fish passage is

operational at NSBL&D and will begin implementing plan within 6 months of the plan's submission.

4. To implement RPM #4 and reduce potential adverse effects to sturgeon from fishways, FERC will incorporate into the license for the Augusta Canal Project and enforce the following conditions:

    a. If construction of fishways occurs once sturgeon have the ability to pass above the NSBL&D, the following terms will apply:

        i. No in-water work in the river downstream of the ADD will occur between January 1 and May 31 or July 1 to October 31. If work during that period is desirable, discussions must be held with NMFS to determine if the work could be performed safely during that time. Work occurring upstream of the ADD may be conducted at any time so long as no downstream effects are anticipated (e.g., sediment plumes that may be transported downstream of the ADD by river currents). The in-water work prohibition applies to any routine, necessary, in-water construction or maintenance activity.

        ii. All in-water construction activities, regardless of when they occur, must comply with NMFS's Protected Species Construction Conditions (available at: https://media.fisheries.noaa.gov/2021-06/Protected_Species_Construction_Conditions_1.pdf?null)

    b. Upstream passage of shortnose and Atlantic sturgeon will not occur until NMFS deems (based on monitoring reports, available research and data, the results of future ESA Section 7 consultations, etc.) that:

        i. Habitat available above the ADD is safe and suitable for sturgeon, and

        ii. Safe and effective downstream passage for shortnose and Atlantic sturgeon is in place. This includes preventing sturgeon from entering the Augusta Canal.

    c. In addition to the upstream fish passage details described in Sections 6.2.1, 6.3, and Attachment 1 of the 2008 draft settlement agreement, physical barrier(s) or other means will be put in place to further minimize entrance by Atlantic and shortnose sturgeon into the fishway and reduce their potential for injuries. Options could include placing a spoiler/baffle plate in the entranceway and/or other measures for excluding sturgeon. The fishway operation and maintenance plan will be provided to the NMFS for review, comment, and approval, as stated in Section A.6 of Attachment 1 to the draft settlement agreement. The city of Augusta will work with the NMFS and a mutually agreed upon fishway expert(s) to determine the most effective means for continually monitoring the fishway for sturgeon. Details of the monitoring plan will be finalized and approved by the NMFS prior to construction of the upstream fishway.

   d. NMFS will be notified immediately (Andrew Herndon, Andrew.Herndon@noaa.gov, 727-824-5312; 1-844-788-7491) if an Atlantic or shortnose sturgeon:
      i. Enters the fishway and passes upstream of the ADD,
      ii. Appears to be trapped in the fishway (e.g., spends greater than 24 hours in the fishway without leaving), or
      iii. Appears to be injured or dead.

5. To implement RPM #4 and ensure the Augusta Canal project is being operated as expected and the anticipated adverse effects from its operation are of the manner and extent considered in this Opinion, FERC shall ensure the applicant meets the following annual reporting requirements:
   a. The city of Augusta will submit an annual flow monitoring report to the NMFS for the Augusta Canal Project. The first report will be submitted one year following completion of the fish-passage facility at NSBL&D, with annual reports thereafter. Annual flow monitoring reports must include:
      i. A record of the Augusta Declaration, the amount of water diverted into the Augusta Canal reported every 15 minutes and the flows over the Augusta Shoals every 15 minutes during the time of year we anticipate sturgeon to be present (i.e., January 1 – May 31; July 1 – October 31).
      ii. Explanations for any periods during which flows entering Augusta Canal exceeded 3,500 cfs or the daily minimum aquatic base flows reaching the Augusta Shoals were less than those described in Table 20.
      iii. A report detailing the quantity and location of available spawning habitat in the Augusta Shoals at the various flows must be prepared and submitted to NMFS in the annual monitoring report.
      iv. All flow monitoring results reports will be sent to: nmfs.ser.esa.consultations@noaa.gov. The subject line of the email should include the SERO number associated with this Opinion and a description of which report is included. Example: Subject: SERO-2012-00004 Augusta Canal Biological Opinion – Annual Report: Flow Monitoring Results.
   b. The city of Augusta will submit an annual sturgeon monitoring report to the NMFS for the Augusta Canal Project. The first report will be submitted 1 year after fish passage is operational at NSBL&D, with annual reports thereafter. Annual sturgeon monitoring reports must include:
      i. All observed occurrences of Atlantic and shortnose sturgeon utilizing the fishway.
      ii. For each observed occurrence, all available data (e.g., species, size, sex, condition, date and time of fishway activity, duration of activity in the fishway, behavior, photos, video, etc.) will be included in the annual monitoring report.

iii. Annual monitoring reports will be sent to: nmfs.ser.esa.consultations@noaa.gov. The subject line of the email should include the SERO number associated with this Opinion and a description of which report is included. Example: Subject: SERO-2012-00004 Augusta Canal Biological Opinion – Annual Report: Sturgeon Interactions with Fishway.

11 CONSERVATION RECOMMENDATIONS

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

FERC and the city of Augusta should strive to make the existing hydroelectric facilities and diversion dam operations sustainable over the term of the new license. Specifically:

1. Support research to better identify effective fish passage for sturgeon and understand the effects of fish passage (e.g., stress, injury, impacts to reproductive success) on sturgeon.
2. Support research to identify the abundance and migration patterns of shortnose and Atlantic sturgeon within the Savannah River system.
3. Support research on sturgeon spawning within the Augusta Shoals and on juvenile sturgeon survival as they move down the Savannah River.
4. Support research that evaluates the relationship between stream flow and sturgeon migration. Additional information on this relationship would provide a better estimate of the flow needed to cue and successfully initiate sturgeon movement. FERC could apply this information to determine future adequate flow rates for other hydropower projects due for licensing or re-licensing.
5. Coordinate basin-wide stakeholder events designed to address/resolve environmental impacts to the Savannah River watershed.

12 REINITIATION OF CONSULTATION

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

13 LITERATURE CITED

Arendt, M., W. C. Post, B. Frazier, M. Taliercio, D. J. Farrae, T. Darden, P. Geer, and C. Kalinowsky. 2017. Temporal and spatial distribution of Atlantic sturgeon (*Acipenser oxyrinchus*) in U.S. territorial waters off South Carolina and Georgia: Final (2013-2017) report to the National Marine Fisheries Service, National Oceanic and Atmospheric Administration. South Carolina Department of Natural Resources, Marine Resources Division and Georgia Department of Natural Resources, Grant Number NA13NMF4720045, Charleston, SC.

ASMFC. 2017. Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report. Atlantic States Marine Fisheries Commission, Arlington, VA.

ASSRT. 2007. Status Review of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Regional Office, Atlantic Sturgeon Status Review Team, Gloucester, Massachusetts.

Bahn, R. A., J. E. Fleming, and D. L. Peterson. 2012. Bycatch of Shortnose Sturgeon in the commercial American shad fishery of the Altamaha River, Georgia. North American Journal of Fisheries Management 32(3):557-562.

Bahr, D. L., and D. L. Peterson. 2016. Recruitment of juvenile Atlantic sturgeon in the Savannah River, Georgia. Transactions of the American Fisheries Society 145(6):1171-1178.

Bahr, D. L., and D. L. Peterson. 2017. Status of the shortnose sturgeon population in the Savannah River, Georgia. Transactions of the American Fisheries Society 146(1):92-98.

Bain, M., N. Haley, D. Peterson, J. R. Waldman, and K. Arend. 2000. Harvest and habitats of Atlantic sturgeon *Acipenser oxyrinchus* Mitchill, 1815 in the Hudson River estuary: lessons for sturgeon conservation. Boletín. Instituto Español de Oceanografía 16:43-53.

Bain, M. B. 1997. Atlantic and shortnose sturgeons of the Hudson River: Common and divergent life history attributes. Environmental Biology of Fishes 48(1-4):347-358.

Beauvais, S. L., S. B. Jones, S. K. Brewer, and E. E. Little. 2000. Physiological measures of neurotoxicity of diazinon and malathion to larval rainbow trout (Oncorhynchus mykiss) and their correlation with behavioral measures. Environmental Toxicology and Chemistry 19(7):1875-1880.

Bednarski, M. 2012 Population dynamics of shortnose sturgeon in the Altamaha River, Georgia. PhD dissertation. University of Georgia, Athens, Georgia.

Belovsky, G. E. 1987. Extinction models and mammalian persistence. Chapter 3 In: Soulé, M.E. (ed), Viable Populations for Conservation. Cambridge University Press, pp.35-57.

Berlin, W. H., R. J. Hesselberg, and M. J. Mac. 1981. Chlorinated hydrocarbons as a factor in the reproduction and survival of Lake Trout (Salvelinus namaycush) in Lake Michigan. Technical Paper 105. U.S. Fish and Wildlife Service.

Berry, R. J. 1971. Conservation aspects of the genetical constitution of populations. Pages 177-206 *in* E. D. Duffey, and A. S. Watt, editors. The Scientific Management of Animal and Plant Communities for Conservation, Blackwell, Oxford.

Bigelow, H. B., and W. C. Schroeder. 1953. Fishes of the Gulf of Maine, volume 53. US Government Printing Office Washington, DC.

Billsson, K., L. Westerlund, M. Tysklind, and P.-e. Olsson. 1998. Developmental disturbances caused by polychlorinated biphenyls in zebrafish (*Brachydanio rerio*). Marine Environmental Research 46(1–5):461-464.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes 48(1):399-405.

Borodin, N. 1925. Biological observations on the Atlantic sturgeon (*Acipenser sturio*). Transactions of the American Fisheries Society 55(1):184-190.

Bovee, K. D., and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Information Paper 3. United States Fish and Wildlife Service FWS/OBS-77/63.

Buckley, J., and B. Kynard. 1985. Habitat use and behavior of pre-spawning and spawning shortnose sturgeon, *Acipenser brevirostrum*, in the Connecticut River. Pages 111-117 *in* F. P. Binkowski, and S. I. Doroshov, editors. North American sturgeons. W. Junk Publishers, Dordrecht, Netherlands.

Cameron, P., J. Berg, V. Dethlefsen, and H. Von Westernhagen. 1992. Developmental defects in pelagic embryos of several flatfish species in the Southern North sea. Netherlands Journal of Sea Research 29(1–3):239-256.

Campbell, J. G., and L. R. Goodman. 2004. Acute sensitivity of juvenile shortnose sturgeon to low dissolved oxygen concentrations. Transactions of the American Fisheries Society 133(3):772-776.

Caron, F., D. Hastin, and R. Fortin. 2002a. Biological Characteristics of Adult Atlantic Sturgeon (Acipenser oxyrinchus) in the St Lawrence River Estuary and the Effectiveness of Management Rules. Journal of Applied Ichthyology 18:580-585.

Caron, F., D. Hatin, and R. Fortin. 2002b. Biological characteristics of adult Atlantic sturgeon (*Acipenser oxyrinchus*) in the St Lawrence River estuary and the effectiveness of management rules. Journal of Applied Ichthyology 18(4-6):580-585.

Cech, J. J., Jr., and S. I. Doroshov. 2005. Environmental requirements, preferences, and tolerance limits of North American sturgeons. Pages 73-86 *in* Sturgeons and Paddlefish of North America. Springer.

Chytalo, K. 1996. Summary of Long Island Sound Dredging Windows Strategy Workshop. Management of Atlantic Coastal Marine Fish Habitat: Proceedings of a workshop for habitat managers. ASMFC Habitat Management Series #2. Atlantic States Marine Fisheries Commission.

Cocherell, D., A. Kawabata, D. Kratville, S. Cocherell, R. Kaufman, E. Anderson, Z. Chen, H. Bandeh, M. Rotondo, and R. Padilla. 2011. Passage performance and physiological stress response of adult white sturgeon ascending a laboratory fishway. Journal of Applied Ichthyology 27(2):327-334.

Cochnauer, T. 1986. Abundance, distribution, growth and management of white sturgeon (Acipenser transmontanus) in the Middle Snake River, Idaho. University of Idaho.

Collette, B., and G. Klein-MacPhee. 2002. Fishes of the Gulf of Maine, 3rd edition. Smithsonian Institution Press.

Collins, M. R., D. Cooke, W. C. Post, J. Crane, J. Bulak, T. I. J. Smith, T. W. Greig, and J. M. Quattro. 2003. Shortnose sturgeon in the Santee-Cooper reservoir system, South Carolina. Transactions of the American Fisheries Society 132(6):1244-1250.

Collins, M. R., W. C. Post, D. C. Russ, and T. I. J. Smith. 2002. Habitat use and movements of juvenile shortnose sturgeon in the Savannah River, Georgia-South Carolina. Transactions of the American Fisheries Society 131(5):975-979.

Collins, M. R., S. G. Rogers, and T. I. J. Smith. 1996. Bycatch of Sturgeons along the Southern Atlantic Coast of the USA. North American Journal of Fisheries Management 16:24-29.

Collins, M. R., and T. I. J. Smith. 1993. Characteristics of the adult segment of the Savannah River population of shortnose sturgeon. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:485-491.

Collins, M. R., and T. I. J. Smith. 1997. Distributions of shortnose and Atlantic sturgeons in South Carolina. North American Journal of Fisheries Management 17(4):955-1000.

Collins, M. R., T. I. J. Smith, W. C. Post, and O. Pashuk. 2000. Habitat utilization and biological characteristics of adult Atlantic sturgeon in two South Carolina rivers. Transactions of the American Fisheries Society 129(4):982-988.

Cooke, D. W., J. P. Kirk, J. J. V. Morrow, and S. D. Leach. 2004. Population dynamics of a migration limited shortnose sturgeon population. Pages 82-91 *in* Annual Conference, Southeastern Association of Fish and Wildlife Agencies.

Cooper, K. 1989. Effects of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans on aquatic organisms. Reviews in Aquatic Sciences 1(2):227-242.

Counihan, T. D., and C. G. Chapman. 2018. Relating river discharge and water temperature to the recruitment of age-0 White Sturgeon (Acipenser transmontanus Richardson, 1836) in the Columbia River using over-dispersed catch data. Journal of Applied Ichthyology 34(2):279-289.

Dadswell, M. J. 1979. Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818 (Osteichthyes: Acipenseridae), in the Saint John River Estuary, New Brunswick, Canada. Canadian Journal of Zoology 57:2186-2210.

Dadswell, M. J. 2006. A review of the status of Atlantic sturgeon in Canada, with comparisons to populations in the United States and Europe. Fisheries 31(5):218-229.

Dadswell, M. J., B. D. Taubert, T. S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Report NMFS 14, FAO Fisheries Synopsis No. 140, Washington, D.C.

Dammerman, K. J., J. P. Steibel, and K. T. Scribner. 2016. Increases in the mean and variability of thermal regimes result in differential phenotypic responses among genotypes during early ontogenetic stages of lake sturgeon (Acipenser fulvescens). Evol Appl 9(10):1258-1270.

Dial-Cordy. 2010. Evaluation of Shortnose Sturgeon Spawning Habitat, Savannah River, Georgia and South Carolina.

Dickerson, D. 2013. Observed takes of sturgeon from dredging operations along the Atlantic and Gulf Coasts. U.S. Army Engineer Research and Development Center Environmental Laboratory, Vicksburg, Mississippi.

Dovel, W., A. Pekovitch, and T. Berggren. 1992. Biology of the shortnose sturgeon (*Acipenser brevirostrum* Lesueur, 1818) in the Hudson River estuary, New York. Pages 187-216 *in* C. L. Smith, editor. Estuarine Research in the 1980s. State University of New York Press, Albany, New York.

Dovel, W. L., and T. J. Berggren. 1983. Atlantic sturgeon of the Hudson Estuary, New York. New York Fish and Game Journal 30(2):140-172.

Drevnick, P. E., and M. B. Sandheinrich. 2003. Effects of dietary methylmercury on reproductive endocrinology of fathead minnows. Environmental Science and Technology 37(19):4390-4396.

Dula, B. T., A. J. Kaeser, M. J. D'Ercole, C. A. Jennings, and A. G. Fox. 2022. Effects of Hurricane Michael on Gulf Sturgeon in the Apalachicola River system, Florida. Transactions of the American Fisheries Society 151(6):725-742.

Duncan, M. S., J. J. Isely, and D. W. Cooke. 2004. Evaluation of shortnose sturgeon spawning in the Pinopolis Dam Tailrace, South Carolina. North American Journal of Fisheries Management 24:932–938.

Duncan, W. W., M. C. Freeman, C. A. Jennings, and J. T. McLean. 2003. Considerations for Flow Alternatives that Sustain Savannah River Fish Populations. Pages 4 *in* K. J. Hatcher, editor Georgia Water Resources Conference. Institute of Ecology, The University of Georgia, Athens, Georgia.

Dunton, K. J., A. Jordaan, K. A. McKown, D. O. Conover, and M. G. Frisk. 2010. Abundance and distribution of Atlantic sturgeon (Acipenser oxyrinchus) within the Northwest Atlantic Ocean, determined from five fishery-independent surveys. Fishery Bulletin 108(4):450-465.

Easterling, D. R., K. E. Kunkel, J. R. Arnold, T. Knutson, A. N. LeGrande, L. R. Leung, R. S. Vose, D. E. Waliser, and M. F. Wehner. 2017. Precipitation change in the United States. Pages 207-230 *in* D. J. Wuebbles, and coeditors, editors. Climate Science Special Report: Fourth National Climate Assessment, Volume I. U.S. Global Change Research Program, Washington, DC, USA.

Entrix. 2002. Savannah River Instream Flow Study for the Augusta Canal Hyrdopower Project and Vicinity (FERC Project 11810), Atlanta, GA.

Entrix. 2003. Technical Memorandum - Implementation of Aquatic Base Flows in the Augusta Shoals and the Resulting Flow Regime - Augusta Canal Hydropower Project (FERC No. 11810).

Erickson, D. L., A. Kahnle, M. J. Millard, E. A. Mora, M. Bryja, A. Higgs, J. Mohler, M. DuFour, G. Kenney, J. Sweka, and E. K. Pikitch. 2011. Use of pop-up satellite archival tags to identify oceanic-migratory patterns for adult Atlantic Sturgeon, Acipenser oxyrinchus oxyrinchus Mitchell, 1815. Journal of Applied Ichthyology 27(2):356-365.

Evermann, B. W., and B. A. Bean. 1898. Indian River and its fishes. U.S. Commission on Fish and Fisheries 22:227-248.

Farrae, D. J., W. C. Post, and T. L. Darden. 2017. Genetic characterization of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in the Edisto River, South Carolina and identification of genetically discrete fall and spring spawning. Conservation Genetics:1-11.

FERC. 2006. Final Environmental Assessment for Hydropower License - Augusta Canal Project, P-11810-004. Federal Energy Regulatory Commission.

Findeis, E. K. 1997. Osteology and phylogenetic interrelationships of sturgeons (Acipenseridae). Environmental Biology of Fishes 48(1/2/3/4):53.

Fleming, J. E., T. D. Bryce, and J. P. Kirk. 2003. Age, growth and status of shortnose sturgeon in the lower Ogeechee River, Georgia. Fish and Wildlife Agencies

Flournoy, P. H., S. G. Rogers, and P. S. Crawford. 1992. Restoration of shortnose sturgeon in the Altamaha River, Georgia. U.S. Fish and Wildlife Service, Atlanta, Georgia.

Fox, A. G., A. Cummins, D. L. Bahr, M. Baker, and D. Peterson. 2020. Assessment of the Atlantic and Shortnose Sturgeon populations in the Savannah River, Georgia - Final Report. Warnell School of Forestry and Natural Resources - University of Georgia, Athens, GA.

Fox, A. G., D. Peterson, I. Wirgin, and A. Cummins. 2019. Quantifying Annual Recruitment and Nursery Habitats of Atlantic Sturgeon in Georgia. National Marine Fisheries Service.

Fox, A. G., and D. L. Peterson. 2017. Occurrence and Movements of Atlantic and Shortnose Sturgeon in Cumberland Sound and the St. Marys River, Georgia. University of Georgia.

Fox, A. G., E. S. Stowe, and D. L. Peterson. 2017. Occurrence and Movements of Shortnose and Atlantic Sturgeon in the St. Johns River, Florida. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA.

Frankham, R., C. J. A. Bradshaw, and B. W. Brook. 2014. Genetics in conservation management: revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation 170:56-63.

Frankson, R., K. E. Kunkel, L. E. Stevens, B. C. Stewart, W. Sweet, B. Murphey, and S. Rayne. 2022. Georgia State Climate Summary. NOAA/NESDIS, Silver Spring, MD, .

Fritts, M., and D. Peterson. 2010. Status of Atlantic sturgeon and shortnose sturgeon in the St. Marys and Satilla Rivers, Georgia. Final report ot the National Marine Fisheries Service. Warnell School of Forestry and Natural Resources - University of Georgia.

Fritts, M. W., C. Grunwald, I. Wirgin, T. L. King, and D. L. Peterson. 2016. Status and Genetic Character of Atlantic Sturgeon in the Satilla River, Georgia. Transactions of the American Fisheries Society 145(1):69-82.

Giesy, J. P., J. Newsted, and D. L. Garling. 1986. Relationships Between Chlorinated Hydrocarbon Concentrations and Rearing Mortality of Chinook Salmon (Oncorhynchus Tshawytscha) Eggs from Lake Michigan. Journal of Great Lakes Research 12(1):82-98.

Gilbert, C. R. 1989. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic Bight): Atlantic and shortnose sturgeons. U.S. Department of the Interior, Fish and Wildlife Service and U.S. Army Corps of Engineers, Waterways Experiment Station, Washington, D. C.

Greene, K. E., J. L. Zimmerman, R. W. Laney, and J. C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission, Washington, D.C.

Guilbard, F., J. Munro, P. Dumont, D. Hatin, and R. Fortin. 2007. Feeding ecology of Atlantic sturgeon and lake sturgeon co-occurring in the St. Lawrence estuarine transition zone. American Fisheries Society Symposium 56:85.

GWC. 2006. Interbasin Transfer Fact Sheet. Georgia Water Coalition, http://www.garivers.org/gawater/pdf%20files/IBT%20fact%20sheet02-06.pdf.

Hall, J. W., T. I. J. Smith, and S. D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon, *Acipenser brevirostrum* in the Savannah River. Copeia (3):695-702.

Hammerschmidt, C. R., M. B. Sandheinrich, J. G. Wiener, and R. G. Rada. 2002. Effects of dietary methylmercury on reproduction of fathead minnows. Environmental Science and Technology 36(5):877-883.

Hansen, D. J. 1985. Environmental assessment of the effects of offshore oil development on marine mammals occurring in Alaska marine waters. Pages 38 *in* Sixth Biennial Conference on the Biology of Marine Mammals, Vancouver, B.C., Canada.

Haro, A. J., M. Chelminski, and R. W. Dudley. 2015. Computational fluid dynamics-habitat suitability index (CFD-HSI) modelling as an exploratory tool for assessing passability of riverine migratory challenge zones for fish. River Research and Applications 31(5):526-537.

Hatin, D., R. Fortin, and F. Caron. 2002. Movements and aggregation areas of adult Atlantic sturgeon (Acipenser oxyrinchus) in the St Lawrence River estuary, Québec, Canada. Journal of Applied Ichthyology 18(4-6):586-594.

Hatin, D., J. Munro, F. Caron, and R. Simons. 2007. Movements, home range size, and habitat use and selection of early juvenile Atlantic sturgeon in the St. Lawrence estuarine transition zone. Pages 129 *in* American Fisheries Society Symposium. American Fisheries Society.

Hayhoe, K., J. Edmonds, R. E. Kopp, A. N. LeGrande, B. M. Sanderson, M. F. Wehner, and D. J. Wuebbles. 2017. Climate Models, Scenarios, and Projections. Pages 133-160 *in* D. J. Wuebbles, and coeditors, editors. Climate Science Special Report: Fourth National Climate Assessment, volume I, Washington, DC, USA,.

Hightower, J. E. 1998. Prioritizing habitat restoration efforts for anadromous fishes in North Carolina. Report to the NC Cooperative Fish and Wildlife Research Unit. U. S. Geological Survey, Biological Resources Division.

Hill, J. 1996. Environmental considerations in licensing hydropower projects: policies and practices at the Federal Energy Regulatory Commission. American Fisheries Society Symposium. 1996.

Hulme, P. E. 2005. Adapting to climate change: is there scope for ecological management in the face of a global threat? Journal of Applied Ecology 42(5):784-794.

Ingram, E. C., and D. L. Peterson. 2016. Annual Spawning Migrations of Adult Atlantic Sturgeon in the Altamaha River, Georgia. Marine and Coastal Fisheries 8(1):595-606.

Ingram, E. C., and D. L. Peterson. 2018. Seasonal movements of shortnose sturgeon (Acipenser brevirostrum) in the Altamaha River, Georgia. River Research and Applications 34(7):873-882.

Ingram, E. C., D. L. Peterson, and A. G. Fox. 2020. Abundance of endangered shortnose sturgeon (Acipenser brevirostrum) in the Altamaha River in Georgia. Fishery Bulletin 118(2):198-204.

IPCC. 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Jager, H. I., W. Van Winkle, J. A. Chandler, K. B. Lepla, P. Bates, and T. D. Counihan. 2002. A simulation study of factors controlling white sturgeon recruitment in the Snake River. Pages 127-150 *in*.

Jarvis, P. L., J. S. Ballantyne, and W. E. Hogans. 2001. The influence of salinity on the growth of juvenile shortnose sturgeon. North American Journal of Aquaculture 63(4):272 - 276.

Jenkins, W. E., T. I. J. Smith, L. D. Heyward, and D. M. Knott. 1993. Tolerance of shortnose sturgeon, *Acipenser brevirostrum*, juveniles to different salinity and dissolved oxygen concentrations. Pages 476-484 *in* Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.

Jorgensen, E. H., O. Aas-Hansen, A. G. Maule, J. E. T. Strand, and M. M. Vijayan. 2004. PCB impairs smoltification and seawater performance in anadromous Arctic charr (*Salvelinus alpinus*). Comparative Biochemistry and Physiology Part C Toxicology & Pharmacology 138(2):203-212.

Kieffer, M. C., and B. Kynard. 1996. Spawning of the shortnosesturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125(2):179-186.

King, T. L., B. A. Lubinski, and A. P. Spidle. 2001. Microsatellite DNA variation in Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and cross-species amplification in the Acipenseridae. Conservation Genetics 2(2):103-119.

Kleinschmidt. 2020. Pre-Application Document (PAD) - Stevens Creek Hyrdoelectric Project - FERC Project No. 2535, Lexington, SC.

Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48(1-4):319-334.

Kynard, B., and M. Horgan. 2002. Ontogenetic behavior and migration of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, and shortnose sturgeon, *A. brevirostrum*, with notes on social behavior. Environmental Biology of Fishes 63(2):137-150.

Kynard, B., M. Kieffer, M. Burlingame, and M. Horgan. 1999. Studies on shortnose sturgeon. Final Report to Northeast Utilities Service Company, Berlin CT and the City of Holyoke, MA.

Laney, R. W., J. E. Hightower, B. R. Versak, M. F. Mangold, and S. E. Winslow. 2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises, 1988-2006. American Fisheries Society Symposium 56:167-182.

Lawson, J. 1709. A New Voyage to Carolina: Containing the Exact Description and Natural History of that Country; Together with the Present State Thereof; and a Journal of a Thousand Miles, Travel'd Thro'Several Nations of Indians, Giving a Particular Account of Their Customs, Manners, Etc. British Surveyor-General of North Carolina.

Longwell, A., S. Chang, A. Hebert, J. Hughes, and D. Perry. 1992. Pollution and developmental abnormalities of Atlantic fishes. Environmental Biology of Fishes 35(1):1-21.

Mac, M. J., and C. C. Edsall. 1991. Environmental contaminants and the reproductive success of Lake Trout in the Great Lakes: an epidemiological approach. Journal of Toxicology and Environmental Health 33:375-394.

Mallin, M., and C. Corbett. 2006. How hurricane attributes determine the extent of environmental effects: Multiple hurricanes and different coastal systems. Estuaries and Coasts 29:1046-1061.

Marcy, B. C., D. E. Fletcher, F. D. Martin, M. H. Paller, and J. M. Reichert. 2005. Fishes of the middle Savannah River Basin: with emphasis on the Savannah River Site. University of Georgia Press.

Matta, M. B., C. Cairncross, and R. M. Kocan. 1997. Effect of a polychlorinated biphenyl metabolite on early life stage survival of two species of trout. Bulletin of Environmental Contamination and Toxicology 59:146-151.

McCord, J. W., M. R. Collins, W. C. Post, and T. I. J. Smith. 2007. Attempts to develop an index of abundance for age-1 Atlantic sturgeon in South Carolina, USA. American Fisheries Society Symposium 56:397-403.

McDonald, M. 1887. The rivers and sounds of North Carolina. The fisheries and fishery industries of the United States, Section V. Pages 625-637 *in* U. S. C. o. F. a. Fisheries, editor, Washington D.C.

McElhany, P., M. H. Ruchelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. NMFS-NWFSC-42:156.

Meyer, J. L., M. Alber, W. Duncan, M. Freeman, C. Hale, R. Jackson, C. Jennings, M. Palta, E. Richardson, R. Sharitz, J. Sheldon, and R. Weyers. 2003. Summary Report Supporting the Development of Ecosystem Flow Recommendations for the Savannah River below Thurmond Dam.

Moore, A., and C. P. Waring. 2001. The effects of a synthetic pyrethroid pesticide on some aspects of reproduction in Atlantic salmon (Salmo salar L.). Aquatic Toxicology 52(1):1-12.

Moser, M. L. 2000. A protocol for use of shortnose and Atlantic sturgeons. Pages 1 online resource (18 p.) *in* NOAA technical memorandum NMFS-OPR ; 18. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, [Silver Spring, Md.].

Moser, M. L., J. B. Bichy, and S. B. Roberts. 1998. Sturgeon Distibution in North Carolina. Center for Marine Science Research, Wilmington, North Carolina.

Moser, M. L., and S. W. Ross. 1993. Distribution and movements of shortnose sturgeon (Acipenser brevirostrum) and other anadromous fishes of the lower Cape Fear River, North Carolina. Final Report. U.S. Army Corps of Engineers, Wilmington, North Carolina.

Moser, M. L., and S. W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124(2):225.

Murawski, S. A., A. L. Pacheco, and United States. National Marine Fisheries Service. 1977. Biological and fisheries data on Atlantic sturgeon, Acipenser oxyrhynchus (Mitchill). Sandy Hook Laboratory, Northeast Fisheries Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, Highlands, N.J.

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

NAST. 2000. Climate change impacts on the United States: the potential consequences of climate variability and change. US Global Change Research Program, Washington D.C. National Assessment Synthesis Team.

NCDC. 2021. Climate at a Glance: National Time Series, published July 2019, retrieved on August 31, 2021. N. N. C. f. E. I. from, editor.

NCDC. 2022. Climate at a Glance: Regional Time Series, published December 2022, retrieved on December 9, 2022 from https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/regional/time-series.

NCDC. 2024. NOAA National Centers for Environmental information, Climate at a Glance: Regional Time Series, published April 2024, retrieved on April 17, 2024 from https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/regional/time-series.

NDMC. 2018. Drought Monitor - National Drought Mitigation Center (NDMC), the U.S. Department of Agriculture (USDA) and the National Oceanic and Atmospheric Association (NOAA).

Niklitschek, E. J., and D. H. Secor. 2005. Modeling spatial and temporal variation of suitable nursery habitats for Atlantic sturgeon in the Chesapeake Bay. Estuarine, Coastal and Shelf Science 64(1):135-148.

Niklitschek, E. J., and D. H. Secor. 2009a. Dissolved oxygen, temperature and salinity effects on the ecophysiology and survival of juvenile Atlantic sturgeon in estuarine waters: I. Laboratory results. Journal of Experimental Marine Biology and Ecology.

Niklitschek, E. J., and D. H. Secor. 2009b. Dissolved oxygen, temperature and salinity effects on the ecophysiology and survival of juvenile Atlantic sturgeon in estuarine waters: II. Model development and testing. Journal of Experimental Marine Biology and Ecology 381(Supplement 1):S161-S172.

NMFS. 1997. Biological Opinion on continued hopper dredging of channels and borrow areas in the southeastern United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, Saint Petersburg, FL.

NMFS. 1998. Final recovery plan for the Shortnose sturgeon (*Acipenser brevirostrum*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD.

NMFS. 2007. Draft Spawning Habitat Suitability Index Models and Instream Flow Suitability Curves, Model I: Shortnose Sturgeon, Southeastern Atlantic Coast River Basins. Prescott H. Brownell, Ed.

NMFS. 2010. A Biological Assessment of Shortnose Sturgeon (*Acipenser brevirostrum*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Regional Office, Woods Hole, Massachusetts.

NMFS. 2011. Biological Opinion on Deepening of the Savannah Harbor Federal Navigational Channel in association with the Savannah Harbor Expansion Project

NMFS. 2013. Permit 16645 for Take of Listed Sturgeon Incidental to the Georgia Commercial Shad Fishery. National Marine Fisheries Service, Silver Spring, MD.

NMFS. 2017a. Amendment to the Biological Opinion for the Deepening of the Savannah Harbor Federal Navigational Channel in association with the Savannah Harbor Expansion Project (SHEP). NOAA Fisheries, St Petersburg, FL.

NMFS. 2017b. Recovery Outline - Atlantic Sturgeon - Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic Distinct Population Segments.

NMFS, and USGS. 2011. Diadromous Fish Passage: A Primer on Technology, Planning, and Design for the Atlantic and Gulf Coasts.

Palmer, M. A., C. A. Reidy Liermann, C. Nilsson, M. Flörke, J. Alcamo, P. S. Lake, and N. Bond. 2008. Climate change and the world's river basins: anticipating management options. Frontiers in Ecology and the Environment 6(2):81-89.

Parsley, M. J., C. D. Wright, B. K. Van Der Leeuw, E. E. Kofoot, C. A. Peery, and M. L. Moser. 2007. White sturgeon (Acipenser transmontanus) passage at the Dalles Dam, Columbia River, USA. Journal of Applied Ichthyology 23(6):627-635.

Payne, T. 2003. The Concept of Weighted Usable Area as Relative Suitability Index. IFIM Users Workshop, 1-5 June 2003, Fort Collins.

PCWS. 2014. Savannah River Monitoring Report Phinizy Center for Water Sciences, Augusta, GA.

PCWS. 2015. Savannah River Monitoring Report. Phinizy Center for Water Sciences, Augusta, GA.

PCWS. 2016. Savannah River Monitoring Report. Phinizy Center for Water Sciences, Augusta, GA.

PCWS. 2017. Savannah River Monitoring Report - Water Year (Oct 1, 2016 – Sept 30, 2017). Phinizy Center for Water Sciences, Augusta, GA.

PCWS. 2019. Savannah River Monitoring Report - Water Year (Oct 1, 2018 – Sept 30, 2019). Phinizy Center for Water Science, Augusta, GA.

PCWS. 2020. Savannah River Monitoring Report - 2020 Water Year (OCt 1, 2019-Sept 30, 2020). Phinizy Center for Water Sciences.

PCWS. 2022. Savannah River Monitoring Report - 2021 and 2022 Water Year (Oct 1, 2020 – Sept 30, 2022). Phinizy Center for Water Sciences, Augusta, GA.

Peterson, D., P. Schueller, R. DeVries, J. Fleming, C. Grunwald, and I. Wirgin. 2008. Annual run size and genetic characteristics of Atlantic sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society 137:393-401.

Peterson, D. L., and M. S. Bednarski. 2013. Abundance and size structure of Shortnose Sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society 142(5):1444-1452.

Peterson, D. L., and D. J. Farrae. 2011. Evidence of metapopulation dynamics in Shortnose Sturgeon in the southern part of their range. Transactions of the American Fisheries Society 140(6):1540-1546.

Poirrier, M., Z. Rey, and E. Spalding. 2008. Acute Disturbance of Lake Pontchartrain Benthic Communities by Hurricane Katrina. Estuaries and Coasts 31:1221-1228.

Post, B., T. Darden, D. Peterson, M. Loeffler, and C. Collier. 2014. Research and Management of Endangered and Threatened Species in the Southeast: Riverine Movements of Shortnose and Atlantic sturgeon. South Carolina Department of Natural Resources.

Post, B., C. Holbrook, C. Norwood, and J. Grigsby. 2016. Evaluating Atlantic and Shortnose Sturgeon Behavior Related to the Savannah Harbor Expansion Project: Annual Report - FY 2016, submitted to the U.S. Army Corps of Engineers for Cooperative Agreement Numbers W912EP-13-2-0002-0004 & W912EP-13-2-0002-0003. South Carolina Department of Natural Resources, Charleston, South Carolina.

Post, B., C. Holbrook, C. Norwood, and J. Grigsby. 2017a. Evaluating Atlantic and Shortnose Sturgeon Behavior Related to the Savannah Harbor Expansion Project: Annual Report - FY 2017, submitted to the U.S. Army Corps of Engineers for Cooperative Agreement Numbers W912EP-13-2-0002-0004 & W912EP-13-2-0002-0003. South Carolina Department of Natural Resources, Charleston, South Carolina.

Post, B., E. Waldrop, C. Norwood, and J. Grigsby. 2018. Evaluating Atlantic and Shortnose Sturgeon Behavior Related to the Savannah Harbor Expansion Project: Annual Report - FY 2018, submitted to the U.S. Army Corps of Engineers for Cooperative Agreement Numbers W912EP-13-2-0002-0004 & W912EP-13-2-0002-0003. South Carolina Department of Natural Resources, Charleston, South Carolina.

Post, B., E. Waldrop, C. Norwood, and J. Grigsby. 2019. Evaluating Atlantic and Shortnose Sturgeon Behavior Related to the Savannah Harbor Expansion Project: Annual Report - FY 2019, submitted to the U.S. Army Corps of Engineers for Cooperative Agreement Numbers W912HN-18-2-0002. South Carolina Department of Natural Resources, Charleston, South Carolina.

Post, B., E. Waldrop, C. Norwood, and J. Grigsby. 2020. Evaluating Atlantic and Shortnose Sturgeon Behavior Related to the Savannah Harbor Expansion Project: Annual Report - FY 2020, submitted to the U.S. Army Corps of Engineers for Cooperative Agreement Numbers W912HN-18-2-0002-P00001 & W912HN-18-2-0002, P00002. South Carolina Department of Natural Resources, Charleston, South Carolina.

Post, G. W. 1987. Revised and Expanded Textbook of Fish Health. T.F.H. Publications, New Jersey.

Post, W. C., S. C. Holbrook, and A. Watford. 2017b. Distribution and movement of shortnose sturgeon, and continued monitoring and maintenance of an existing acoustic receiver array. Progress Report to the Santee Accord Management Board:11.

Pottle, R., and M. J. Dadswell. 1979. Studies on larval and juvenile shortnose sturgeon (Acipenser brevirostrum). Report to the Northeast Utilities Service Company, Hartford, Connecticut.

Rogers, S. G., and W. Weber. 1994. Occurrence of shortnose sturgeon (Acipenser brevirostrum) in the Ogeechee-Canoochee river system, Georgia, during the summer of 1993.

Rogers, S. G., and W. Weber. 1995. Status and Restoration of Atlantic and Shortnose Sturgeons in Georgia. Final Report for Anadromous Grants Program Project Award Number NA46FA102-01. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida.

Roscoe, D. W., S. G. Hinch, S. J. Cooke, and D. A. Patterson. 2011. Fishway passage and post-passage mortality of up-river migrating sockeye salmon in the Seton River, British Columbia. River Research and Applications 27(6):693-705.

Rosenthal, H., and D. F. Alderdice. 1976. Sub-lethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. Journal of the Fisheries Research Board of Canada 33:2047-2065.

Ruddle, V. K. 2018. Age Structure, Reproduction, and Recruitment of Atlantic sturgeon (Acipenser oxyrinchus) and Shortnose sturgeon (Acipenser brevirostrum) in the Cooper River, South Carolina. College of Charleston.

Ruelle, R., and C. Henry. 1992. Organochlorine compounds in pallid sturgeon. Contaminant Information Bulletin.

Ruelle, R., and K. D. Keenlyne. 1993. Contaminants in Missouri River pallid sturgeon. Bulletin of Environmental Contamination and Toxicology 50(6):898-906.

Ruhl, J. B. 2003. Equitable Apportionment of Ecosystem Service: New Water Law for a New Water Age. Florida State University College of Law forum on "The Future of the Appalachicola-Chattahoochee-Flint River System: Legal, Policy, and Scientific Issues".

Runkle, J., K. E. Kunkel, L. E. Stevens, R. Frankson, B. C. Stewart, W. Sweet, and S. Rayne. 2022. South Carolina State Climate Summary NOAA/NESDIS, Silver Spring, MD.

Salwasser, H., S. P. Mealey, and K. Johnson. 1984. Wildlife population viability: a question of risk. Pages 421-439 *in* Transactions of the North American Wildlife and Natural Resources Conference.

Savoy, T. 2007. Prey eaten by Atlantic sturgeon in Connecticut waters. American Fisheries Society Symposium 56:157.

Savoy, T., and D. Pacileo. 2003. Movements and important habitats of subadult Atlantic sturgeon in Connecticut waters. Transactions of the American Fisheries Society 132:1-8.

SCDNR. 2017. Sturgeon Monitoring Study Report - 2012-2016 - Santee Accord Sturgeon Monitoring. SCDNR.

SCDNR. 2020. Diadromous Fish Project - Annual Progress Report (Full Report). SCDNR, SCR 1-43, Charleston, SC.

SCDNR. 2021a. Diadromous Fish Project - Annual Progress Report (Full Report). SCDNR, SCR 1-44, Charleston, SC.

SCDNR. 2021b. Great Pee Dee River Sturgeon Monitoring Annual Report. South Carolina Department of Natural Resources, Charleston, SC.

SCDNR. 2022. Diadromous Fish Project - Annual Progress Report. SCDNR

SCE&G. 2010. Stevens Creel Hydroelectric Project - FERC Project No. 2535 - GA, SC - Water Quality Data Summary.

SCE&G. 2011. Stevens Creel Hydroelectric Project - FERC Project No. 2535 - GA, SC - Water Quality Data Summary, Cayce, SC.

Scholz, N. L., N. K. Truelove, B. L. French, B. A. Berejikian, T. P. Quinn, E. Casillas, and T. K. Collier. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 57(9):1911-1918.

Schueller, P., and D. L. Peterson. 2010. Abundance and Recruitment of Juvenile Atlantic Sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society 139(5):1526-1535.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada., Fisheries Research Board of Canada Bulletin.

Secor, D. H. 1995. Chesapeake Bay Atlantic sturgeon: current status and future recovery. Summary of findings and recommendations from a workshop convened 8 November 1994 at Chesapeake Biological Laboratory. Chesapeake Bay Biological Laboratory, Center for Estuarine and Environmental Studies, University of Maryland System, Solomons, MD.

Secor, D. H. 2002. Atlantic sturgeon fisheries and stock abundances during the late nineteenth century. Pages 89-98 *in* American Fisheries Society Symposium.

Secor, D. H., and T. E. Gunderson. 1998. Effects of hypoxia and temperature on survival, growth, and respiration of juvenile Atlantic sturgeon (*Acipenser oxyrinchus*). Fishery Bulletin U.S. 96:603-613.

Shaffer, M. L. 1981. Minimum Population Sizes for Species Conservation. BioScience 31(2):131-134.

Sindermann, C. J. 1994. Quantitative effects of pollution on marine and anadromous fish populations. NOAA Technical Memorandum NMFS-F/NEC-104. National Marine Fisheries Service, Woods Hole, Massachusetts.

Smith, J. A., H. J. Flowers, and J. E. Hightower. 2015. Fall spawning of Atlantic Sturgeon in the Roanoke River, North Carolina. Transactions of the American Fisheries Society 144(1):48-54.

Smith, T. I. J. 1985. The fishery, biology, and management of Atlantic sturgeon, *Acipenser oxyrhynchus*, in North America. Environmental Biology of Fishes 14(1):61-72.

Smith, T. I. J., and J. P. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. Environmental Biology of Fishes 48(1-4):335-346.

Smith, T. I. J., E. K. Dingley, and E. E. Marchette. 1980. Induced spawning and culture of Atlantic sturgeon Progressive Fish Culturist 42:147-151.

Smith, T. I. J., D. E. Marchette, and R. A. Smiley. 1982. Life history, ecology, culture and management of Atlantic sturgeon, Acipenser oxyrhynchus, Mitchill, in South Carolina. Final Report to U.S. Fish and Wildlife Service Resources Department.

Smith, T. I. J., J. W. McCord, M. R. Collins, and W. C. Post. 2002. Occurrence of stocked shortnose sturgeon *Acipenser brevirostrum* in non-target rivers. Journal of Applied Ichthyology 18(4-6):470-474.

Soulé, M. E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-170 *in* M. E. Soulé, and B. A. Wilcox, editors. Conservation Biology: An Evolutionary-Ecological Perspective. Sinauer Associates, Sunderland, MA.

Soulé, M. E. 1987. Where do we go from here? Chapter 10 In: Soulé, M.E. (ed), Viable Populations for Conservation. Cambridge University Press, pp.175-183.

Spencer, D., and L. B. Muzekari. 2002. Source Water Assessment Plans Across State Lines Beaufort Jasper Water & Sewer Authority and the City of Savannah. South Carolina Environmental Conference.

Stein, A. B., K. D. Friedland, and M. Sutherland. 2004. Atlantic sturgeon marine distribution and habitat use along the northeastern coast of the United States. Transactions of the American Fisheries Society 133:527-537.

Stevenson, J. C., and D. H. Secor. 1999. Age determination and growth of Hudson River Atlantic sturgeon (*Acipenser oxyrinchus*). Fishery Bulletin 97:153-166.

Taubert, B. D. 1980. Biology of the shortnose sturgeon (*Acipenser brevirostrum*) in Holyoke Pool, Connecticut River, Massachusetts. University of Massachusetts.

Thiem, J. D., T. R. Binder, J. W. Dawson, P. Dumon, D. Hatin, C. Katopodis, D. Zhu, and S. J. Cooke. 2011. Behaviour and passage success of upriver-migrating lake sturgeon Acipenser fulvescens in a vertical slot fishway on the Richelieu River, Quebec, Canada. Endangered Species Research 15:1-11.

Thomas, C. D. 1990. What Do Real Population Dynamics Tell Us About Minimum Viable Population Sizes? Conservation Biology 4(3):324-327.

Turek, J., A. J. Haro, and B. Towler. 2016. Federal interagency nature-like fishway passage design guidelines for Atlantic coast diadromous fishes. NOAA National Marine Fisheries Service.

USFWS. 1993. Pallid Sturgeon Recovery Plan. U.S. Fish and Wildlife Service, Bismarck, North Dakota.

USFWS. 2003. DRAFT - Fish and Wildlife Coordination Act Report on Savannah River Basin Comprehensive Study. United States Fish and Wildlife Service.

USFWS. 2019. Fish Passage Engineering Design Criteria. USFWS, Hadley, Massachusetts.

USFWS, and NMFS. 2022. Gulf Sturgeon (Acipenser oxyrinchus desotoi) 5-Year Review: Summary and Evaluation.

USFWS, NMFS, and SCDNR. 2001. Santee-Cooper Basin Diadromous Fish Passage Restoration Plan. 72 pp.

USGRG. 2004. U.S. National Assessment of the Potential Consequences of Climate Variability and Change, Regional Paper: The Southeast. U.S. Global Research Group. Washington, D.C., August 20, 2004.

Van Eenennaam, J., S. Doroshov, G. Moberg, J. Watson, D. Moore, and J. Linares. 1996. Reproductive conditions of the Atlantic sturgeon (*Acipenser oxyrinchus*) in the Hudson River. Estuaries and Coasts 19(4):769-777.

Van Eenennaam, J. P., and S. I. Doroshov. 1998. Effects of age and body size on gonadal development of Atlantic sturgeon. Journal of Fish Biology 53(3):624-637.

Varanasi, U. 1992. Chemical contaminants and their effects on living marine resources. Pages 59-71 *in* R. H. Stroud, editor Stemming the Tide of Coastal Fish Habitat Loss. Proceedings of the Symposium on Conservation of Fish Habitat, Baltimore, Maryland, Marine Recreational Fisheries Number 14. National Coalition for Marine Conservation, Inc., Savannah, Georgia.

Vine, J. R., S. C. Holbrook, W. C. Post, and B. K. Peoples. 2019. Identifying Environmental Cues for Atlantic Sturgeon and Shortnose Sturgeon Spawning Migrations in the Savannah River. Transactions of the American Fisheries Society 148(3):671-681.

Vladykov, V. D., and J. R. Greely. 1963. Order Acipenseroidei. Fishes of Western North Atlantic. Yale.

Von Westernhagen, H., H. Rosenthal, V. Dethlefsen, W. Ernst, U. Harms, and P. D. Hansen. 1981. Bioaccumulating substances and reproductive success in baltic flounder (*Platichthys flesus*). Aquatic Toxicology 1(2):85-99.

Vose, R. S., D. R. Easterling, K. E. Kunkel, A. N. LeGrande, and M. F. Wehner. 2017. Temperature changes in the United States. Pages 185-206 *in* D. J. Wuebbles, and coeditors, editors. Climate Science Special Report: Fourth National Climate Assessment, Volume I. U.S. Global Change Research Program, Washington, DC, USA.

Waldman, J., S. E. Alter, D. Peterson, L. Maceda, N. K. Roy, and I. Wirgin. 2018. Contemporary and historical effective population sizes of Atlantic sturgeon Acipenser oxyrinchus oxyrinchus. Conservation Genetics.

Waldman, J. R., C. Grunwald, J. Stabile, and I. Wirgin. 2002. Impacts of life history and biogeography on the genetic stock structure of Atlantic sturgeon Acipenser oxyrinchus oxyrinchus, Gulf sturgeon A. oxyrinchus desotoi, and shortnose sturgeon A. brevirostrum. Journal of Applied Ichthyology 18(4-6):509-518.

Waldman, J. R., and I. I. Wirgin. 1998. Status and restoration options for Atlantic sturgeon in North America. Conservation Biology 12(3):631-638.

Waring, C. P., and A. Moore. 2004. The effect of atrazine on Atlantic salmon (Salmo salar) smolts in fresh water and after sea water transfer. Aquatic Toxicology 66(1):93-104.

Weber, W., and C. A. Jennings. 1996. Endangered species management plan for the shortnose sturgeon, *Acipenser brevirostrum*. Final Report to Port Stewart Military Reservation, Fort Stewart, GA.

Welsh, S. A., S. M. Eyler, M. F. Mangold, and A. J. Spells. 2002. Capture locations and growth rates of Atlantic sturgeon in the Chesapeake Bay. Pages 183-194 *in* American Fisheries Society Symposium.

Winger, P. V., P. J. Lasier, D. H. White, and J. T. Seginak. 2000. Effects of Contaminants in Dredge Material from the Lower Savannah River. Archives of Environmental Contamination and Toxicology 38(1):128-136.

Wirgin, I., C. Grunwald, E. Carlson, J. Stabile, D. L. Peterson, and J. Waldman. 2005. Range-wide population structure of shortnose sturgeon *Acipenser brevirostrum* based on sequence analysis of the mitochondrial DNA control region. Estuaries 28(3):16.

Wirgin, I., C. Grunwald, J. Stabile, and J. R. Waldman. 2010. Delineation of discrete population segments of shortnose sturgeon Acipenser brevirostrum based on mitochondrial DNA control region sequence analysis. Conservation Genetics 11(3):689-708.

Wirgin, I., and T. King. 2011. Mixed stock analysis of Atlantic sturgeon from coastal locales and a non-spawning river. NMFS Northeast Region Sturgeon Workshop, Alexandria, Virginia.

Wirgin, I., J. Waldman, J. Stabile, B. Lubinski, and T. King. 2002. Comparison of mitochondrial DNA control region sequence and microsatellite DNA analyses in estimating population structure and gene flow rates in Atlantic sturgeon Acipenser oxyrinchus. Journal of Applied Ichthyology 18(4-6):313-319.

Wirgin, I., J. R. Waldman, J. Rosko, R. Gross, M. R. Collins, S. G. Rogers, and J. Stabile. 2000. Genetic structure of Atlantic sturgeon populations based on mitochondrial DNA control region sequences. Transactions of the American Fisheries Society 129(2):476-486.

Wrona, A., D. Wear, J. Ward, R. Sharitz, J. Rosenzweig, J. P. Richardson, D. Peterson, S. Leach, L. Lee, and C. R. Jackson. 2007. Restoring ecological flows to the lower Savannah River: a collaborative scientific approach to adaptive management. Pages 27-29 *in* Proceedings of the 2007 Georgia Water Resources Conference.

Young, J. R., T. B. Hoff, W. P. Dey, and J. G. Hoff. 1988. Management recommendations for a Hudson River Atlantic sturgeon fishery based on an age-structured population model. Fisheries Research in the Hudson River. State of University of New York Press, Albany, New York.

Ziegeweid, J., C. Jennings, and D. Peterson. 2008. Thermal maxima for juvenile shortnose sturgeon acclimated to different temperatures. Environmental Biology of Fishes 82(3):299-307.

Appendix 1: 2008 Draft Settlement Agreement

SETTLEMENT AGREEMENT

CONCERNING THE LICENSING OF THE AUGUSTA CANAL PROJECT FERC PROJECT NO. 11810

1 Introduction

1.1 Parties. This Settlement Agreement constitutes an offer of settlement pursuant to Rule 602 of the Rules of Practice and Procedure of the Federal Energy Regulatory Commission (FERC or Commission), 18 C.F.R. § 385.602, by and among Augusta, Georgia (Augusta); the Georgia Department of Natural Resources (GDNR); the South Carolina Department of Natural Resources (SCDNR); the U.S. Department of the Interior (DOI), through the U.S. Fish and Wildlife Service (FWS); and the U.S. Department of Commerce, through the National Marine Fisheries Service (NMFS or NOAA Fisheries). The above are referred to individually as "Party" or collectively as "Parties."

1.2 Recitals.

1.2.1 The Augusta Canal was constructed in approximately 1845 through 1847, pursuant to an ordinance passed by the City Council of the City of Augusta on March 15, 1845, "to provide for the construction of a Canal, for manufacturing purposes, and for the better securing an abundant supply of water for the city," and pursuant to an Act of the General Assembly of the State of Georgia which created the Augusta Canal Company (Ga. Laws 1845, p. 138). The latter enactment was subsequently amended to convey the Canal to the City of Augusta (Ga. Laws 1849, p. 85). In 1995 the Georgia General Assembly created the consolidated political subdivision now known as Augusta, Georgia (Augusta), effective January 1, 1996, by consolidating the former governments of the City of Augusta and Richmond County (1995 Ga. Laws, p. 3648, as amended). Augusta is the successor in interest to all the rights and responsibilities of both the former City of Augusta and Richmond County, Georgia, having the powers of both a municipality and a county.

1.2.2 Augusta owns and operates the Augusta Canal together with the diversion dam, head works and facilities therein.

1.2.3 The Augusta Diversion Dam (ADD) is an eleven and one-half (11.5)-foot in height run-of-the-river type stonemasonry dam. Its primary function is to divert water from the Savannah River through the Canal Headgates into the Augusta Canal. The ADD is located at Savannah River Mile 206.6, approximately nine-tenths (0.9) of a mile downstream from South Carolina Electric & Gas Company's (SCE&G's) Stevens Creek Dam. The ADD is 1,666 ft long and extends between the Georgia and South Carolina Savannah River shores. The ADD impounds a normal maximum surface area of 190 acres at a normal maximum elevation of 160 MSL. It has no usable storage capacity. The pool elevation and rate of flow through the impoundment are determined primarily by operations of the Stevens Creek Dam and the United States Army Corps of Engineers' (USACE's) J. Strom Thurmond Dam.

1.2.4 The Augusta Canal roughly parallels the Savannah River, including the area known as the Augusta Shoals, for approximately 7 miles, from the Canal Headgates to the Thirteenth Street Gates. The Augusta Canal provides hydro- mechanical power to pump raw water to Augusta's Water Treatment Plant for public water supply uses. Augusta presently operates four intake structures to supply motive water and raw water to its pumping facilities. It plans to build a new intake structure a short distance upstream of the existing structures and relegate the existing intakes to historical and reserve operating modes, but the timing of such construction and operation is uncertain. The intakes are located at the Augusta Raw Water Pump Station (RWPS), approximately 3.5 miles downstream of the Canal Headgates. The hydro-mechanical facilities are not going to be licensed and are not part of or subject to this Settlement Agreement.

1.2.5 Augusta does not generate hydroelectric power and has no plans to do so, but it provides waterpower to three hydroelectric users through the Augusta Canal. Those users are the Sibley Mill (FERC Project No. 5044), which is located approximately 5.4 miles downstream of the Canal Headgates; the King Mill (FERC Project No. 9988), approximately 5.55 miles downstream of the Canal Headgates; and the Graniteville Enterprise Mill (FERC Project No. 2935), approximately 6.35 miles downstream of the Canal Headgates. The Sibley, King and Graniteville Enterprise Mills are separately licensed by the FERC, and those licenses are not a part of or subject to this Settlement Agreement.

1.2.6 The Augusta Canal is not presently licensed by the FERC. Augusta filed an application for a FERC license on January 30, 2003, and a revised license application on June 20, 2003.

2 <u>Purpose and General Provisions</u>

2.1 Purpose. The purpose of this Settlement Agreement is to resolve among the Parties issues that have been or could have been raised in this licensing proceeding related to (1) the allocation of water flow between the Savannah River and the Augusta Canal, and (2) installation and operation of upstream and downstream fish passage facilities at the Augusta Canal Project.

2.2 Settlement as Basis for License Conditions. The Parties respectfully request the FERC to approve this Settlement Agreement and to incorporate the provisions of Section 4, Attachment 1 (Proposed License Articles for Fishways), and Attachment 2 (Augusta Declaration Flow) of this Settlement Agreement into a license for the Augusta Canal Project, without material modification, and not to impose any conditions in a license that are inconsistent with any of the provisions of this Settlement Agreement.

2.3 Termination of Settlement. This Settlement Agreement shall terminate: (a) upon expiration of the new license for the Project, or (b) in accordance with Section 3.

2.4 Modification of Settlement. This Settlement Agreement may only be modified: (a) upon the unanimous, written consent of all Parties, or (b) in accordance with Section 3.

2.5 Compliance with Legal Responsibilities. Nothing in this Settlement Agreement is intended or shall be construed to affect or limit the authority of any Party to fulfill its existing contractual responsibilities or existing and future statutory and regulatory responsibilities under applicable law. Provided, by entering into this Settlement Agreement the Parties with such responsibilities represent that they believe that their responsibilities with respect to matters agreed to in this Settlement Agreement have been, are, or can be met for the purpose stated in Section 2.1 consistent with this Settlement Agreement. Provided further, nothing in this Settlement Agreement is intended to preempt or restrict the FWS or NMFS from taking future actions, consistent with federal law, as necessary to meet obligations under the Endangered Species Act.

2.6 Modification of Recommendations. The Parties agree that following the execution and filing of this Settlement Agreement with the FERC, to the extent that recommendations submitted by the State and Federal Agency Parties pursuant to Federal Power Act (FPA) Sections 10(a) or 10(j) are inconsistent with the terms of this Agreement, such recommendations shall be deemed to have been modified and superseded by the terms of this Settlement Agreement.

2.7 Communications. The Parties recognize the importance of continuing to maintain effective and timely communication protocols after the FERC license is issued and agree that such communications ought to include all critical stakeholders who have an interest in the efficient operation of the Augusta Canal. This list includes but may not be limited to Augusta, the FWS, the NMFS (NOAA Fisheries), the GDNR, the SCDNR, and other parties or agencies as needed.

3 Inconsistent Fishway Prescriptions or Water Quality Conditions

3.1 The Parties have negotiated the Proposed License Articles for Fishways at the Augusta Canal Project (Attachment 1). DOI, on behalf of the FWS, and NMFS will file with FERC modified Section 18 fishway prescriptions consistent with the fish passage provisions in Attachment 1 to this Settlement Agreement within 45 days of the close of the comment period on the Commission's Notice of Offer of Settlement.

3.1.1 Nothing in this Settlement Agreement is intended to prohibit the FWS or NMFS from considering any comments or information filed with FERC, or submitted to the FWS or NMFS, in response to this Settlement Agreement that directly pertain to the fish passage provisions in Attachment 1.

3.1.2 In the event the DOI or NMFS do not file modified Section 18 fishway prescriptions consistent with the fish passage provisions of Attachment 1 in accordance with Section 3.1, Augusta may withdraw from this Settlement Agreement and/or take any other action allowed by law. Augusta will notify the other Parties of the inconsistency within 30 days of the filing of inconsistent Section 18 prescriptions.

3.1.3 In the event the Commission issues a license that does not adopt and incorporate the FWS' or NMFS' modified Section 18 fishway prescriptions as described in

Section 3.1, the FWS or NMFS may withdraw from this Settlement Agreement and/or take any action allowed by law. In such circumstances, the FWS or NMFS will notify the other Parties of its intention within 30 days of license issuance.

3.2 In the event that a final Clean Water Act Section 401 Water Quality Certification is issued by either Georgia or South Carolina which, after the conclusion of any appeals proceedings, incorporates any conditions that are not consistent with Section 4 of this Settlement Agreement, any Party may withdraw from this Settlement Agreement and/or take any other action allowed by law. Any such Party will notify the other Parties of the inconsistency within 30 days of the subject Water Quality Certificate becoming final.

3.3 In the event any Party withdraws from this Settlement Agreement pursuant to Section 3.1.2, 3.1.3, or 3.2, any other Party may withdraw and/or take any action allowed by law. Any Party who chooses to withdraw from this Settlement Agreement pursuant to this Section will so notify the other Parties within 30 days of a notice of withdrawal.

4. <u>Flow Conditions</u>[24]

4.1 The Parties agree that Aquatic Base Flow reservations for the Augusta Shoals will be as stated in Section 4.3. All numbers are in cubic feet per second (cfs). The first column identifies the levels of inflows to the ADD, which are sometimes described as "Tier 1" (ADD inflows greater than 5,400 cfs), "Tier 2" (ADD inflows between 4,500 and 5,399 cfs), "Tier 3" (ADD inflows between 3,600 and 4,499 cfs), and "Tier 4" (ADD inflows less than 3,600 cfs).

4.2 Inflows to the ADD are described as the "Augusta Declaration." The Augusta Declaration will be calculated as follows:

(1) Acquire daily SEPA Declaration for the Thurmond Dam.

(2) Determine additional inflow between the Thurmond Dam and the ADD for same date as SEPA Declaration. The agreed method of calculating additional inflow is described in Attachment 2, which is incorporated into and made a part of this Settlement Agreement. The Parties will agree to standardize the time of day to read the United States Geological Survey (USGS) Modoc gauge (as described in Attachment 2) for the purpose of calculating inflows.

(3) The sum of the daily SEPA Declaration and additional inflow from Step (2) equals the daily Augusta Declaration.

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[24] The terms "reserve," "reserved," "Aquatic Base Flow reservations," or other similar terms, in this Section 4 and elsewhere in this Settlement Agreement, are used in their ordinary sense and without reference to the doctrine of "reserved water rights" under the western states law of prior appropriation. The meaning attached to such terms under the law of prior appropriation does not apply to those terms as used in this Settlement Agreement.

4.3 Agreed Aquatic Base Flows:

		FEB/MAR	APR	MAY 1-15	MAY 16-31	JUNE- JAN
Tier 1	≥5400	3300	3300	2500	1900	1900
Tier 2	4500-5399	2300	2200	1800	1800	1500
Tier 3	3600-4499	2000	2000	1500	1500	1500
Tier 4	<3600	1800	1800	1500	1500	1500

4.4 The difference between the Augusta Declaration and the agreed Aquatic Base Flow for each day will be the amount that may be diverted to the Augusta Canal, as needed, sometimes referred to as the daily allowable diversion flow rate. For purposes of determining compliance, the quantity of water that will flow in the Canal shall not exceed 105% of the daily allowable diversion flow rate.

4.5 The City will make one flow setting for the Canal Headgates on a daily basis, based upon the daily Augusta Declaration. There will be no adjustments to the canal flow setting during such 24 hour period, except for compliance purposes or an emergency.

4.6 The flows stated in Section 4.3 are not minimum flows but base flows. This means that based on a 40 year historical average and as projected over the expected FERC license term, the flows will be greater than stated, especially at the Tier 1 Level, a majority of the time. This is because total flow in the Savannah River will often exceed the sum of the allocations for the Canal and Augusta Shoals, and any surplus water will flow into the Augusta Shoals.

4.7 Between May 16 and the following January 31 of each year, the specified Aquatic Base Flows will be reserved at least 90% of the time under Tier 1 (≥ 5400 cfs) flow conditions, based on a 60-day rolling period. Stated otherwise, the Aquatic Base Flow reservation will be satisfied at least 54 days of any consecutive 60-day period (subject to the 5% "margin of error" condition set out in Section 4.4, which states that for purposes of determining compliance the quantity of water that will flow in the Canal shall not exceed 105% of the daily allowable diversion flow rate). During the balance (no more than 10% or 6 days) of each consecutive 60-day period, Augusta will reserve a daily average flow at not more than 500 cfs below the Aquatic Base Flow level.

4.8 Between February 1 and May 15 of each year, the specified Aquatic Base Flows will be reserved at least 95% of the time under Tier 1 (≥ 5400 cfs) flow conditions, based on a 60-day rolling period. Stated otherwise, the Aquatic Base Flow reservation will be satisfied at least 57 days of any consecutive 60-day period (subject to the 5% "margin of error" condition set out in Section 4.4, which states that for purposes of determining compliance the quantity of water that will flow in the Canal shall not exceed 105% of the daily allowable diversion flow rate). During the balance (no more than 5% or 3 days) of each consecutive 60-day period, Augusta will reserve a daily average flow at not more than 500 cfs below the Aquatic Base Flow level.

4.9 The Aquatic Base Flow will be met 90% of the time in a running count of any 60-day period year-round. In addition, the Aquatic Base Flow will be met 95% of the time in a running count for any 60-day period that begins on or after February 1 or ends on or before May 15. In other words, the specified Aquatic Base Flows will be reserved at least 90% of the time under Tier 1 (≥ 5400 cfs) flow conditions for the full 60-day rolling period year-round (subject to the 5% "margin of error" condition set out in Section 4.4, which states that for purposes of determining compliance the quantity of water that will flow in the Canal shall not exceed 105% of the daily allowable diversion flow rate). The deviation will be not more than 6 days during any 60-day period year-round, and in addition, will be not more than 3 days during any 60 day period between February 1 and May 15.

4.10 For purposes of determining compliance with either the 90%/60 day rule or the 95%/60 day rule, circumstances beyond the control of Augusta shall not be counted as a violation of Augusta's license, including but not limited to the following: downstream users violating anticipated allocations, downstream users' violations of their license conditions, catastrophic failure of the gates or canal banks, or operational emergencies. Further, periods of canal re-watering shall not be counted in the allowed percentage deviations. The purpose of the 5%/10% deviation allowed, as provided herein, is to give Augusta operational flexibility, at its discretion, to meet the needs of the canal users. The 90%/60-day rule and the 95%/60-day rule shall apply only to Tier 1 flow conditions.

4.11 Augusta will, at its option, either:

a. Within 90 days following the execution of this Settlement Agreement, submit the procedure for determining the "Augusta Declaration," described in Section 4.2 and Attachment 2 hereof, to an independent third party agreeable to all Parties to verify that the procedure is a reasonable method to determine how much water would be available to meet the needs of the Augusta Canal after first reserving the Aquatic Base Flows (averages over a twenty-four hour period) indicated in Section 4.3. The independent third party will be a qualified hydrologist. The hydrologist will be asked to render an Opinion, based on the historic record, on the likelihood that the Aquatic Base Flow or larger quantity of water will reach the Augusta Shoals on a daily average basis. In the event such verification can not be provided for any reason, Augusta agrees to implement option (b) below; or

b. Upon acceptance of FERC license, place at its expense into the pool above the ADD a device for monitoring the pool daily average stage in that section of the River.

4.12 Augusta will work with the USACE and/or the USGS to provide appropriate gauging equipment in the Canal. In so doing, Augusta will consult with the FWS, NMFS, GDNR and SCDNR. Augusta will not monitor the flow in the Augusta Shoals, nor will there be any instantaneous, or continuous, minimum flow condition for the Augusta Shoals, except for the 1000 cfs provided in Section 5.3 and Attachment 1 to this Settlement Agreement.

4.13 Should Augusta's demands for water from the Canal exceed 4,600 cfs during the term of the expected FERC license, Augusta agrees to submit any proposed future increase in

Canal flows and an evaluation of any impacts such flows would have on the Augusta Shoals to a technical committee composed of representatives of the GDNR, SCDNR, and Augusta Utilities Department, which committee shall make a recommendation to FERC regarding any such proposed increase in Canal flows. The technical committee shall notify the FWS and NMFS regarding any proposed increase in Canal flows and shall keep the FWS and NMFS advised of discussions regarding same. The technical committee shall provide the FWS and NMFS with a copy of any proposed increase in Canal flows and shall allow the FWS and NMFS to review and provide written comments. Any comments by the FWS and NMFS shall be forwarded to FERC by the technical committee as a part of any report from the committee. Any Party may also comment separately to FERC regarding such increase, but it is the intent of the Parties not to reopen the FERC license (this clause is applicable only to this Section 4.13). FERC shall make the final decision regarding such increases in Canal flows and any impacts those flows would have on the Augusta Shoals.

5. Fish Passage

5.1 The Parties agree that upstream fish passage will be as described by the FWS and NMFS in the Modified Prescriptions for Fishways dated August 4, 2005, and August 24, 2005, with attraction flows supplied by either a permanent notch, Obermeyer type inflatable crest gates, or other similar structure, as specified in Section 5.3 herein, waiving the conditions that Augusta expressed in its license application. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install upstream fish passage in accordance with the provisions of Attachment 1.

5.2 The Parties agree that downstream fish passage shall be fully operational within three years of the FWS or NMFS notifying the licensee that shortnose sturgeon have been documented to successfully pass above the Augusta Diversion Dam through the upstream fishway. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install downstream fish passage in accordance with the provisions of Attachment 1.

5.3 The Parties agree that until such time as upstream fish passage facilities are constructed at the ADD, Augusta will provide a temporary notch or other similar structure (within one year of the issuance of a FERC license) using existing facilities (*e.g.*, stoplogs). The temporary notch or other similar structure will be sized to provide a minimum flow of approximately 1,000 cfs over or through the Dam at all times, including leakage (which includes leakage from any part of the Dam, including but not limited to flow through the existing fish ladder). When fish passage facilities are constructed at the Dam, Augusta will provide either a permanent notch in the Dam adjacent to the new fishway, which will be incorporated into the new fishway design, or Obermeyer type inflatable crest gates, or other similar structure, either of which will be sized to provide a minimum flow of approximately 1,000 cfs over or through the Dam at all times, including leakage. These requirements have been incorporated into Attachment 1 (Proposed License Articles for Fish Passage). Augusta shall install the temporary notch or other similar structure and either the permanent notch, Obermeyer type inflatable crest gates, or other similar structure in accordance with the provisions of Attachment 1.

6. <u>Miscellaneous Provisions</u>

6.1 In the event this Settlement Agreement is terminated, all documents related to negotiation of this Settlement Agreement shall remain confidential and shall not be disclosed or discoverable or admissible in any forum or proceeding for any purpose to the fullest extent allowed by applicable law, including 18 C.F.R. § 385.606 (2005) (Confidentiality in Dispute Resolution Proceedings).

6.2 The Parties entered into the negotiations and discussions leading to this Settlement Agreement with the understanding that, to the extent allowed by law, all discussions and documents relating to the development of this Settlement Agreement were and shall remain confidential. Positions advanced or discussed and documents prepared by the Parties during negotiation of this Settlement Agreement shall not be used by any Party in any manner, including admission into evidence, in connection with this Settlement Agreement or in any other proceedings related to the subject matter of this Settlement Agreement, except to the extent that disclosure may be required by law. This Section 6.2 shall survive any termination of this Settlement Agreement or transfer of the Project License pursuant to Section 8 of the FPA and shall apply to any Party that withdraws from or becomes no longer subject to this Settlement.

6.3 This Settlement Agreement establishes no principle or precedent with regard to any issue addressed in this Settlement Agreement or with regard to any Party's participation in any other pending or future licensing proceeding. Further, no Party to this Settlement Agreement shall be deemed to have approved, accepted, agreed to, or otherwise consented to any operation or principle underlying any of the matters covered by this Settlement Agreement, except as expressly provided by this Settlement Agreement. By entering into this Settlement Agreement, no Party shall be deemed to have made any admission or waived any contention of fact or law that it did make or could have made in any FERC proceeding relating to the issuance of the license. This Section 6.3 shall survive any termination of this Settlement Agreement or transfer of the Project License pursuant to Section 8 of the FPA and shall apply to any Party that withdraws from or becomes no longer subject to this Settlement Agreement.

6.4 The provisions of this Settlement Agreement are not severable. This Settlement Agreement is made on the understanding that each provision is in consideration of and in support of every other provision, and each provision is a necessary part of the entire Settlement Agreement.

6. Execution of Settlement Agreement

6.1 Signatory Authority. Each signatory to this Settlement Agreement represents that he or she is authorized to execute this Settlement Agreement and to legally bind the Party he or she represents, and that such Party shall be fully bound by the terms hereof upon such signature without any further act, approval, or authorization by such Party. This Agreement may be executed and delivered by facsimile. Facsimile signatures shall have the same legal effect as manual signatures.

6.2 Signing in Counterparts. This Settlement Agreement may be executed in any number of counterparts. Each executed counterpart shall have the same force and effect as an original instrument as if all the signatory Parties to all of the counterparts had signed the same instrument.

Executed and agreed to by the following Parties: Augusta,

Georgia

By: ____

Name: ____

Title: ____

Date: ____

Georgia Department of Natural Resources

By: ____

Name: ____

Title: ____

Date: ____

South Carolina Department of Natural Resources By:

Name: ____

Title: ____

Date: ____

U.S. Department of the Interior,
through the U.S. Fish and Wildlife Service

By: ____

Name: ____

Title: ____

Date: ____

U.S. Department of Commerce,
through the National Marine Fisheries Service

By: ____

Name: ____

Title: ____

Date: ____

Attachment 1

PROPOSED LICENSE ARTICLES FOR FISHWAYS AT THE AUGUSTA CANAL PROJECT

A. General Terms and Conditions for Fishways

To ensure the timely contribution of the proposed fishway to the Savannah River fish restoration effort, the following measures are included and shall be incorporated by the licensee to ensure the effectiveness of the fishway pursuant to Section 1701(b) of the 1992 National Energy Policy Act (P.L. 102-0486, Title XVII, 106 Stat. 3008).

1. Fishways shall be constructed, operated, and maintained to provide effective (safe, timely, convenient) passage for American shad, blueback herring, striped bass, shortnose sturgeon, American eel, and robust redhorse at the licensee's expense.

2. The design population for each target species is:

Target species	Upstream Fishway Design Populations
American shad	111,000
Blueback herring	550,000
Robust redhorse	(unquantified)
Striped bass	(unquantified)
American eel	(unquantified)
Shortnose sturgeon	(unquantified)

3. Upstream fishways shall be operational during the designated migration period at river flows up to approximately 30,000 cfs.

4. The upstream fishway shall be fully operational as soon as possible but no later than three years after the date of issuance of a new license so that the benefits of passage improvements may be realized as soon as practicable. The downstream fishway shall be fully operational within three years of the FWS or NMFS notifying the licensee that shortnose sturgeon have been documented to successfully pass above the Augusta Diversion Dam through the upstream fishway. The licensee shall (1) notify and (2) obtain approval from the FWS and NMFS for any extensions of time to comply with the provisions included in this prescription for fishways. A detailed schedule and time line for all work required shall be developed in coordination with the FWS and NMFS.

5. Following installation of the respective fishway, such fishways shall be maintained and operated at the licensee's expense throughout the migration periods for the target species. The migration periods for diadromous target species are as follows:

Species	Upstream Migration	Downstream Migration
American shad	**Feb. 1 – May 15**	**essentially year round**
Blueback herring	**Feb. 1 – May 15**	**essentially year round**
Robust redhorse	**Feb. 1 – May 15**	**essentially year round**
Striped bass	**Feb. 1 – May 15**	**essentially year round**
American eel	**Feb. 1 – May 15**	**unknown**
Shortnose sturgeon	**Feb. 1 – Apr. 15**	**essentially year round**

Any of these migration periods may be amended or otherwise changed during the term of the license by the FWS and NMFS in consultation with the GDNR, SCDNR and the licensee, based on experience, data, or new information.

6. The licensee shall keep the fishway in proper order and shall keep fishway areas clear of trash, logs, and material that would hinder passage. Anticipated maintenance shall be performed sufficiently before a migratory period such that fishway can be tested and inspected, and will operate effectively prior to and during the migratory periods. In consultation with the FWS, NMFS, GDNR, and SCDNR, the licensee shall develop a fishway operation and maintenance plan (O&M plan) describing the anticipated fishway operational protocols, maintenance, maintenance schedule, and contingencies. The plan, containing the consultation comments of the state resource agencies, shall be submitted to the FWS and NMFS for review and approval. Upon such approval, the Plan shall be submitted to the Commission for approval. If the licensee disagrees with any requirements or modifications imposed by the FWS and NMFS as conditions of their approval, it shall provide an explanation in its filing with the Commission.

7. The licensee shall provide FWS, NMFS, GDNR, and SCDNR personnel reasonable access to the project site and to pertinent project records for the purpose of inspecting the fishway to determine compliance with the fishway prescriptions and for general evaluation and oversight observations.

8. The licensee shall develop in consultation with, and submit for approval by, FWS and NMFS all functional and final design plans, construction schedules, and any hydraulic model or other studies for the fishways described herein. For the upstream fishway, functional design drawings will be submitted within eight months, and final design drawings will be submitted within fifteen months of license issuance. For the downstream fishway, functional design drawings must be submitted within eight months of the FWS or NMFS notifying the licensee that shortnose sturgeon have been documented to successfully pass above the

Augusta Diversion Dam through the upstream fishway, and final design drawings must be submitted within fifteen months of the FWS or NMFS notifying the licensee that shortnose sturgeon have been documented to successfully pass above the Augusta Diversion Dam through the upstream fishway.

9. The licensee shall develop plans for, and conduct fishway effectiveness evaluations in consultation with the FWS and NMFS on both upstream and downstream facilities. The plans and results of effectiveness studies shall be submitted to the NMFS, FWS, GDNR and SCDNR for review and comment prior to being filed for approval by the Commission. If the licensee disagrees with any of the comments and recommendations from the resource agencies, it shall provide an explanation in its filing with the Commission.

10. The licensee shall reserve aquatic base flows downstream of the Augusta Diversion Dam in accordance with Section 4.0 of the Settlement Agreement.

B. Upstream Fishway

1. Temporary Notch

Until such time as upstream fish passage facilities are constructed at the ADD, Augusta will provide a temporary notch or other similar structure (within one year of the issuance of a FERC license) using existing facilities (*e.g.*, stoplogs). The temporary notch or other similar structure will be sized to provide a minimum flow of approximately 1,000 cfs over or through the Dam at all times, including leakage (which includes leakage from any part of Dam, including but not limited to flow through the existing fish ladder). Licensee shall consult with the FWS and NMFS over the size and location of the temporary notch or other similar structure.

2. Fishway

To provide for the upstream passage of the target species listed above, a Vertical Slot Type Fishway is proposed on the South Carolina side of the Augusta Diversion Dam. The fishway will be constructed of concrete on a 1 on 16 slope and have approximately twenty-one pools (or the number of pools needed based on the vertical drop), each 10 ft long x 9 ft wide with baffles having an adjustable width (16" - 20") full depth slot to accommodate the passage of target species including shortnose sturgeon. The fishway baffles can be cast in place concrete or constructed of prefabricated elements bolted in place. The maximum drop per pool should be 7.5 inches. Rock substrate or similar artificial substrate material should be added to the fishway pools to create roughness and low-velocity areas to facilitate the upstream passage of juvenile American eel and other weak-swimming migrants. The fishway entrance should be 7 ft wide and extend down to the streambed to facilitate passage of bottom species and discharge up to 120 cfs attraction flow. Other features include a fish-counting station with viewing window at the upstream end of the fishway which could be expanded to include public viewing facilities, a fish trap and sampling device adjacent to the fish counting station, and either a permanent notch, Obermeyer type inflatable crest gates, or other similar structure adjacent to the new fishway to provide a suitable fish attraction flow field for upstream passage and an avenue for downstream migrant passage and for sluicing debris. The permanent notch, Obermeyer type inflatable crest gates, or other similar structure will be adjacent to the new fishway, incorporated into the fishway design, and sized to provide a combined minimum flow of approximately 1,000 cfs over or through the Augusta Diversion Dam at all times, including leakage and flows through the new fishway. An approach channel should also be provided in the river channel below the fishway and permanent notch, Obermeyer type inflatable crest gates, or other similar structure to facilitate the attraction of upstream migrants to the South Carolina side. The fishway should be self-regulating as far as accommodating varying flow conditions, and we recommend operation up to approximately 30,000 cfs river flow.

The fishway shall incorporate the following design features, unless the design features are modified in consultation with, and the approval of, the FWS and NMFS.

Fishway Type	Vertical slot
Suggested Location	South Carolina side of dam
Pool Size	10 ft long x 9 ft wide x 5 ft normal depth
Baffle Slot Width	Adjustable 16" - 20"
Number of Pools	As needed based on the vertical drop
Drop per Pool	7.5 inches (Maximum)
Normal Flow through Slots	30 cfs at 16" slot @ 5 ft deep
Floor Slope	1 on 16
Operating Range	Up to 30, 000 cfs river flow
Fish Counting Station	In fishway exit channel with side viewing window
Fish Trap and Sampling Facility	Adjacent to fishway exit channel
Fishway Entrance	7 ft wide to channel bottom

Attraction Flow	Up to 120 cfs at fishway entrance
Attraction Flow Diffusion Chamber	90 cfs capacity, floor type with
diffusion	grillage and grating located in entrance channel. Maximum exit velocity = 1 fps
Trash Rack	At fishway exit – 10" wide bar spacing
Trash Boom	Floating trash boom (optional) in headpond near fishway
Notch	Located adjacent to fishway and sized to provide a combined minimum flow of 1,000 cfs over or through the Augusta Diversion Dam at all times, including leakage
Fishway approach channel	Channel approximately 3 ft deep x 12 ft wide
Miscellaneous Equipment	Safety railings, walkway grating, access ladders, rock substrate in pools

C. Downstream Fishways

The Services are prescribing downstream fish facilities within the Augusta Canal to minimize the entrainment of downstream migrants and provide safe and effective downstream passage. Downstream passage facilities shall include the installation of screens and bypass systems at the two proposed intakes at the Raw Water Pumping Facility. Augusta will consult with FWS and NMFS fishway engineers concerning the design of the facilities. Augusta will design new Raw Water Pumping Station intakes to be able to accommodate a bypass to the Savannah River for additional downstream passage and protection.

The licensee shall initiate development of the downstream screen and bypass facilities at the Raw Water Pumping Station upon notice from NMFS that shortnose sturgeon are passing or have passed upstream at the Augusta Diversion Dam fish passage facility. NMFS will make its determination of successful upstream shortnose sturgeon passage employing observations at the fishway counting station or other means that demonstrate upstream passage through the fishway. NMFS will promptly notify the licensee to commence development of downstream passage and protection facilities within three years from the date of notification. Upon notification, the licensee shall initiate coordination with NMFS and FWS to develop the final conceptual and functional design plans for the downstream passage facilities.

During development of the downstream passage design, an addendum to the fishway operation and maintenance plan (O&M plan) prepared in accordance with Section A.6 of this Attachment shall be prepared to address the downstream passage facilities. The O&M plan shall include a protocol for shortnose sturgeon related procedures, data collection, and reporting; coordination and consultation roles, responsibilities and contacts, and measures to minimize the potential for incidental take during normal and emergency operations.

If during the three-year design and construction period for the downstream passage facilities, or thereafter during the license term shortnose sturgeon are determined to be injured (which includes verification of the purported harm by NMFS) by operation of the hydromechanical turbines, Augusta Canal facilities, fish passage facilities, or incidentally through other means under the control of the licensee, this take will be reported to FERC which must then initiate ESA consultation with NMFS' Protected Resources Division. The licensee shall coordinate with NMFS to develop appropriate measures to protect shortnose sturgeon. Approved construction and normal operation of the fishways prescribed by NMFS and as described in this agreement and the fishway operations and maintenance plan are anticipated to provide safe upstream and downstream passage for shortnose sturgeon and preclude fish passage-related incidental take.

Attachment 2

AUGUSTA DECLARATION FLOWS

Background

The Canal Operating Plan relies on the Augusta Declaration Flow, which is the sum of the daily SEPA declaration for Thurmond Dam and the daily tributary inflow, to allocate flows for the Augusta Canal and the Augusta Shoals. A method to estimate tributary inflow between Thurmond Dam and the ADD as part of the Canal Operating Plan (COP) is described below.

The drainage area between Thurmond Dam and the ADD is 1,006 square miles. Much of this intervening drainage area is represented by Stevens Creek, and the gauge for Stevens Creek at Modoc (USGS No. 02196000) accounts for approximately 545 square miles, or 54 percent of the total drainage area between the two dams. The streams in the Stevens Creek drainage area appear to be mostly unregulated and the watershed lies substantially in the Sumter National Forest.

The Stevens Creek gauge at Modoc is located within the watershed of interest, represents over one-half of total drainage area between Thurmond Dam and the ADD, is representative, and has an extended period of flow records (period 1941 through 1977 and 1984 through 2000, a record of 54 years). The Stevens Creek at Modoc flow data represent the best available information regarding historic tributary inflow in that area. Most importantly, daily flow data is available online and is updated each day.

Method to Estimate Tributary Inflow Using Stevens Creek at Modoc Data

The following steps would provide daily estimates of daily tributary inflow for the intervening drainage area between Thurmond Dam and Augusta Diversion Dam to be used in the calculation of the Augusta Declaration Flow.

1. Obtain the most recent daily Stevens Creek at Modoc (USGS No. 02196000) flow estimate once each morning from the USGS website at:

   http://waterdata.usgs.gov/sc/nwis/dv/?site_no=02196000&PARAmeter_cd=00060,00065 or other then current Internet site

2. Multiply the daily Stevens Creek flow by 1.85 (ratio of the drainage areas: 1,006/545 = 1.85) to account for the entire drainage area between Thurmond Dam and the ADD, resulting in “total estimated tributary inflow.”

3. If a daily flow for that day is not available from the USGS website for the morning in question, then the most recent flow estimate from the previous day will be obtained and used as a substitute. If no data is available from the day in question or the previous day or if the website is temporarily unavailable, the daily total estimated tributary inflow would be

determined by using the calculated flow duration table for the area between Thurmond Dam and the ADD (Table 1) depending on the month as follows:

- If the USACE is not in a declared drought or if the USACE is in declared drought level 1, then the 50 percentile flow from Table 1 will be used
- If the USACE is in declared drought level 2, then the 75 percentile flow from Table 1 will be used
- If the USACE is in declared drought level 3, then the 90 percentile flow from Table 1 will be used

Declared drought levels 1, 2, and 3 are defined in the USACE's Savannah River Basin Drought Contingency Plan (2006).

4. Add the total estimated tributary inflow to the SEPA declaration on a daily basis to compute the Augusta Declaration Flow.

Table 1. Estimated flow duration statistics for the drainage area between Thurmond Dam and the ADD

Percent of time exceeded	Stream Flow												
	Annual	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	**48,470**	**35,890**	**29,600**	**35,890**	**39,035**	**24,975**	**26,270**	**9,639**	**48,470**	**12,599**	**40,330**	**29,785**	**36,630**
5%	**3,053**	**6,050**	**6,618**	**8,479**	**4,072**	**1,667**	**1,212**	**1,419**	**878**	**511**	**951**	**1,445**	**2,757**
10%	**1,478**	**3,016**	**3,978**	**4,138**	**2,074**	**912**	**526**	**650**	**453**	**285**	**365**	**509**	**1,279**
15%	**962**	**1,925**	**2,553**	**2,629**	**1,385**	**601**	**354**	**416**	**316**	**198**	**215**	**313**	**827**
20%	**703**	**1,378**	**1,833**	**1,998**	**1,058**	**461**	**276**	**289**	**229**	**148**	**148**	**241**	**614**
25%	**544**	**1,104**	**1,471**	**1,526**	**864**	**384**	**217**	**224**	**179**	**120**	**113**	**196**	**481**
30%	**427**	**921**	**1,216**	**1,264**	**715**	**329**	**185**	**185**	**141**	**104**	**93**	**163**	**398**
35%	**348**	**779**	**1,036**	**1,079**	**627**	**286**	**161**	**148**	**118**	**89**	**80**	**135**	**335**
40%	**285**	**675**	**873**	**936**	**542**	**251**	**141**	**125**	**100**	**76**	**63**	**109**	**289**
45%	**229**	**592**	**765**	**825**	**483**	**224**	**130**	**105**	**85**	**65**	**56**	**91**	**242**
50%	**189**	**522**	**679**	**734**	**428**	**204**	**115**	**93**	**72**	**56**	**46**	**74**	**192**
55%	**154**	**447**	**586**	**657**	**385**	**187**	**102**	**78**	**61**	**49**	**41**	**63**	**157**
60%	**126**	**390**	**516**	**588**	**353**	**168**	**93**	**67**	**54**	**43**	**37**	**56**	**130**
65%	**102**	**336**	**448**	**539**	**318**	**150**	**83**	**59**	**46**	**37**	**32**	**50**	**109**
70%	**81**	**279**	**392**	**483**	**287**	**133**	**74**	**52**	**39**	**30**	**28**	**44**	**89**
75%	**63**	**233**	**350**	**426**	**261**	**117**	**65**	**44**	**33**	**26**	**24**	**41**	**76**
80%	**50**	**192**	**292**	**381**	**233**	**102**	**56**	**37**	**26**	**20**	**20**	**33**	**61**
85%	**39**	**152**	**244**	**333**	**205**	**83**	**44**	**30**	**20**	**16**	**16**	**28**	**52**
90%	**28**	**123**	**211**	**285**	**172**	**68**	**35**	**24**	**16**	**11**	**10**	**18**	**43**
95%	**16**	**90**	**163**	**214**	**139**	**52**	**26**	**18**	**11**	**7**	**6**	**10**	**31**
100%	**0**	**20**	**50**	**87**	**70**	**12**	**7**	**2**	**2**	**0**	**0**	**0**	**9**

Notes:

Based on flow data for Stevens Creek at Modoc, SC (USGS No. 02196000) for 1941 to 1977 and 1984 to 2000.

a Median flow, flow equaled or exceeded 50% of the time on an annual or monthly basis.

b 75 percentile flow, flow equaled or exceeded 75% of the time on an annual or monthly basis.

c 90 percentile flow, flow equaled or exceeded 90% of the time on an annual or monthly basis.

Appendix 2: Requirements for Handling Sturgeon and Collecting Genetic Samples

General Handling of Sturgeon

1. If the animal appears energetic, active, and otherwise healthy enough to undergo handling, it should be done so in accordance with guideline #3 below. If the animal is not healthy enough to undergo the procedures described, ensure the vessel is in neutral and release it over the side, head first.
2. Animals should be handled rapidly, but with care and kept in water to the maximum extent possible during holding and handling. During handling procedures the animal must be kept wet at all times using water from which it was removed (e.g., river water). While moving the animal or removing it from gear, covering its eyes with a wet towel may help calm it.
3. All handling procedures (i.e., measuring, PIT tagging, photographing, and tissue sampling) should be completed as quickly as possible, and should not exceed 20 minutes from when the sturgeon is first brought on board the vessel. Handling procedures should be prioritize in the following order: 1) collect a tissue sample (see procedure described below); 2) scan for existing PIT tags, apply new PIT tag if no pre-existing PIT tag is found; 3) measure the animal; 4) photograph the animal. If all of the handling procedures cannot be completed within 20 minutes, the animal should be returned to the water; indicate which procedures were not completed when reporting the incidental take to NMFS.
4. A sturgeon maybe held on board for longer than 20 minutes only when held in a net pen/basket floating next to the vessel or placed in flow through tanks, where the total volume of water is replaced every 15-20 minutes.

Genetic Tissue Sampling for Atlantic Sturgeon

5. Genetic tissue samples must be taken from every Atlantic sturgeon captured unless conditions are such that collecting a sample would imperil human or animal safety.
6. Tissue samples should be a small (1.0 cm^2) fin clip collected from soft pelvic fin tissue. Use a knife, scalpel, or scissors that has been thoroughly cleaned and wiped with alcohol. Samples should be preserved in RNAlater™ preservative. Gently shake to ensure the solution covers the fin clip. Once the fin clip is in buffer solution, refrigeration/freezing is not required, but care should be taken not to expose the sample to excessive heat or intense sunlight. Label each sample with the fish's unique ID number. Do not use glass vials; a 2 ml screw top plastic vial is preferred (e.g., MidWest Scientific AVFS2002 and AVC100N).

PIT Tagging

7. Every sturgeon should be scanned for PIT tags along its entire body surface ensuring it has not been previously tagged. The PIT tag readers must be able to read both 125 kHz and 134 kHz tags. When a previously implanted tag is detected the PIT tag information should be recorded on the reporting spreadsheet ("Sturgeon Genetic Sample Submission sheet"). Indicate the animal was a recapture in the "comment" field of the reporting spreadsheet.

8. Sturgeon without an existing PIT tag should have one implanted. The recommended frequency for PIT tags is 134.2 kHz. The tag information should be reported in the appropriate fields on the reporting spreadsheet.
9. Sturgeon smaller than 250mm shall not be PIT tagged. Sturgeon measuring 250-350 mm TL shall only be tagged with 8mm PIT tags. Sturgeon 350 mm or greater shall receive standard sized PIT tags (e.g., 11 or 14 mm).
10. PIT tags should be implanted to the left of the spine immediately anterior to the dorsal fin, and posterior to the dorsal scutes (Figure Appendix 2.1). This positioning optimizes the PIT tag's readability over the animal's lifetime. If necessary, to ensure tag retention and prevent harm or mortality to small juvenile sturgeon of all species, the PIT tag can also be inserted at the widest dorsal position just to the left of the 4th dorsal scute.
11. Scan the newly implanted tag following insertion to ensure it is readable before the animal is released. If the tag is not readable, one additional tag should be implanted on the opposite side following the same procedure, if doing so will not jeopardize the safety of the animal.

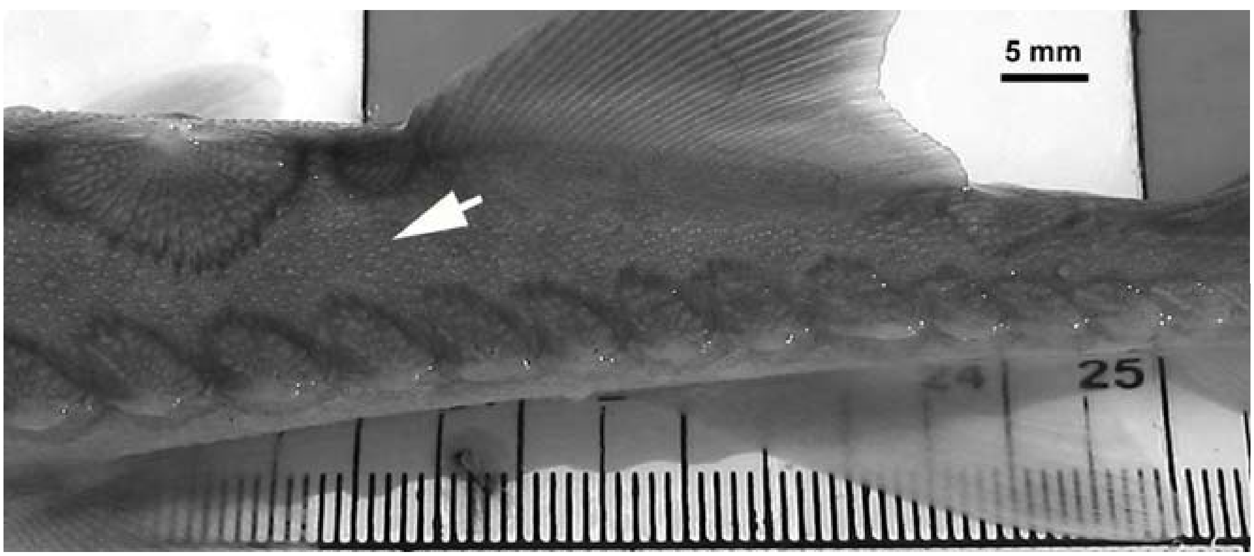

Figure Appendix 2.1. Standardized Location for PIT Tagging all Gulf, Atlantic, and shortnose sturgeon (Photo Credit: J. Henne, USFWS)

Measuring

12. Length measurements for all sturgeon should be taken as a straight line measurement from the snout to the fork in the tail (i.e., fork length – FL), and as a straight line measurement from the snout to the tip of the tail (i.e., total length – TL) (Figure Appendix 2.2). Do not measure the curve of the animal's body.

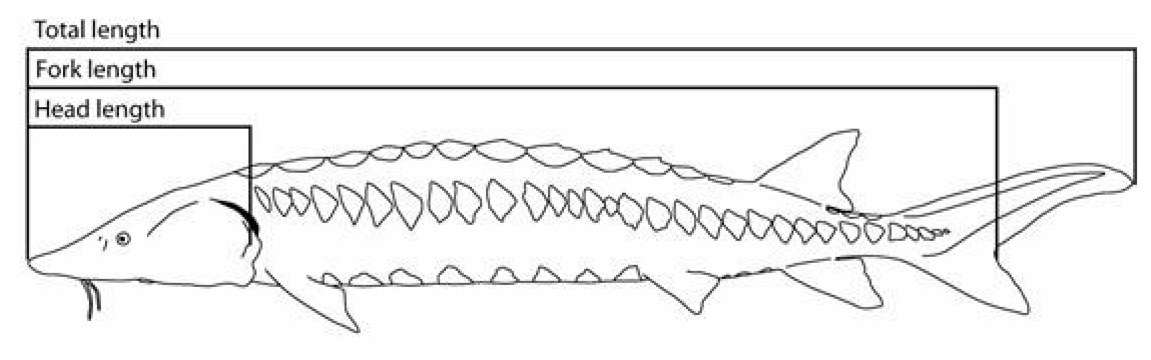

Figure Appendix 2.2. Diagram of different types of measurements for sturgeons. (Drawings by Eric Hilton, Virginia Institute of Marine Science in Mohead and Kahn 2010)

Reporting Captures/Samples

13. *Reporting Captures and Genetic Samples*: Incidental captures and genetic samples may be reported using the same reporting spreadsheet ("Sturgeon Genetic Sample Submission Sheet"). Electronic metadata for each sample must be provided to properly identify and archive samples. Submit the reporting spreadsheet via email to: rjohnson1@usgs.gov and takereport.nmfsser@noaa.gov. When submitting electronic metadata samples, identify the project name and biological opinion (SER #) in the subject line.

14. *Reporting Captures with NO Genetic Sample*: If no genetic sample could be safely collected, the incidental capture must still be reported using the Sturgeon Genetic Sample Submission Sheet. Submit the reporting spreadsheet via email to takereport.nmfsser@noaa.gov. When submitting electronic metadata samples, identify the project name and biological opinion (SER #) in the subject line.

Transport of Genetic Samples

15. Package vials containing genetic samples together (e.g., in one box) with an absorbent material within a double-sealed container (e.g., zip lock baggie).

16. When submitting tissue samples via mail, identify the project name and biological opinion (SER #) under which the take was authorized in the shipping container. Ship tissue samples to:

Mail samples to:
Robin Johnson
EESC Leetown Research Laboratory
11649 Leetown Rd.
Kearneysville, WV 25430