NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency:	Federal Highway Administration (FHWA), Army Corps of Engineers (USACE), New England District
Activity Considered:	Maine Department of Transportation (MaineDOT) Replacement of the Frank J. Wood Bridge **NER-2017-14574** **GARFO-2017-01420**
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1.0 INTRODUCTION

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) issued pursuant to Section 7 of the Endangered Species Act (ESA) of 1973, as amended, on the effects of your (Federal Highway Administration (FHWA)) proposed replacement of the Frank J. Wood Bridge, which carries Route 201 over the Androscoggin River between Topsham and Brunswick, Maine. Maine Department of Transportation (MaineDOT) is proposing the replacement; however, you are funding the project, and the project will require a permit from the U.S. Army Corps of Engineers (USACE) under their Section 404 permitting process. This Opinion is based on your November 2017 Biological Assessment (BA). That analysis, along with scientific papers and other sources of information as cited in the references section also helped form the basis of this Opinion. A complete administrative record of this consultation will be kept at our NMFS Greater Atlantic Regional Fisheries Office.

2.0 ESA CONSULTATION HISTORY

Prior to your submission of the BA, our agencies took part in a series of pre-consultation coordination meetings, inclusive of project site visits, conference calls, and in-person meetings (Table 1). The existing Frank J. Wood Bridge is immediately downstream (approximately 115 m) of the Brunswick hydroelectric project, Project No. 2284 (owned by Brookfield Renewable and licensed by the Federal Energy Regulation Commission (FERC)). Upstream passage at the Brunswick hydroelectric project occurs via a vertical slot fishway located adjacent to the powerhouse and on the western bank upstream of the bridge. At its closest point, the fishway is less than 30 m from the existing bridge. For this reason, you considered passage at this facility when evaluating direct and indirect effects of replacing the bridge on ESA-listed species and critical habitat.

Table 1: Pre-Consultation Coordination Meetings

Date	Participants	Topic
5/12/2016	MaineDOT, MDMR*, NMFS, FHWA	Natural resources coordination meeting
9/16/2016	MaineDOT, NMFS, ACOE, Brookfield, FHWA	Coordination meeting
6/1/2017	MaineDOT, NMFS, Brookfield	Coordination meeting
7/31/2017	MaineDOT, NMFS, Brookfield, MDMR, FHWA	Coordination meeting
8/23/2017	MaineDOT, NMFS, FHWA	Coordination meeting
8/29/2017	MaineDOT, NMFS, FHWA	Coordination meeting
10/5/2017	MaineDOT, NMFS, FHWA	Coordination meeting

*Maine Department of Marine Resources

A portion of the proposed bridge replacement falls within FERC's Brunswick Hydroelectric Project Boundary (No. 2284); however, in a December 12, 2017 email, you stated that through coordination with FERC, you had confirmed that FERC has no approval authority over the proposed bridge project, and therefore, no action as it relates to the project. You must coordinate with the Project No. 2284 licensee, Brookfield Renewable, under the land use article of the project's license. In an email sent December 7, 2017, USACE agreed that you would be the lead Federal action agency for ESA section 7 formal consultation.

In a June 2, 2017 letter, we provided preliminary comments on your March 10, 2017 analysis of alternatives for repairing or replacing the bridge. Following subsequent coordination, you identified a preferred alternative for the bridge replacement. On November 2, 2017, you submitted a final draft of your BA and a letter requesting initiation of formal consultation. Formal consultation regarding the replacement of the Frank J. Wood Bridge is appropriate as you have determined the project is likely to adversely affect the endangered Gulf of Maine Distinct Population Segment (GOM DPS) of Atlantic salmon, critical habitat designated for the GOM DPS of Atlantic salmon, threatened GOM DPS of Atlantic sturgeon, critical habitat designated for the GOM DPS of Atlantic sturgeon, and endangered shortnose sturgeon.

All information required to initiate formal section 7 consultation was included in your November 2, 2017 letter and BA, or is otherwise accessible for our consideration and reference; therefore, the date of the November 2, 2017 correspondence served as the commencement of the formal consultation process.

3.0 DESCRIPTION OF THE PROPOSED ACTION

MaineDOT proposes to construct a new bridge to replace the existing Frank J. Wood Bridge, which carries US 201/ME 24 over the Androscoggin River between the Towns of Brunswick and Topsham. After the new bridge is constructed, MaineDOT will remove the existing Frank J. Wood Bridge.

3.1 Description of the Existing Bridge

The Frank J. Wood Bridge is an 85-year-old, 805-foot-long, three span steel through-truss bridge with spans of 310'-310'-175' (Figure 1). Approximately 115 m upriver of the bridge sits the Brunswick Hydroelectric Project (FERC No. 2284) which is owned and operated by Brookfield Renewable. On the southern (Brunswick side) side of the bridge sits the 250th Anniversary Park on the east and the Fort Andross Mill Complex (originally the Cabot Mill) on the west. The Topsham approach features the Bowdoin Mill Complex (originally the Pejepscot Paper Company) on the eastern side.

Figure 1: View of the existing Frank J. Wood Bridge as seen from the upstream side and western shoreline

The Frank J. Wood Bridge underwent rehabilitation efforts during 1985, 2006, and 2015. MaineDOT has reported that it is a “fracture critical” structure, indicating it is vulnerable to sudden collapse if certain components fail; in this case, the truss diagonal and bottom chord members and their connections and the floor beams. Detailed inspections by MaineDOT in 2012, June 2016 and August 2016 found a number of deteriorated areas. You have classified the bridge as structurally deficient with superstructure and deck condition ratings of 4 out of 9 (poor condition). The three truss spans are fracture critical, meaning that failure of certain steel tension members could cause any of the three spans to collapse. Some of the steel truss bridge components are fatigue sensitive, susceptible to cracking and fracture as a result of heavy cyclic loading. The floor beams and stringers within the truss spans do not meet current design load or MaineDOT legal load standards.

Due to the ongoing deterioration of the structural steel, MaineDOT has completed temporary repairs to address the worst issues so the bridge can maintain its current load rating for up to five years. However, MaineDOT is proposing to implement a long-term solution within the 5-year timeframe this maintenance provides.

3.2 Description of the Proposed Replacement Bridge

MaineDOT announced the preferred alternative (i.e., bridge replacement with the new permanent bridge placed on the upstream side of the existing bridge) for the Frank J. Wood Bridge project on June 27, 2017. Final design is not complete and will not be complete until post ESA consultation and post NEPA in accordance with 23 CFR 771.113.

3.2.1 Project Design

During the early phase of project development, MaineDOT considered five alternative designs including construction of a replacement structure located either upstream or downstream of the existing Frank J. Wood Bridge, as well as rehabilitation of the existing structure. Many factors were considered prior to selection of the preferred alternative, including the presence of and potential impacts to federally endangered fish species (as well as other migratory fish species), federally protected critical habitat, changes to the hydraulic conditions present within the river channel associated with each proposed bridge alignment, and minimizing impacts to the surrounding communities during construction.

On June 27, 2017, MaineDOT announced the preferred alternative (Alternative #2). The original Alternative #2 design consisted of a new 254.5m (835-foot), five span, steel girder bridge with a curved upstream alignment. Since the announcement of the preferred alternative, further discussions with the resource agencies and other interested entities have resulted in further refinement to the span arrangement of the preferred alternative. MaineDOT modifications to the originally proposed Alternative #2 include removal of a southern pier from the tailrace area. This modification was made to minimize physical impacts to critical habitat designated under the ESA and impacts to in-river flow patterns which may potentially impact the upstream fishway associated with the Brunswick hydroelectric project. Additional information related to the proposed alternative designs and the selection process is available online[1].

3.2.2 Construction

A variety of methodologies will be employed to complete the preparation, construction, and demolition activities associated with this project. MaineDOT anticipates construction of the new Brunswick-Topsham Bridge to follow the presumed construction sequence described below. Details of the equipment, techniques used, sequence and timing of construction will be determined by the selected contractor. Although portions of the construction plan may change, the effects described from the plan are not expected to change. If you find that certain construction plan changes may result in effects not analyzed in this Opinion, reinitiating consultation may be necessary. You have stated that contractors will conduct the work according to their MaineDOT approved construction schedule and project submittals, and any adaptive management decisions arrived at during construction.

The following list describes the anticipated project activities that will occur and the presumed sequence of these activities. If any changes to this sequence of presumed construction activities occur, MaineDOT will analyze the changes to determine if reinitiation of this consultation is necessary.

1. Implement Soil Erosion and Water Pollution Control Plan (SEWPCP) plan that includes approved erosion and sediment control plan and Spill Prevention, Control and Countermeasures (SPCC) plan.
2. Clear vegetation for equipment access.
3. Mobilize construction equipment and materials.
4. Install access points for temporary trestle and new bridge abutments.
5. Install pile supported temporary work trestle.

[1] Additional information related to proposed alternative designs for the Frank J. Wood Bridge project can be found online at the Maine DOT website (http://www.maine.gov/mdot/env/frankjwood)

6. Install cofferdam at southern abutment and the three bridge piers.
7. Construct abutments, wing walls, install riprap slope protection.
8. Construct in-river piers.
9. Remove cofferdams.
10. Install bridge superstructure.
11. Complete approach roadwork, open to traffic.
12. Remove superstructure of old Frank J. Wood Bridge.
13. Remove piers and abutments of old Frank J. Wood Bridge.
14. Remove temporary trestle.
15. Final site stabilization.

All elements of the project will be conducted in compliance with MaineDOT's Standard Specifications (MaineDOT 2014[2]). The Standard Specifications is a textual compilation of provisions and requirements for the performance of any MaineDOT work and includes general Avoidance and Minimization Measures (AMMs). AMMs are measures that prevent or reduce the impact of a project on listed species or habitats. AMMs can be precautionary, avoidance, or protection procedures, such as timing restrictions or buffers around sensitive habitats and habitat features that are important to listed species. In addition to following MaineDOT AMMs, construction actions also include implementation of best management practices (BMPs). BMPs are methods, facilities, build elements, and techniques implemented or installed during project construction to prevent or reduce project impacts on natural resources, such as water quality, soil, and animal habitats. AMMs and BMPs are measures that are considered part of the proposed activity that will be implemented. Each description below is followed by, or references, previous appropriate AMMs that address potential impacts from construction actions. AMMs are stated and numbered in order to ensure they can be clearly transferred to MaineDOT's contract process.

Table 2 provides a preliminary schedule of the proposed construction sequence in relation to the in-water work window AMM. The conceptual schedule was developed to ensure that bridge construction can occur within a specified timeframe and account for seasonal in-water work windows to avoid potential species effects. The selected contractor will be required to submit their proposed final schedule to MaineDOT prior to start of construction. Activities that include potentially injurious noise levels (i.e., blasting, hydraulic rock breaker) will be confined to the period from November 8 to March 15. You will make us aware of any proposed alterations of the in-water work construction commitments to determine if the changes will require reinitiation of consultation, whereas schedules for land-based or "in the dry "construction tasks that will not affect ESA-listed species or critical habitat are subject to change. The proposed in-water work window avoids the majority but not all of the sensitive spawning and migratory periods for listed fish species expected to occur in the action area. Construction is proposed to begin on September 1, 2018 and last for approximately 801 days, finishing on March 23, 2021. The actual schedule may vary, depending on work progress and contractor efficiency.

[2] Source: Maine DOT (http://maine.gov/mdot/contractors/publications/standardspec/)

Table 2: Proposed work schedule for Frank J. Wood Bridge replacement project

Construction Task	Duration	Start	Finish
Mobilize	1 day	9/1/18	9/1/18
Construct Temporary Trestle	60 days	9/3/18	11/10/18
Construct Cofferdams	20 days	11/12/18	12/4/18
Build Superstructure	135 days	12/5/18	5/10/19
Remove Cofferdams	5 days	9/2/19	9/6/19
Place Structural Steel	60 days	9/4/19	11/12/19
Place &Cure Deck	150 days	11/13/19	5/5/20
Remove Existing Superstructure	90 days	9/2/20	12/15/20
Remove Existing Substructure	30 days	12/16/20	1/19/21
Remove Temporary Trestle	30 days	2/17/21	3/23/21
In-Water work window	*Aug 1 to March 15*		

3.3 In-Water Activity Descriptions and Related AMMs

3.3.1 Implementation of SWEPCP Plan and Site Preparation

Prior to mobilization, MaineDOT requires contractors to complete and submit a Soil Erosion and Water Pollution Control Plan (SEWPCP). The SEWPCP documents what practices and management procedures will be used to prevent a discharge of sediment and pollutants. The contractor will develop and submit the SEWPCP to the resident engineer overseeing the project. The resident engineer will rely on support from the environmental office field representatives from MaineDOT to review and approve the SEWPCP. Review of the SEWPCP and planning the use of each BMP is a critical point of construction planning. The SEWPCP contains the contractors proposed cofferdam locations, cofferdam materials, dirty water treatment design and location, downstream flow maintenance plan, temporary soil erosions control methods, and the SPCC Plan.

AMM 1- *Contractors will submit a SEWPCP for review and approval of MaineDOT staff prior to the start of work. The plan includes the review of the implementation of any AMMs proposed.*

On-site work begins with contractors installing the appropriate erosion control measures around the perimeter of the land-based work areas and removing vegetation from the work areas. Work areas will include the construction footprint surrounding both abutments of the new bridge, project offices, and any associated equipment or materials staging area. Contractors use work areas to preposition heavy machinery, stockpile new construction material, and transfer demolition rubble from the old bridge.

AMM 2- *Prior to soil disturbance, the erosion control portion of the SEWPCP will be reviewed and in place.*

3.3.2 In-water Work Window

MaineDOT staff collected site-specific resource information to develop appropriate time of year restrictions for in-water activities with the potential to affect listed species in the action area. Given the proximity of the bridge replacement to sensitive spawning and migratory habitat, MaineDOT commits to an in-water work window defined by this species occurrence data (See

Environmental Baseline - Section 5.0). Activities that include potentially injurious noise levels may include hoe-ramming and rock-blasting.

AMM 3 – *In-water work window. MaineDOT and FHWA commit to avoiding all activities that could result in in-water noise that could result in fish disturbance (louder than 150 dB re 1μPa RMS) and turbidity producing activities between March 16 and July 31.*

3.3.3 Contaminant Releases

The risk for contaminants entering the Androscoggin River has the potential to increase slightly during construction, possibly degrading habitat conditions. To avoid and minimize the potential for introducing contaminants into the river during construction activities, MaineDOT will require that all contractors follow AMM 4:

AMM 4 - *No equipment, materials, or machinery shall be stored, cleaned, fueled, or repaired within any wetland or watercourse; dumping of oil or other deleterious materials on the ground will be forbidden; the contractor shall provide a means of catching, retaining, and properly disposing of drained oil, removed oil filters, or other deleterious material; and all oil spills shall be reported immediately to the appropriate regulatory body.*

Following proper spill prevention and control techniques make a spill on the project unlikely to occur. These BMPs will reduce the likelihood of any contaminant releases into the river during construction activities.

3.3.4 Construction of Temporary Work Trestle

In-water work will require installation of a temporary work trestle to facilitate construction while avoiding disruption of traffic flow on the existing bridge during the project. The temporary work trestle will support equipment used to construct the piers, erect steel girders, and construct the concrete bridge deck. The proposed temporary trestle will extend from the access point on the Topsham side to a point near the mid-channel of the lower portion of the tailrace and will sit on the upstream side of the preferred alignment.

The method and design of the temporary work trestle access should minimize environmental effects to the surrounding landscape. MaineDOT will require contractors to take precautions to protect the stability of river bank that intersects with the work trestle to prevent degradation from the construction access. Contractors will use utilize proper BMPs at the site according to the approved SEWPCP and include proper planning, perimeter erosions controls, and daily temporary stabilization measures.

Trestle construction will begin with the installation of a temporary access point from the Topsham bank installed during the in-water work window. The access point footprint may include up to 2,000 square feet (a 40-foot by 50-foot area) of temporary fill below the normal high water line upstream from the new abutment. Fill will consist of non-erodible material, appropriately sized to remain stable at high flows. Depending on the condition of the river banks adjacent to the temporary work trestle, contractors may choose to install a temporary abutment fill retention structure to increase stability of the banks.

AMM 5– *Contractors are required to install turbidity curtains around areas planned for in-water fill associated with construction of the temporary trestle access point. All in-water trestle construction will occur between August 1 and March 15. In-river (i.e., not the ponded/bedrock falls habitat on the Topsham side) trestle construction and removal (~60 sq. ft. footprint) will occur between September 1 and March 15.*

The proposed bridge replacement includes a span length of 79.2m (260 feet) stretching from the southernmost pier to the abutment on the Brunswick side. Conversations with designers revealed that the 79.2m bridge span length will require two specialized cranes to simultaneously lift the longer beams. One crane will be deployed adjacent to the new abutment on the Brunswick side, and a second crane will be placed on the temporary trestle over the lower portion of the tailrace. Located on either end of the 79.2m span, the two cranes will perform a dual lift of the southern span.

Construction of the temporary work trestle into the lower tailrace allows for the removal of the southernmost pier associated with the original Alternative #2 design and results in a shift from the permanent impacts associated with the construction and presence of the originally proposed bridge pier to temporary impacts from the construction and short-term presence of the temporary work trestle. Removal of the southernmost pier originally included in Alternative #2 also resulted in the relocation of the southern (Brunswick) bridge abutment approximately 6.1m (20 feet) closer to the river but still above the normal high water line.

AMM 6 *– Removal of the fourth pier (leaving three in-water piers) from preliminary design to avoid impacts to critical habitat as well as potential effects to fishway function.*

The contractor will determine the number of piles needed to construct the temporary work trestle (see example in Figure 2). Based on past experience, MaineDOT estimates the temporary work trestle may require 13 bents (support sections) spaced 50 feet apart and consisting of up to 5 piles per bent. The temporary work trestle could be up to 630 feet long to span from Topsham shoreline to mid-channel of the tailrace. Due to the presence of bedrock substrate, driving the piles associated with the temporary work trestle is not feasible. As a result, pile size restrictions to reduce hydroacoustic effects are not proposed as a part of this project. Temporary trestle piles may range from 24 to 48 inches in diameter. Installation of temporary trestle piles will result in temporary in-water impacts of approximately 408 to 816 square feet of riverbed to the west of the new alignment. Construction of the temporary work trestle is anticipated to take 60 days from September 3, 2018 to November 10, 2018, within the in-water work window.

As driving piles for the temporary work trestle will not be an option because of the type of substrate in the project area, the contractor will need to seek an alternative method to attach piles to the exposed bedrock. On previous projects, MaineDOT has used several alternative pile attachment methods for areas of bedrock substrate as described below.

1) Pinning piles to the bedrock. The pin is set by drilling into the bedrock, setting in the pin, and applying grout to secure the pin into the drilled socket. The depth of the pin and size

of the pin is determined by stability calculations. The drilling and pin setting occurs inside of a pile that has been placed onto the bedrock. After the pin has been secured, grout is placed into the pile to secure the pile to the pin.

2) Securing the piles to bedrock using a system with plates. Plates are attached to the bedrock using divers, drills, and large bolts drilled into the ledge. Once the plate has been secured, piles can be fastened to the plate and used to support the trestle.

Figure 2: Example of a pile-supported temporary work trestle adjacent to a sheet pile cofferdam

3.3.5 Cofferdam Construction

Sheet pile cofferdams will be constructed around each of the three proposed in-water bridge piers creating a mostly dry workspace by blocking river flow and tidal fluctuations from the work site (Figure 3). Construction of the southern (Brunswick) abutment will also occur within a cofferdam. Although the southern abutment is above the normal high water line, the area may become inundated during high water events. Only the cofferdam for Pier 1 (labeled as cofferdam 2 in Figure 3) occurs in habitat currently accessible to sturgeon. Installation of the cofferdam will prevent the potential flooding of the worksite during high flows. The four cofferdams will be constructed during the in-water work window. Although the southern abutment cofferdam will be constructed above the water line, the structure will be constructed during the in-water work window to reduce potential noise impacts to the adjacent fishway. To complete construction of all four cofferdams in a timely fashion during the in-water work window, the cofferdams may be constructed concurrently.

AMM 7 – *All four cofferdams shall be constructed and removed during the in-water work window, between August 1 and March 15, with the exception of the cofferdam for Pier 1, which will occur between September 1 and March 15.*

Because the substrate in the project area is predominantly exposed bedrock, sheetpiles for cofferdams cannot be driven into the substrate. The proximity of bedrock requires that sheet pile cofferdams be cut to fit the contour of the bedrock and then placed (as opposed to driven) and braced with internal structural supports. Contractors will pour a concrete seal at the base of the cofferdam, providing a watertight workspace. Any in-river rock excavation will occur behind a cofferdam.

Once the cofferdam enclosures are installed and braced, a portion of the ledge on the inside will be cut away creating a level base on which to found the piers. Modification of the ledge may be completed with a hydraulic breaker (or hoe ram). Hoe rams are the most common way of removing bedrock. A hoe ram acts as a large jack hammer and breaks up rock by using a series of short quick, strikes until a level surface is achieved. Dismantled portions of the bedrock are bucketed from the cofferdam by excavator or crane and trucked off site.

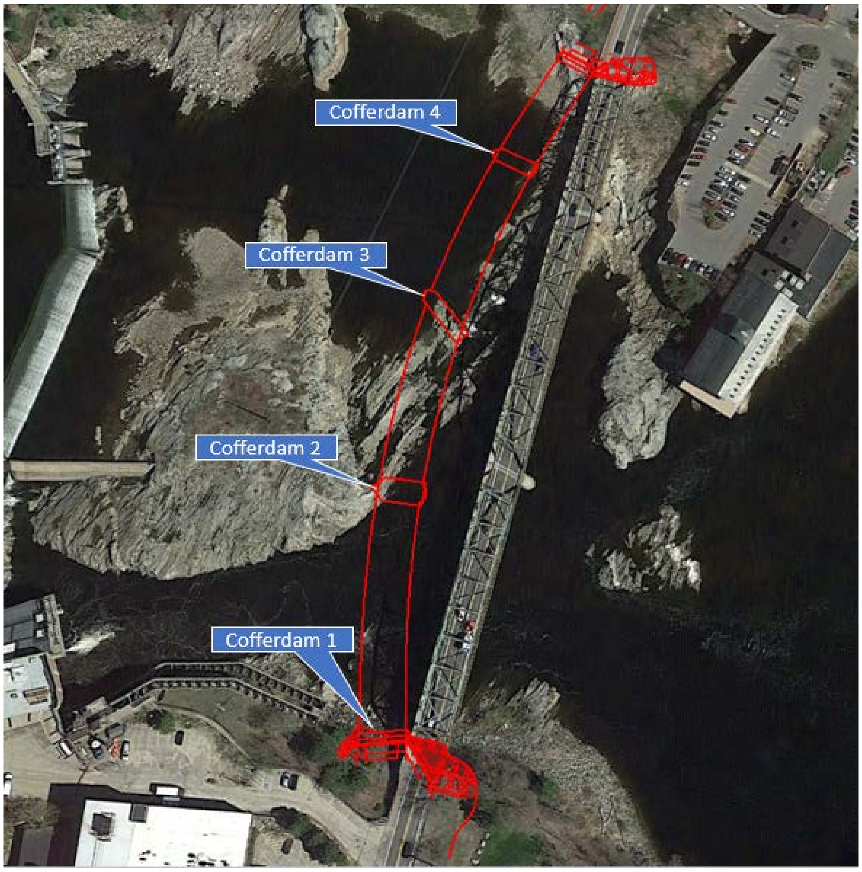

Figure 3: Schematic showing proposed locations of cofferdams required for installation of new Brunswick-Topsham Bridge

Alternatively, contractors may choose to set a small detonation to level the pier footprint. Blasting has the advantage of being faster and possibly easier to mobilize into deep cofferdams. If a controlled explosives technique is deemed necessary to level bedrock base of the piers, a plan will be submitted to us (NMFS) at least 150 days prior to the proposed timing of work. The blast plan will establish the expected pressure levels, the proposed timing, and minimization measures. No blasting will be conducted outside of the November 8 to March 15 time window. No blasting will occur before we review and approve the blast plan.

AMM 8- *Bedrock leveling and substructure removal using hydraulic breakers (or hoe rams), blasting, or other methods generating underwater noise above 150 dB RMS will occur from November 8 to March 15.*

AMM 9- *Plans for any project-related blasting will be submitted with 150 days for NOAA to review, will not occur outside of the in-water work window (August 1 to March 15), and will be designed to remain below potential fish injury limits (206 dB Peak (2.89 PSI)).*

AMM 10- *Any blasting activities between November 8 and November 30 will incorporate the following minimization measures to reduce potential impacts to adult Atlantic salmon which may still be present in the area:*

- *Active acoustic monitoring of the action area for any tagged fish potentially present in the Androscoggin River.*
- *Minimize charge sizes and the number of days of exposure to blasting.*
- *Deploy scare charges prior to the main blast.*
- *Conduct visual inspection of the action area post-blast to document any impacts to fish.*

Once final bedrock elevations within each cofferdam enclosure are achieved, contractors will apply sandbags and/or tremie poured concrete seals around the inside base of the cofferdams to create a dry workspace for pier construction. Concrete used to seal the base of the cofferdams will increase water pH but will be mostly contained inside of the cofferdam. A portion of the higher pH water from inside the cofferdam structures will leak out into the Androscoggin River during installation of the concrete seal. While it is impossible to quantify the amount of elevated pH water leaking from the cofferdam, it is presumed to be significantly less than 1% of the river flow and will be quickly neutralized in the surrounding river current with no effect on the overall pH in the Androscoggin River.

Three of the four proposed cofferdams are below the high-water line and will be “wetted”. Of the three wetted cofferdams, the area of each of the concrete cofferdam seals ranges from approximately 1,500 square feet to 2,000 square feet, with an anticipated overall sealed cofferdam footprint of approximately 5,000 square feet.

AMM 11- *Fresh concrete will be poured inside of cofferdams and will not come into contact with flowing water.*

To avoid any fish stranding during dewatering of the cofferdam structures or potential exposure to elevated pH within the cofferdam structures during concrete pouring, MaineDOT (or approved consultants) will survey inside the cofferdams to capture and remove any individual fish prior to dewatering and application of concrete seals. If Atlantic salmon or any sturgeon species are observed during cofferdam construction, all activities shall cease and MaineDOT will immediately contact us.

AMM 12*- MaineDOT will deploy a diver into the cofferdams to visually search for endangered fish species. Should a salmon or sturgeon be observed within a cofferdam structure, MaineDOT will coordinate with the resource agencies for evacuation of those individuals prior to proceeding with construction.*

Once the cofferdams have been verified to contain no listed fish species and the concrete seal is poured and cured, contractors will install water pumps inside the cofferdam to pump out any water seeping through the structure. Pumps will run intermittently for the entire duration of the pier construction process to remove any water that leaks into the cofferdam.

AMM 13*- Water pumped out of the cofferdam will be within one pH unit of background (MaineDOT standard specifications). A representative of the MaineDOT Surface Water Quality Unit will periodically evaluate pH to determine whether the water is within the allowable tolerance to be pumped directly back into the river or whether it needs to be treated prior to discharge.*

3.3.6 Pier Construction and Cofferdam Removal

Once the cofferdams are sealed and pumped dry, construction of the bridge piers will begin. Bridge piers will be constructed of solid shaft reinforced concrete supported on concrete seals founded on ledge. All preparation of rock inside the cofferdams will take place during the in-water work window to avoid impacts to listed species (AMM 8). Forms for the piers will be built inside of each cofferdam. Steel rebar is placed into the forms and fastened together. Concrete is then poured around the rebar, vibrated, and left to cure. This process occurs in stages until the pier reaches the design height. Because the forms will be inside the dry, isolated cofferdam, no uncured cement will be introduced into the river. Preliminary construction timelines estimate 135 days to build the substructure, beginning in early December to mid-May (Table 2).

The cofferdams will be removed in early September, once the pier concrete has cured and all necessary in-the-dry work is completed. First, any sandbags used to seal the base of the cofferdam will be removed by hand or by an excavator. Internal bracing will be removed from the cofferdam. The concrete seal will be broken when the first sheet is removed with a vibratory extractor (hammer) and the cofferdam enclosure will be allowed to fill with water. A vibratory extractor will remove each of the remaining sheets.

3.3.7 Abutment Construction

The new bridge includes a deep cantilevered concrete abutment on the Brunswick side and stubbed cantilevered concrete abutment on the Topsham side. Both abutments will be supported on concrete sub-footings founded on ledge. The abutment designs have been optimized to reduce the overall footprint of the required foundation. Between the abutments and river will be 1.75H:1V riprapped slopes to minimize wetland impacts. The north (Topsham) abutment will be constructed above the normal high water line in the dry and will not require a cofferdam to isolate the construction area. The southern (Brunswick) abutment will also be constructed in the dry, but the slope and proximity to the waterline may require installation of a cofferdam to stabilize the downslope during construction as well as protecting the construction site during high water events. As stated above for the pier construction section, a limited amount of blasting may be required to remove bedrock material to achieve the required elevation for abutment footings. Work on the southern abutment will adhere to AMMs 8 through 10 to reduce noise levels in adjacent habitat during the in-water work window.

3.3.8 Bridge Superstructure Construction

The bridge superstructure (girder spans, stringers, deck, railings, and wearing surface) will be built once the concrete piers and abutments are completed. Contractors will be required to ensure no construction materials are spilled into the water during superstructure construction.
The northernmost bridge spans can be lifted by a single crane stationed on the adjacent temporary work trestle. However, the construction of the 260-foot span between the Brunswick abutment and pier 1 will be challenging from a construction standpoint. As described above, large cranes and an extension of the temporary work trestle will be required to complete the dual crane lift. After the bridge stringers are lifted into place, contractors will form the concrete bridge deck, apply surface treatments, and install sidewalks and lighting.

3.3.9 Demolition of Existing Bridge

Once construction of the new bridge is complete, traffic will be shifted to the new alignment and demolition of the Frank J. Wood bridge will begin. All in-water demolition work will occur within the in-water work window (Table 2). The superstructure of the existing bridge will be completely removed. The north abutment will be removed to finished grade and the Brunswick abutment will remain in place (MaineDOT 2015). The abutment sites will be stabilized according to the Maine DOT BMPs following their removal. The existing pier nearest the Topsham shore will also remain in place. Results from a hydraulic analysis indicated that removing the pier would leave downstream structures vulnerable during flood stage flows; therefore, the pier will remain in place as a hydraulic buffer for the structures during high flows. The old bridge superstructure (bridge deck and truss members) is expected to be removed by the traditional wrecking method, which utilizes a crane-mounted wrecking ball, hydraulic hammers, or jackhammers to pound, break, and tear the concrete and steel reinforcing apart (Oviatt and Archibald 2000). The pieces may also be cut with a torch or large mechanical snips into sizes that can be managed by excavators and placed into trucks to be removed from the site. The pieces of the old bridge deck would then be lifted and removed using a crane on a barge to load a vehicle for offsite disposal.

AMM 14 - *Superstructure demolition debris will be contained using control devices and cannot enter the water.*

Demolition of the existing pier nearest the Brunswick shore (also known as the center pier) will likely be completed from a barge. Contractors may choose to use a hydraulic breaker or blast the structure to rubble. Inspection of the center pier revealed a deteriorated condition that will fracture easily when detonated. If blasting is deemed necessary, a blasting plan will be submitted to us at least 150 days prior to blasting (see AMMs 8 – 10). Contractors will use an excavator to remove pier debris from the river bottom. MaineDOT anticipates up to 2 to 4 weeks for the demolition of the pier.

AMM 15 – *The existing pier structure will be removed down to the underlying bedrock and debris from the structure will be removed from the river to restore potential natural spawning substrate for sturgeon species.*

3.3.10 Post-Project Restoration

Post-project site restoration activities at the Brunswick –Topsham Bridge will include re-grading and restoring staging areas and re-vegetating disturbed areas to prevent sedimentation and siltation in the river. All MaineDOT construction project contracts are required to be in accordance with the most recent version of the MaineDOT Standard Specifications. All construction project contracts require that contractors prepare and submit a SEWPCP (See Section 2.3.1) that must be approved by MaineDOT and is enforced as a contractual agreement. This SEWPCP is prepared and performed in accordance with the most recent version of the *MaineDOT Best Management Practices for Erosion and Sedimentation Control* (MaineDOT 2008). Section IID: Guidance for Sensitive Water Bodies of the BMP Manual specifies under what conditions a project will be designated as a Sensitive project. Criteria include: state or federal designation of the water bodies, project scope of work, proximity of the project to the water body, etc. This project is considered sensitive due to the potential presence of endangered and threatened species and their critical habitat. A representative of the MaineDOT Surface Water Quality Unit will be assigned to the bridge replacement construction project. Prior to construction, this MaineDOT representative will provide a contract Special Provision that identifies additional project-specific requirements to be addressed in the SEWPCP.

3.2.11 Removal of Temporary Work Trestle

As explained above, the temporary work trestle may be attached to bedrock using several methods. If plates are attached to bedrock with large anchors they will be removed by unbolting or cutting the bolts flush at the attachment points. Alternatively, piles that are pinned into the ledge will be freed and pins will be cut flush with the surrounding substrate. Removal of bolted or pinned trestles may require boats and divers to unbolt, or cut trestle connections to the bedrock. Excavators will stabilize the piles while they are cut free and will lift the piles from the attachment points. Once the piles are removed the remaining pins or bolts will be cut or ground flush with the bedrock.

Once the temporary trestle is dismantled, contractors will remove the temporary in-water fill used on the Topsham approach of the trestle. Materials will be removed during the in-water work window and the area restored to existing substrate elevation.

3.3.12 Vessel Use

The contractor is likely to use some vessels to support in-water work during construction. During the installation of the cofferdams and the temporary trestle, most of the work will be completed from the temporary work trestle. However, divers may be used for portions of that construction, including inspection, placement of temporary trestle attachment points, and removal of trestle pins during trestle removal. Divers may require boat access to construction sites using ‘work boats’ that are approximately 20 feet long with outboard motors that draft between 2 and 3 feet. Use of these boats would be sporadic and could range three or four trips per day to the construction site from a downstream boat landing (~ 0.75 miles downstream) to no boat traffic

for weeks during construction. It not anticipated that larger vessels or an increased frequency of trips beyond the suspected maximum of three to four per day will occur during construction. The high velocity water and dangerous conditions make boat access problematic and unlikely.
A construction barge may be used during the demolition of the existing pier. Typical barge sizes range from 6,000 to 9,600 square feet (150' X 40' to 160' X 60') with an approximately ~4 foot draw. The barge used during construction and demolition is at the discretion of the selected contractor. The barge would be pushed into the work area with a tug boat and provide a work platform for construction equipment during the removal of the existing center pier and collection of the demolition debris.

AMM 16- *Construction crews will visually monitor for ESA-listed fish in equipment and on barges and report any sightings to MaineDOT environmental staff.*

AMM 17 - *Vessels will travel at "slow speeds, typically less than 6 knots" (6.9 miles per hour) in the construction zone.*

3.3.13 Summary of AMMs

For ease of reference, we have an included a summary of all of you proposed AMMs below, as well as in Appendix A:

Table 3: Summary of Avoidance and Minimization Measure (AMMs)

Avoidance and Minimization Measure (AMMs)	**Description of AMM**
Soil Erosion and Water Pollution Control Plan (SEWPCP)	
1	Contractors will submit a SEWPCP for review and approval of MaineDOT staff prior to the start of work. The plan includes the review of the implementation of any AMMs proposed.
2	Prior to soil disturbance, the erosion control portion of the SEWPCP will be reviewed and in place.
In-water Work Window	
3	In-water work window. MaineDOT and FHWA commit to avoiding all activities that could result in in-water noise that could result in fish disturbance (louder than 150 dB RMS) and turbidity producing activities between March 16 and July 31.
Contaminant Releases	
4	No equipment, materials, or machinery shall be stored, cleaned, fueled, or repaired within any wetland or watercourse; dumping of oil or other deleterious materials on the ground will be forbidden; the contractor shall provide a means of catching, retaining, and properly disposing of drained oil, removed oil filters, or other deleterious material; and all oil spills shall be reported immediately to the appropriate regulatory body.
Construction of Temporary Work Trestle	
5	Contractors are required to install turbidity curtains around areas planned for in-water fill associated with construction of the temporary

	trestle access point. All in-water trestle construction will occur between August 1 and March 15. In-river (i.e., not the ponded/bedrock falls habitat on the Topsham side) trestle construction and removal (~60 sq. ft footprint) will occur between September 1 and March 15.
6	Removal of the fourth pier (leaving three in-water piers) from preliminary design to avoid impacts to critical habitat as well as potential effects to fishway function.
In-Water Pier and Cofferdam Construction	
7	All four cofferdams shall be constructed and removed during the in-water work window, between August 1 and March 15, with the exception of the cofferdam for Pier 1, which will occur between September 1 and March 15.
8	Bedrock leveling and substructure removal using hydraulic breakers (or hoe rams), blasting, or other methods generating underwater noise above 150 dB RMS will occur from November 8 to March 15.
9	Plans for any project-related blasting will be submitted with 150 days for NOAA to review and will be designed to remain below potential fish injury limits (206 dB Peak (2.89 PSI)).
10	Any blasting activities between November 8 and November 30 will incorporate the following minimization measures to reduce potential impacts to adult Atlantic salmon which may still be present in the area: • Active acoustic monitoring of the action area for any tagged fish potentially present in the Androscoggin River. • Minimize charge sizes and the number of days of exposure to blasting. • Deploy scare charges prior to the main blast. • Conduct visual inspection of the action area post-blast to document any impacts to fish.
11	Fresh concrete will be poured inside of cofferdams and will not come into contact with flowing water.
12	MaineDOT will deploy a diver into the cofferdams to visually search for endangered fish species. Should a salmon or sturgeon be observed within a cofferdam structure, MaineDOT will coordinate with the resource agencies for evacuation of those individuals prior to proceeding with construction.
13	Water pumped out of the cofferdam will be within one pH unit of background (MaineDOT standard specifications). A representative of the MaineDOT Surface Water Quality Unit will periodically evaluate pH to determine whether the water is within the allowable tolerance to be pumped directly back into the river or whether it needs to be treated prior to discharge.
Demolition of Existing Bridge	
14	Superstructure demolition debris will be contained using control devices and cannot enter the water.
15	The existing pier structure will be removed down to the underlying bedrock and debris from the structure will be removed from the river to

	restore potential natural spawning substrate for sturgeon species.
Vessel Use	
16	Construction crews will visually monitor for ESA-listed fish in equipment and on barges and report any sightings to MaineDOT environmental staff.
17	Vessels will travel at “slow speeds, typically less than 6 knots” (6.9 miles per hour) in the construction zone.

3.4 Action Area

3.4.1 Defining the Action Area

The action area is defined as “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area (project area) involved in the proposed action” (50 CFR 402.02). The action area for this consultation includes the area affected by both construction of the new bridge and removal of the Frank J. Wood Bridge and abutments, inclusive of underwater noise, sedimentation and turbidity, construction related boat traffic, and temporary and permanent habitat modification.

Considering the point where the Androscoggin River meets Merrymeeting Bay as river kilometer (rkm) 0, the bridge replacement construction site occurs at approximately rkm 8.4 (Wippelhauser and Squiers 2015). You have stated that construction related vessel traffic will originate at the public boat landing approximately 1.2 rkm (0.75 miles) downriver at rkm 7.2. Therefore, the action area will extend along vessel transit routes from rkm 7.2 to 8.4. The action area will also encompass the effects of in water construction. Blasting effects will be limited to an area with a radius of 152m (500 feet) around the detonation sites. We expect the effects of rock breaking activity with a hoe ram to be limited to a 72m (236-foot) radius around the locations of the three in-water bridge piers. Because of the substrate in the construction area (i.e., predominantly bedrock and cobble), sediment plumes are not generally expected. However, as a precautionary measure, turbidity curtains will be employed (AMM5) around temporary trestle construction areas. Hoe ram and pier construction work will occur within cofferdams that have been pinned to the bedrock and sealed with concrete. Lastly, the action area includes areas impacted by temporary and permanent habitat modification:

- The river area temporarily isolated within cofferdams during construction. An estimated 5,000 ft^2 will be encompassed by the three cofferdams installed for pier construction (Pier 1 = ~2000ft^2, Pier 2 = ~ 1,500 ft^2, Pier 3 = ~1,500 ft^2).
- The river area occupied by the 630 foot long temporary work trestle which will require approximately 65 temporary trestle piles (ranging in size from 24 to 48 inches) resulting in ~800 ft^2 of temporarily impacted aquatic substrate.
- The river area to be permanently affected by new pier structures (i.e., 2,500 ft^2 of habitat in the ponded and bedrock falls area not accessible to sturgeon and 900 ft^2 of habitat within the main river channel), the river area to be affected by removal of current structures (i.e., 800 ft^2 of habitat presently occupied by the existing center pier) and the final net loss of in-river habitat of approximately 100 ft^2.

The upstream and downstream boundaries of the action area have been defined based on activities with the greatest reach upstream and downstream of the in-water work location. This corresponds to points roughly 152m (500 feet) upstream and downstream of the project area based on the extent of ensonification from the loudest potential activity (blasting)(Figure 4).

Figure 4: Boundaries of the action area (500 feet) for the Brunswick-Topsham Bridge project on the Androscoggin River showing the existing and proposed structures, as provided by MaineDOT in the BA

To estimate the total area of the action area, we used the map notes area feature in ArcGIS Online to create an approximation of the polygon in Figure 4 (~13.8 acres), and added a vessel traffic lane with an approximately 200-foot buffer to the public boat launch site (~13.6 acres). Therefore, the entire action area covers approximately 27.4 acres (Figure 5).

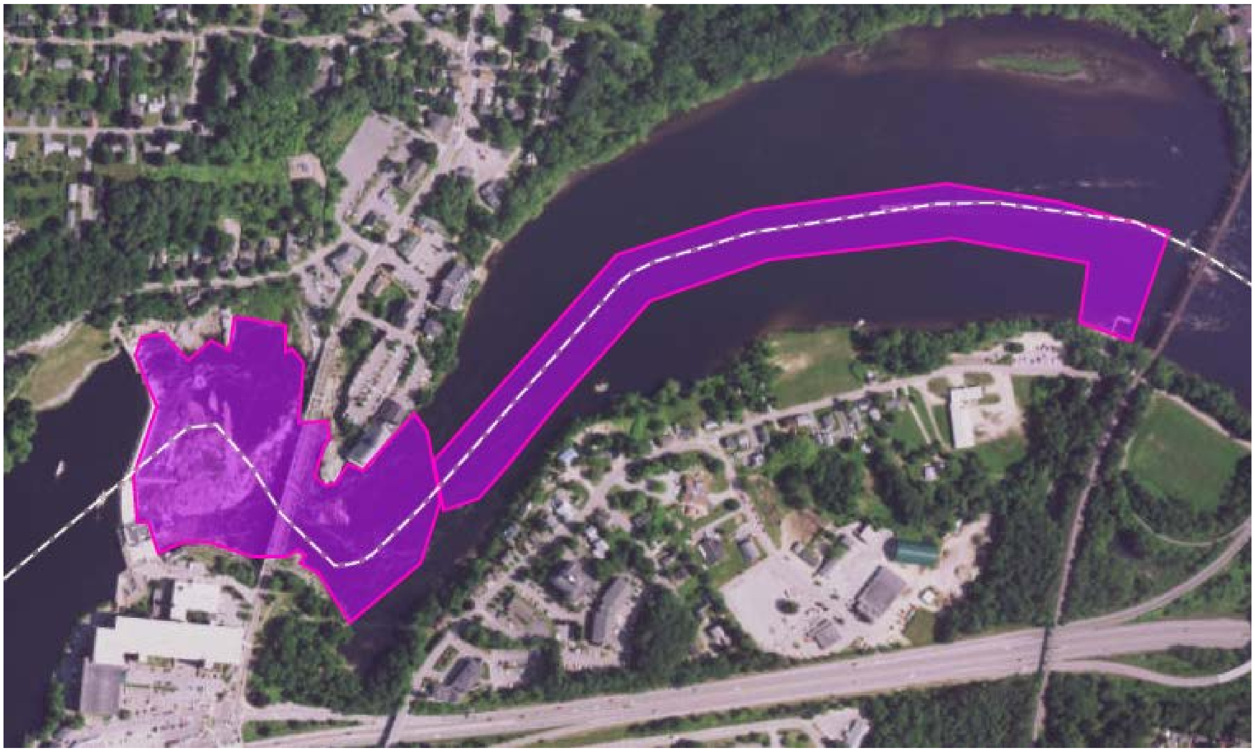

Figure 5: NOAA Fisheries approximation of the action area, including vessel transit lane to public boat launch

For a more detailed description of the physical aquatic habitat and biota present within this section of the Androscoggin River see Section 5.0 (Environmental Baseline) of this document.

3.4.2 Habitat in the Action Area

The Androscoggin River is 162 miles long and runs from Umbagog Lake in northeast New Hampshire to Merrymeeting Bay where it meets the Kennebec River. The Androscoggin River watershed drains 3,450 square miles of rolling hills dominated by industrial forest, with floodplains used for both historic and modern agricultural. The habitat in the action area is greatly influenced by the flow regime orchestrated by the operation of upstream dams. Therefore, we find it useful to include an overview of these factors and how they influence the water levels, velocities, quality, and substrate below the Brunswick Dam surrounding the existing and proposed bridge structures.

On the Androscoggin River, upstream headwater storage projects including Mooselookmeguntic Lake (Upper Dam), Richardson Lake (Middle Dam) (FERC No. 11834), and Aziscohos Lake (FERC No. 4026), regulate river flow in the Androscoggin River in order to provide a more consistent flow in the summer months. These dams have been in place dating back into the 1800s. Peak flows typically occur in the spring because of snowmelt and rainfall, with April having the highest monthly average flows and August having the lowest monthly average flow.

There are 10 major hydropower facilities along the Androscoggin River. The Brunswick Project is the lowest of the 10 dams on the Androscoggin River and is located immediate upstream of the Frank J. Wood Bridge at the head of tide. The dam and powerhouse span the Androscoggin at a site originally known as Brunswick Falls. Historically, Brunswick Falls extended across the width of the river and was the upstream extent of the range for both shortnose and Atlantic sturgeon, although the falls were passable for other migratory fish species (Houston *et al.* 2007). During construction of the dam, builders excavated an approximately 20-foot deep, 150-foot wide section of Brunswick Falls to form the 500-foot long tailrace below the powerhouse on river right. The remaining portion of Brunswick Falls remains intact on river left, forming a ponded area. A 21-foot concrete wall and sections of concrete caps filling the low spots and preventing fish from moving into the pond during moderate to low flows enhanced the natural bedrock perimeter of the pond. Below the larger ponded area, a series of ledge ridges create small step pools that carry water from the pond into the main channel below.

The Brunswick Project includes a 300-acre reservoir; a 605-foot long and 40-foot high concrete gravity dam; a gate section containing two Taintor gates and an emergency spillway; and a powerhouse and intake. The Brunswick Project also has vertical slot fishway (located adjacent to the powerhouse and on the western bank), a 21-foot high fish barrier wall between the dam and Shad Island, and a three foot high by 20-foot long concrete fish barrier weir across Granney Hole Stream in Topsham. The concrete gravity dam consists of two ogee overflow spillway sections separated by a pier and barrier wall. The right spillway section, about 128-foot long, is topped with wooden flashboards that are 2.6 feet high. The left section does not have flashboards. The intake structure and powerhouse are integral with the dam and located adjacent to the Brunswick shoreline. The powerhouse contains three vertical propeller turbine generators. Unit I has a hydraulic capacity of 4,400 cfs, and units 2 and 3 have a hydraulic capacity of 1,200 cfs.

The Androscoggin River discharges through the Brunswick Dam at several points including, the tailrace on the Brunswick side, the flood gates on the Topsham side, and the mid-channel spillway. The various release points depend on several factors including water levels, turbine maintenance, or management agreements with regulatory agencies. At lower flows, the majority of water flows through the powerhouse into the tailrace. During times of increased flows, or scheduled maintenance, water may flow over the spillway, or through opened flood gates. Given these various discharge points, velocities under the existing and proposed bridge vary depending on the stage of river flow and which release points are flowing. At the lowest flows, the ponded area may be nearly stagnant and the majority of flow moves through the powerhouse and tailrace. River velocities patterns change during moderate and high flows. At increased flows, water may discharge into the river over the spillway causing flow through the pond, potentially allowing downstream fish passage for salmon through the ponded area. Also, at high flows, salmon may have temporary access into the ponded area from the main channel below the dam (flows would likely be too high for adult sturgeon); however, no upstream passage from the ponded area is possible. At the highest flows, the flood gates on the Topsham side open causing increased flows and higher velocity through the left side of the river. At normal flows, velocities in the tailrace range from approximately 6.0 to 8.0 feet per second.

The channel topography is highly variable and significantly influences the flow. Below the Brunswick Dam, the flow splits into two channels then flowing together under the Frank J. Wood Bridge. Substrate in the river below the Frank J Wood Bridge is less scoured by high velocities and diversifies into hard bottom boulder and cobble substrate with pockets of sand. The dominant flow channel moves water through the powerhouse and downstream tailrace. Substrate within the tailrace is scoured ledge. On the Brunswick side of the channel depth ranges from 15 feet to 20 feet deep. On the Topsham side, the ponded portion of the channel ranges from five feet deep along the edges to 20 feet deep directly upstream of the bedrock ridge at the lower end of the pond. While most of the action area between the boat launch and the project site is within the deeper portions of the channel, indirect effects from underwater noise and turbidity, as well as the boat launch itself, extend into shallow portions of the riverbanks (see Figure 5). The Frank J Wood Bridge is located approximately 200 feet upstream of the narrowest point of the river downstream of the Brunswick Dam. Both shores are bounded by ledge outcroppings, and there is a small ledge island approximately 100 feet downstream from the existing bridge.

At increased flows, water discharges over the spillway and flood gates causing flow through the pond on the river left side of the channel. Higher flows form a channel of increased flow through deeper sections of the pond, spilling over the bedrock ridge. At normal flows, velocities in the pond range from 2.0 feet per second along the edges of the pond to 10.0 feet per second through the center of the pond. During low flows, the pond remains somewhat stagnant.

4.0 STATUS OF LISTED SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

We have determined that the action being considered in this biological opinion may affect the following endangered or threatened species and critical habitat under our jurisdiction (Table 4):

Table 4: ESA-listed species and critical habitat in the action area

ESA-Listed Species	**Latin Name**	**Distinct Population Segment (DPS)**	**Federal Register (FR) Citation**	**Recovery Plan**
Atlantic Salmon	*Salmo salar*	Gulf of Maine	74 FR 29344	Draft Recovery plan: NMFS & USFWS 2016
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Gulf of Maine	77 FR 5880	N/A
Shortnose Sturgeon	*Acipenser brevirostrum*	Range-wide	32 FR 4001	NMFS 1998
Designated Critical Habitat (species)	**Latin Name**	**Distinct Population Segment (DPS)**	**Federal Register (FR) Citation**	**Recovery or River Unit**
Atlantic Salmon	*Salmo salar*	Gulf of Maine	74 FR 29300	Merrymeeting Bay Salmon Habitat Recovery Unit
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Gulf of Maine	82 FR 39160	Androscoggin River Unit

This section will focus on the status of the species and critical habitat within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action.

4.1 Atlantic Salmon (Gulf of Maine DPS)

The GOM DPS of anadromous Atlantic salmon was initially listed by USFWS and us (collectively, the Services) as an endangered species on November 17, 2000 (65 FR 69459). A subsequent rule issued by the Services (74 FR 29344, June 19, 2009) expanded the geographic range for the GOM DPS of Atlantic salmon. The GOM DPS of Atlantic salmon is defined as all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment. The marine range of the GOM DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland. Included in the GOM DPS are all associated conservation hatchery populations used to supplement these natural populations; currently, such conservation hatchery populations are maintained at Green Lake National Fish Hatchery (GLNFH) and Craig Brook National Fish Hatcheries (CBNFH), both operated by the USFWS, as well as private watershed-based facilities (Downeast Salmon Federation's East Machias and Pleasant River facilities). Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry (74 FR 29344, June 19, 2009).

Coincident with the June 19, 2009 endangered listing, we designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009). The final rule was revised on August 10, 2009. In this revision, designated critical habitat for the expanded GOM DPS of Atlantic salmon was reduced to exclude trust and fee holdings of the Penobscot Indian Nation and a table was corrected (74 FR 39003; August 10, 2009).

4.1.1 Life History

Atlantic salmon spend most of its adult life in the ocean and returns to freshwater to reproduce. Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas (Figure 6). During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Spawning

Adult Atlantic salmon return to rivers in Maine from the Atlantic Ocean and migrate to their natal streams to spawn. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July (Meister 1958; Baum 1997), but may enter at any time between early spring and late summer. Early migration is an adaptive trait that ensures adults have sufficient time to reach spawning areas (Bjornn and Reiser 1991). Salmon that return in early spring spend nearly five months in the river before spawning, often seeking cool water refuge (e.g., deep pools, springs, and mouths of smaller tributaries) during the summer months.

From mid-October to mid-November, adult females select sites in rivers and streams for spawning. Spawning sites are positioned within flowing water, particularly where upwelling of groundwater occurs, allowing for percolation of water through the gravel (Danie *et al.*1984). These sites are most often positioned at the head of a riffle (Beland *et al.* 1982), the tail of a pool, or the upstream edge of a gravel bar where water depth is decreasing and water velocity is increasing (McLaughlin and Knight 1987; White 1942). The female salmon creates an egg pit (redd) by digging into the substrate with her tail and then deposits eggs while male salmon release sperm to fertilize the eggs. After spawning, the female continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel. Females produce a total of 1,500 to 1,800 eggs per kilogram of body weight, yielding an average of 7,500 eggs per two sea-winter (SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum and Meister 1971). After spawning, male and female Atlantic salmon either return to sea immediately or remain in fresh water until the following spring before returning to the sea (Fay *et al.* 2006).

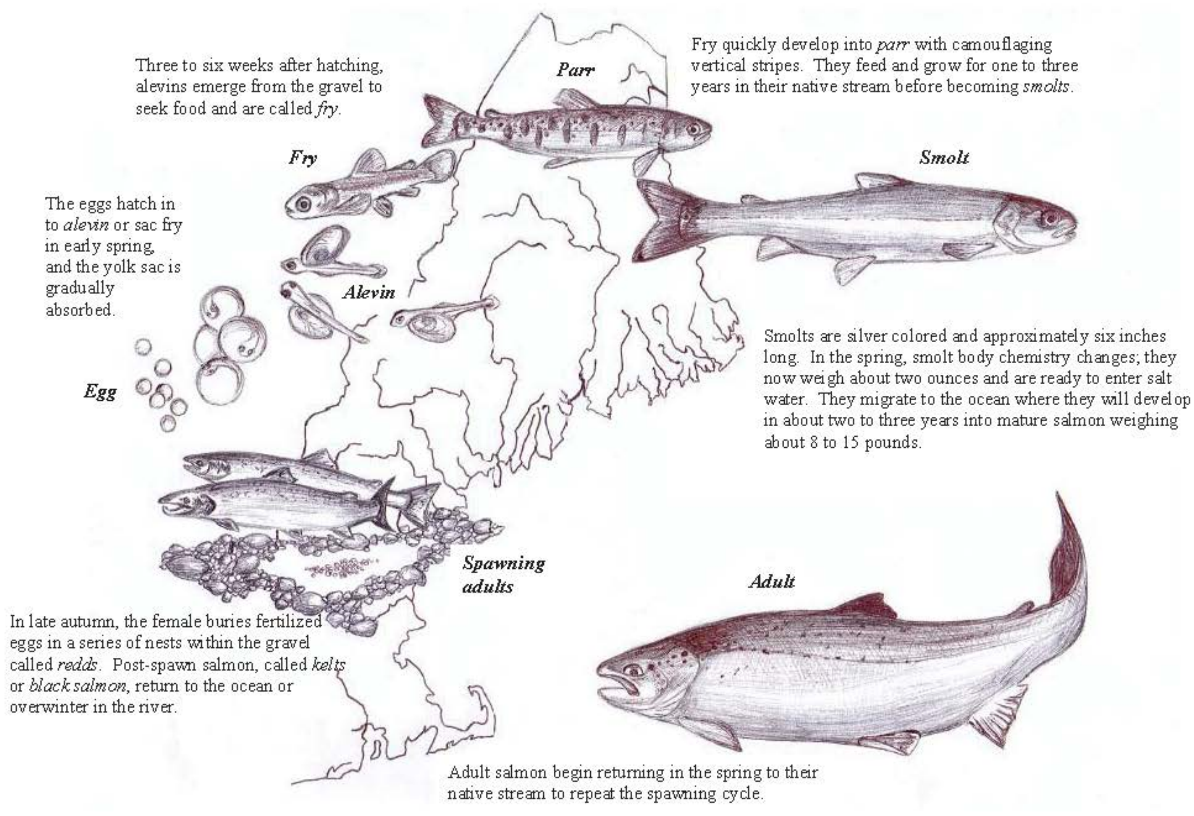

Figure 6: Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller)

After spawning, the adults ("kelts") move downstream toward the sea. Movement may be triggered by increased water temperatures or flows. Some migrate toward the sea immediately, either moving partway downstream or returning to the ocean (Ruggles 1980; Don Pugh, U.S. Geological Survey (USGS) personal communication). Most kelts, however, overwinter in the river and return to the sea in the spring. Kelts that remain in the river appear to survive well through the winter (Ruggles 1980; Jonsson *et al.* 1990). The relative survival of kelts, however, has not been calculated for Maine rivers. After reaching the ocean, few kelt survive as indicated by the lack of repeat spawners in the GOM DPS (NMFS and USFWS 2005).

Eggs

The fertilized eggs develop in the redd for a period of 175 to 195 days, hatching in late March or April (Danie *et al.*1984).

Alevins and Fry

Newly hatched salmon, also referred to as sac fry, remain in the redd for approximately six weeks after hatching and are nourished by their yolk sacs (Gustafson-Greenwood and Moring 1991). In three to six weeks, they consume most of their yolk sac, travel to the surface to gulp air to fill their swim bladders, and begin to swim freely; at this point they are called "fry." Survival from the egg to fry stage in Maine is estimated to range from 15 to 35% (Jordan and Beland 1981).

Parr

When fry reach approximately 4 cm in length, the young salmon are termed "parr" (Danie *et al.* 1984). Most parr remain in the river for two to three years before undergoing smoltification, the process in which parr go through physiological changes in order to transition from a freshwater environment to a saltwater marine environment. Some male parr may not go through smoltification and will become sexually mature and participate in spawning with sea-run adult females. These males are referred to as "precocious parr."

Smolts

During the smoltification process, parr markings fade and the body becomes streamlined and silvery with a pronounced fork in the tail. Naturally reared smolts in Maine range in size from 13 to 17 cm, and most smolts enter the sea during May to begin their first ocean migration (USASAC 2004). The spring migration of smolts to the marine environment takes 25 to 45 days. Most smolts migrate rapidly, exiting the estuary within several tidal cycles (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004, 2005).

Post-smolts

Smolts are termed post-smolts after ocean entry to the end of the first winter at sea (Allan and Ritter 1977). Post-smolts generally travel out of coastal systems on the ebb tide and may be delayed by flood tides (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004, 2005). Lacroix and McCurdy (1996), however, found that post-smolts exhibit active, directed swimming in areas with strong tidal currents. Studies in the Bay of Fundy and Passamaquoddy Bay suggest some aggregation and common migration corridors related to surface currents (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004). Post-smolt distribution may reflect water temperatures (Reddin and Shearer 1987) and/or the major surface-current vectors (Lacroix and Knox 2005). Post-smolts travel mainly at the surface of the water column (Renkawitz *et al.* 2012) and may form shoals, possibly of fish from the same river (Shelton *et al.*

1997). Post-smolts grow quickly, achieving lengths of 30-35 cm by October (Baum 1997). Smolts can experience high mortality during the transition to saline environments for reasons that are not well understood (Kocik *et al.* 2009; Thorstad *et al.* 2012).

During the late summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off of the west coast of Greenland, with the highest concentrations between 56˚N. and 58˚N. (Reddin 1985; Reddin and Short 1991; Reddin and Friedland 1993, Sheehan *et al.* 2012). Atlantic salmon located off Greenland are primarily composed of non-maturing first sea winter (1SW) fish, which are likely to spawn after their second sea winter (2SW), from both North America and Europe, plus a smaller component of previous spawners who have returned to the sea prior to their next spawning event (Reddin 1988; Reddin *et al.* 1988). The following spring, 1SW and older fish are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the east coast of the Grand Banks (Reddin 1985; Dutil and Coutu 1988; Ritter 1989; Reddin and Friedland 1993; and Friedland *et al.* 1999).

Adults

Some salmon may remain at sea for another year or more before maturing. After their second winter at sea, the salmon likely over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin and Shearer 1987). Reddin and Friedland (1993) found non-maturing adults located along the coasts of Newfoundland, Labrador, and Greenland, and in the Labrador and Irminger Sea in the later summer and autumn.

The average size of Atlantic salmon is 71-76 cm (28-30 inches) long and 3.6-5.4 kg (8-15 pounds) after two to three years at sea. Although uncommon, adults can grow to be as large as 30 pounds (13.6 kg). The natural life span of Atlantic salmon ranges from two to eight years (ASBRT 2006). Following spawning in the fall, Atlantic salmon kelts may immediately return to the sea, or over-winter in freshwater habitat and migrate in the spring, typically April or May (Baum 1997).

4.1.2 Reproduction, Distribution, and Abundance of Atlantic salmon

The reproduction, distribution, and abundance of Atlantic salmon within the range of the GOM DPS have been generally declining since the 1800s (Fay *et al.* 2006). A comprehensive time series of adult returns to the GOM DPS dating back to 1967 exists (Fay *et al.* 2006, USASAC 2013). Contemporary abundance levels of Atlantic salmon within the GOM DPS are several orders of magnitude lower than historical abundance estimates. For example, Foster and Atkins (1869) estimated that roughly 100,000 adult salmon returned to the Penobscot River alone before the river was dammed, whereas estimates of abundance for the entire GOM DPS have rarely exceeded 5,000 individuals in any given year since 1967 (Fay *et al.* 2006, USASAC 2013).

After a period of population growth between the 1970s and the early 1980s, adult returns of salmon in the GOM DPS peaked between approximately 1984 and 1991 before declining during the 2000s. Adult returns have fluctuated over the past decade. Presently, the majority of all adults in the GOM DPS return to a single river, the Penobscot, which accounted for over 90% of all adult returns to the GOM DPS over the last decade. The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from GLNFH (constructed in 1974). Marine survival remained relatively high throughout the 1980s, and salmon populations in the GOM DPS remained relatively stable until the early 1990s. In the early 1990s, marine survival rates decreased, leading to the declining trend in adult abundance observed throughout the 1990s and early 2000s. The increase in abundance of returning adult salmon observed between 2008 and 2011 may be an indication of improving marine survival; however the declines –since 2011 may suggest otherwise. Returns to U.S. waters in 2013 were only 611 fish, which ranks 43rd in the 47-year time-series (USASAC 2014). A total of 450 adults returns were estimated for 2014; the lowest for the 1991- 2014 time series. The returns in 2015 were somewhat higher at 881, and then dropped again in 2016 to 614 (USASAC 2016, 2017). Despite consistent smolt production, there has been extreme variability in annual returns.

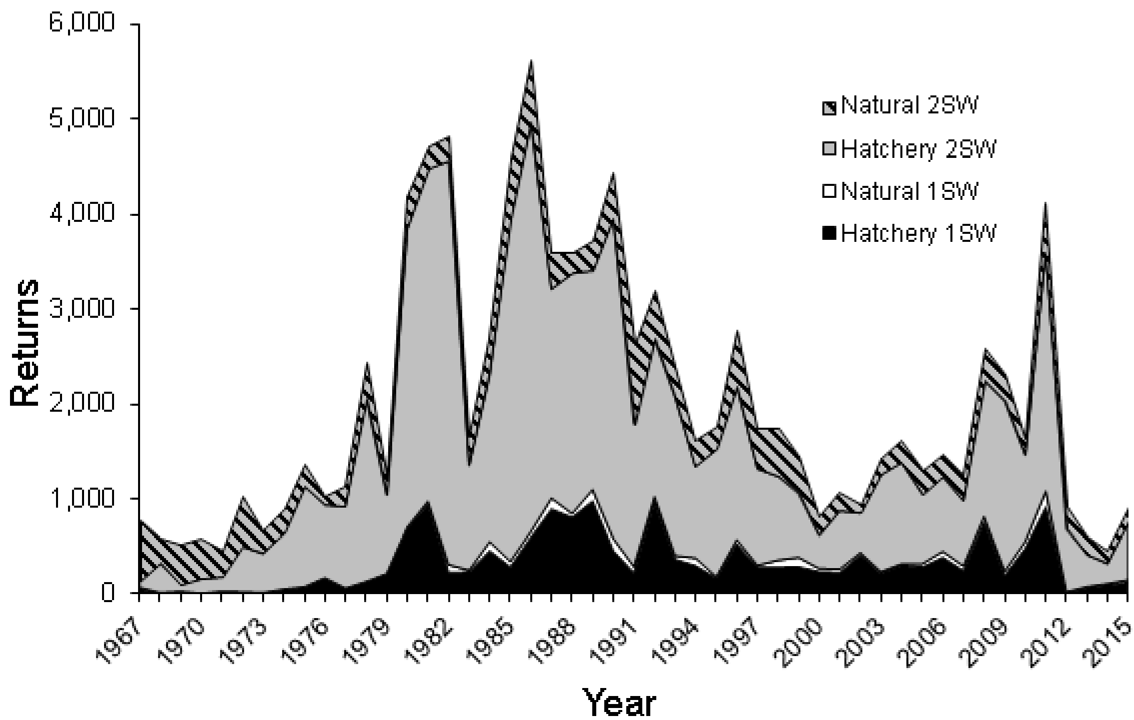

Figure 7: Summary of natural vs. hatchery adult salmon returns to the GOM DPS Rivers between 1967 and 2014 (USASAC 2015)

Since 1967 when numbers of adult returns were first recorded, the vast majority of adult returns have been the result of smolt stocking; only a small portion of returning adults were naturally reared (Figure 7). Natural reproduction of the species is contributing to only a fraction of Atlantic salmon returns to the GOM DPS. The term naturally reared includes fish originating from both natural spawning and from stocked hatchery fry (USASAC 2012). Hatchery fry are included as naturally reared because hatchery fry are not marked, and therefore cannot be distinguished from fish produced through natural spawning. Low abundances of both hatchery-origin and naturally reared adult salmon returns to Maine demonstrate continued poor marine survival.

The abundance of Atlantic salmon in the GOM DPS has been low, and the trend has been either stable or declining over the past several decades. The proportion of fish that are of natural origin is very small (approximately 6% over the last ten years), but appears stable. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels. However, stocking of hatchery fry and smolts has not contributed to an increase in the overall abundance of salmon and, as yet, has not been able to increase the naturally reared component of the GOM DPS. Continued reliance on the conservation hatchery program is expected to prevent extinction in the short term, but recovery of the GOM DPS will not be accomplished without significant increases in naturally reared salmon.

The historic distribution of Atlantic salmon in Maine has been described extensively by Baum (1997) and Beland (1984), among others. In short, substantial populations of Atlantic salmon existed in nearly every river in Maine that was large enough to maintain a spawning population. The upstream extent of the species' distribution extended far into the headwaters of even the largest rivers. Today, the spatial structure of Atlantic salmon is limited by obstructions to passage and also by low abundance levels and the majority of all adults return to the Penobscot River. Within the range of the GOM DPS, the Kennebec, Androscoggin, Union, and Penobscot Rivers contain dams that severely limit passage of salmon to significant amounts of spawning and rearing habitat. Atlantic salmon presently have unobstructed access to only about 8% of their historic spawning and rearing habitat in the Maine (NMFS 2016b).

4.1.3 Salmon Habitat Recovery Units

As part of the 2009 GOM DPS listing and designation of critical habitat, we defined three Salmon Habitat Recovery Units (SHRU): the Merrymeeting Bay SHRU, the Penobscot Bay SHRU, and the Downeast SHRU (Figure 8). As defined in the Endangered Species Consultation Handbook[3], a Recovery Unit is a "management subset of the listed species that is created to establish recovery goals or carry out management actions." The NMFS Interim Recovery Plan Guidance[4] goes on to state that recovery units are frequently managed as management units, though makes the distinction that recovery units are deemed necessary to both the survival and recovery of the species, whereas management units are defined as not always being "necessary" to both the survival and recovery.

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[3] http://www.nmfs.noaa.gov/pr/pdfs/laws/esa_section7_handbook.pdf
[4] http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf

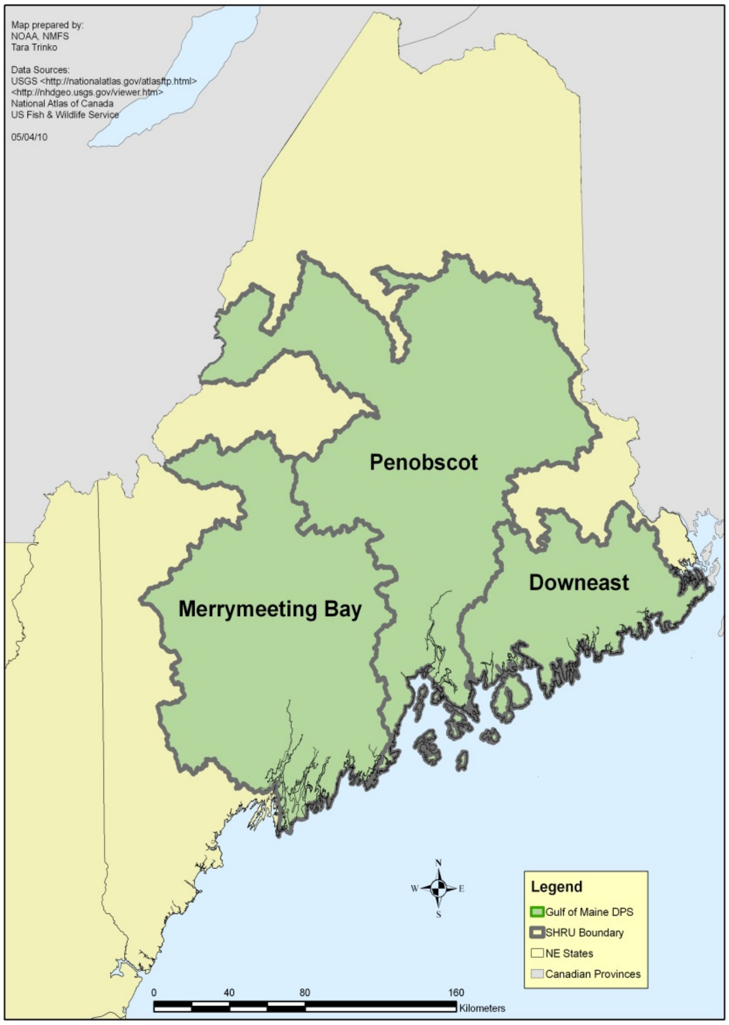

Figure 8: Location of Atlantic salmon Habitat Recovery Units (SHRU) in the GOM DPS

Merrymeeting Bay SHRU

Today, dams are the greatest impediment, outside of marine survival, to the recovery of salmon in the Penobscot, Kennebec, and Androscoggin river basins (Fay *et al.* 2006). Hydropower dams in the Merrymeeting Bay SHRU significantly impede the migration of Atlantic salmon and other diadromous fish and either reduce or eliminate access to roughly 352,000 units of historically accessible spawning and rearing habitat. In addition to hydropower dams, agriculture and urban development largely affect the lower third of the Merrymeeting Bay SHRU by reducing substrate and cover, reducing water quality, and elevating water temperatures. Additionally, smallmouth bass and brown trout introductions, along with other non-indigenous species, significantly degrade habitat quality throughout the Merrymeeting Bay SHRU by altering natural predator/prey relationships.

Downeast Coastal SHRU

Impacts to substrate and cover, water quality, water temperature, biological communities, and migratory corridors, among a host of other factors, have impacted the quality and quantity of habitat available to Atlantic salmon populations within the Downeast Coastal SHRU. Two hydropower dams on the Union river, and, to a lesser extent, the small ice dam on the lower Narraguagus River, limit access to roughly 18,500 units of spawning and rearing habitat within these two watersheds. In the Union River, which contains over 12,000 units of spawning and rearing habitat, physical and biological features have been most notably limited by high water temperatures and abundant smallmouth bass populations associated with impoundments. In the Pleasant River and Tunk Stream, which collectively contain over 4,300 units of spawning and rearing habitat, pH has been identified as possibly being the predominate limiting factor. The Machias, Narraguagus, and East Machias rivers contain the highest quality habitat relative to other HUC 10s in the Downeast Coastal SHRU and collectively account for approximately 40 percent of the spawning and rearing habitat in the Downeast Coastal SHRU.

Penobscot Bay SHRU

The mainstem Penobscot has the highest biological value to the Penobscot SHRU because it provides a central migratory corridor crucial for the entire Penobscot SHRU. Dams, along with degraded substrate and cover, water quality, water temperature, and biological communities, have reduced the quality and quantity of habitat available to Atlantic salmon populations within the Penobscot SHRU. A combined total of 20 FERC-licensed hydropower dams in the Penobscot SHRU significantly impede the migration of Atlantic salmon and other diadromous fish to nearly 300,000 units of historically accessible spawning and rearing habitat. Agriculture and urban development largely affect the lower third of the Penobscot SHRU below the Piscataquis River sub-basin by reducing substrate and cover, reducing water quality, and elevating water temperatures. Introductions of smallmouth bass and other non-indigenous species significantly degrade habitat quality throughout the mainstem Penobscot and portions of the Mattawamkeag, Piscataquis, and lower Penobscot sub-basins by altering predator/prey relationships. Similar to smallmouth bass, recent Northern pike introductions threaten habitat in the lower Penobscot River. Of the 323,700 units of spawning and rearing habitat (within 46 HUC 10 watersheds), approximately 211,000 units of habitat are considered to be currently occupied (within 28 HUC 10 watersheds). Of the 211,000 occupied units within the Penobscot SHRU, NMFS calculated these units to be the equivalent of nearly 66,300 functional units or approximately 20 percent of the historical functional potential.

4.1.4 Survival and Recovery of the GOM DPS

In light of the 2009 GOM DPS listing and designation of critical habitat, the Services issued a new recovery plan for Atlantic salmon on March 31, 2016 for public review and comment. The draft 2016 Recovery Plan presents a recovery strategy based on the biological and ecological needs of the species as well as current threats and conservation accomplishments that affect its long-term viability. The plan is based upon a planning approach recently endorsed by the USFWS and, for this plan, by us. The new approach, termed the Recovery Enhancement Vision (REV), focuses on the three statutory requirements in the ESA, including site-specific recovery actions; objective, measurable criteria for delisting; and time and cost estimates to achieve recovery and intermediate steps. The 2016 Recovery Plan is based on two premises: first, that recovery must focus on rivers and estuaries located in the GOM DPS until the Services have a better understanding of the threats in the marine environment, and second, that survival of Atlantic salmon in the GOM DPS will be dependent on conservation hatcheries through much of the recovery process. In addition, the scientific foundation for the plan includes conservation biology principles regarding population viability, an understanding of freshwater habitat viability, and threats abatement needs.

Under the 2016 Recovery Plan, reclassification of the GOM DPS from endangered to threatened will be considered when all of following criteria are met:

1. The DPS has a total annual escapement of at least 1,500 naturally reared adults spawning in the wild, with at least 2 of the 3 SHRUs having at least 500 naturally reared adults.
2. The population in each of at least two of the three SHRUs has a population growth rate of greater than 1.0 in the 10-year period preceding reclassification.
3. Adults originating from hatchery-stocked eggs, fry, and parr are included when estimating population growth rates.
4. Sufficient suitable spawning and rearing habitat for the offspring of the 1,500 naturally reared adults is accessible and distributed throughout designated Atlantic salmon critical habitat, with at least 7,500 accessible and suitable habitat units (Hus) in each of at least two of the three SHRUs, located according to the known and potential migratory patterns of returning salmon.

4.1.5 Summary of Rangewide Status of Atlantic salmon

The GOM DPS of Atlantic salmon currently exhibits critically low spawner abundance, poor marine survival, and is confronted with a variety of additional threats. The abundance of GOM DPS Atlantic salmon has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is extremely low (approximately 6% over the last ten years) and is continuing to decline. The spatial distribution of the GOM DPS has been severely reduced relative to historical distribution patterns. The conservation hatchery program assists in slowing the decline and helps stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS. Continued reliance on the conservation hatchery program could prevent extinction in the short term, but recovery of the GOM DPS must be accomplished through increases in naturally reared salmon.

4.2 Critical Habitat Designated for the GOM DPS of Atlantic salmon

Coincident with the June 19, 2009 endangered listing, we designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009)(Figure 9). The final rule was revised on August 10, 2009. In this revision, designated critical habitat for the expanded GOM DPS of Atlantic salmon was reduced to exclude trust and fee holdings of the Penobscot Indian Nation and a table was corrected (74 FR 39003; August 10, 2009).

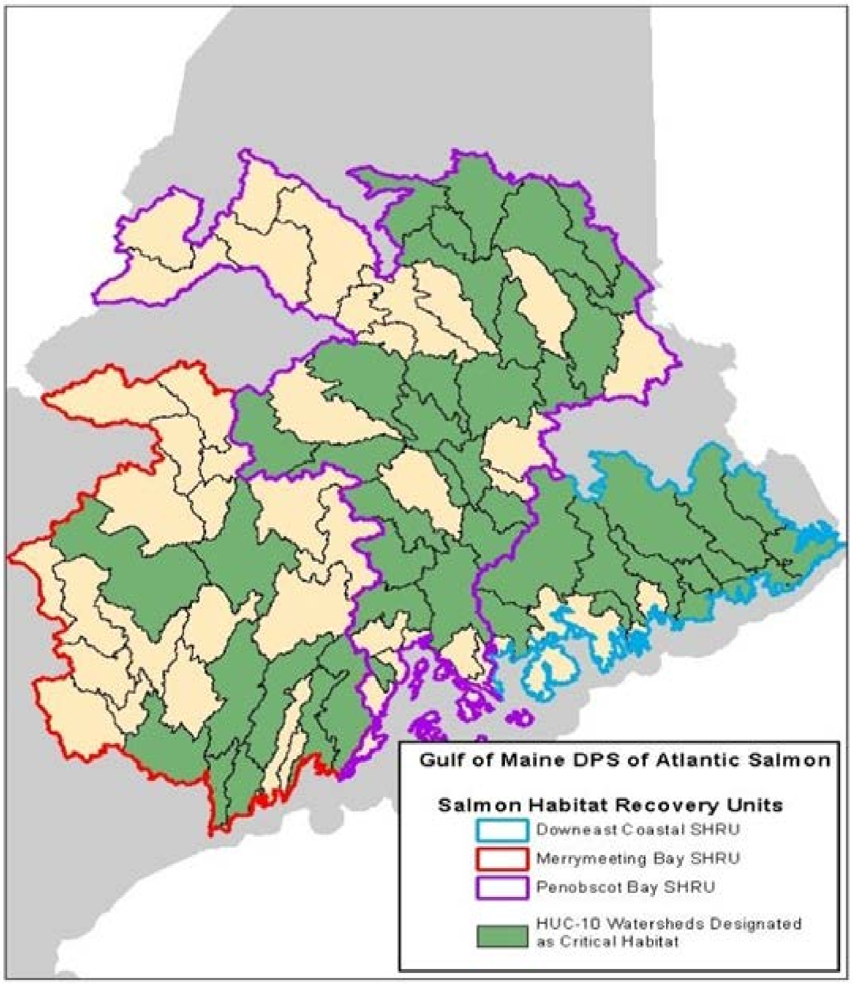

Figure 9: HUC-10 Watersheds Designated as Atlantic Salmon Critical Habitat and Salmon Habitat Recovery Units within the GOM DPS

4.2.1 Essential Features of Atlantic Salmon Critical Habitat

Designation of critical habitat is based on the known physical and biological features within the occupied areas of a listed species that are deemed essential to the conservation of the species. For the GOM DPS, the physical and biological features (PBFs) essential for the conservation of Atlantic salmon are: 1) sites for spawning and rearing, and, 2) sites for migration (excluding marine migration[5]). We chose not to separate spawning and rearing habitat into distinct PBFs, although each habitat does have distinct features, because of the GIS-based habitat prediction model approach that was used to designate critical habitat (74 FR 29300; June 19, 2009). This model cannot consistently distinguish between spawning and rearing habitat across the entire range of the GOM DPS.

[5] Although successful marine migration is essential to Atlantic salmon, we were not able to identify the essential features of marine migration and feeding habitat or their specific locations at the time critical habitat was designated.

The physical and biological features for Atlantic salmon critical habitat are as follows:

Physical and Biological Features of Spawning and Rearing Habitat

1. Deep, oxygenated pools and cover (*e.g.*, boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.
2. Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.
3. Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development, and feeding activities of Atlantic salmon fry.
4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
5. Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production.
6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

Physical and Biological Features of Migratory Habitat

1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
2. Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (*e.g.*, boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.
5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration.
6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

Habitat areas designated as critical habitat must contain one or more physical and biological features within the acceptable range of values required to support the biological processes for which the species uses that habitat. Critical habitat includes all perennial rivers, streams, and estuaries and lakes connected to the marine environment within the range of the GOM DPS, except for those areas that have been specifically excluded as critical habitat. Critical habitat has only been designated in areas (HUC-10 watersheds) considered currently occupied by the species. Critical habitat includes the stream channels within the designated stream reach and includes a lateral extent as defined by the ordinary high-water line or the bankfull elevation in the absence of a defined high-water line. In estuaries, critical habitat is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater.

To facilitate and standardize determinations of effect for section 7 consultations involving Atlantic salmon critical habitat, we developed the "Matrix of Essential Features for Designated Atlantic Salmon Critical Habitat in the GOM DPS" (Table 5). The matrix lists the physical and biological features (essential features) of Atlantic salmon habitat, and the potential conservation status of critical habitat within an action area. Two essential features in the matrix (spawning and rearing, and migration) are described in regards to five distinct Atlantic salmon life stages: (1) adult spawning; (2) embryo and fry development; (3) parr development; (4) adult migration; and, (5) smolt migration. The conservation status of the essential features may exist in varying degrees of functional capacity within the action area. The three degrees of functional capacity used in the matrix are described in ascending order: (1) fully functioning; (2) limited function; and (3) not properly functioning.

Migratory habitat physical and biological features (PBFs) 1-4 are present in the action area. We have determined that neither the spawning and rearing PBFs 1-7, nor migratory habitat PBFs 5-6, occur in the action area. We explain this determination and discuss these features and their current status in the action area below in the Environmental Baseline (Section 5).

Table 5: Matrix of essential features for assessing the environmental baseline of the action area

Essential Features	Conservation Status Baseline Fully Functioning	Limited Function	Not Properly Functioning
A) Adult Spawning (October 1st - December 14th)			
Substrate	highly permeable course gravel and cobble between 1.2 to 10 cm in diameter	40- 60% cobble (22.5-256 mm dia.) 40-50% gravel (2.2 – 22.2 mm dia.); 10-15% course sand (0.5 -2.2 mm dia.), and <3% fine sand (0.06-0.05mm dia.)	more than 20% sand (particle size 0.06 to 2.2 mm), no gravel or cobble
Depth	17-30 cm	30 - 76 cm	< 17 cm or > 76 cm
Velocity	31 to 46 cm/sec.	8 to 31cm/sec. or 46 to 83 cm/sec.	< 5-8 cm/sec. or > 83cm/sec.
Temperature	7^o to 10^oC	often between 7^o to 10^oC	always < 7^o or > 10^oC
pH	> 5.5	between 5.0 and 5.5	< 5.0
Cover	Abundance of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Limited availability of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks	Absence of pools 1.8-3.6 meters deep (McLaughlin and Knight 1987). Large boulders or rocks, over hanging trees, logs, woody debris, submerged vegetation or undercut banks
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
B) Embryo and Fry Development: (October 1st - April 14th)			
Temperature	0.5^oC and 7.2^oC, averages nearly 6oC from fertilization to eye pigmentation	averages < 4oC, or 8 to 10^oC from fertilization to eye pigmentation	>10^oC from fertilization to eye pigmentation
D.O.	at saturation	7-8 mg/L	< 7 mg/L
pH	> 6.0	6 - 4.5	< 4.5
Depth	5.3-15cm	NA	<5.3 or >15cm
Velocity	4 – 15cm/sec.	NA	<4 or > 15cm/sec.
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

Table 1 continued…

	Conservation Status Baseline		
Essential Features	Fully Functioning	Limited Function	Not Properly Functioning
C) Parr Development: (All year)			
Substrate	gravel between 1.6 and 6.4 cm in diameter and boulders between 30 and 51.2 cm in diameter. May contain rooted aquatic macrophytes	gravel < 1.2cm and/or boulders > 51.2. May contain rooted aquatic macrophytes	no gravel, boulders, or rooted aquatic macrophytes present
Depth	10cm to 30cm	NA	<10cm or >30cm
Velocity	7 to 20 cm/sec.	< 7cm/sec. or > 20 cm/sec.	velocity exceeds 120 cm/sec.
Temperature	15º to 19ºC	generally between 7-22.5oC, but does not exceed 29oC at any time	stream temperatures are continuously <7oC or known to exceed 29oC
D.O.	> 6 mg/l	2.9 - 6 mg/l	< 2.9 mg/l
Food	Abundance of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Presence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows	Absence of larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates and small fish such as alewives, dace or minnows
Passage	No anthropogenic causes that inhibit or delay movement	Presence of anthropogenic causes that result in limited inhibition of movement	barriers to migration known to cause direct inhibition of movement
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species

Table 1 continued…

Essential Features	Conservation Status Baseline Fully Functioning	Limited Function	Not Properly Functioning
D) Adult migration (April 15th- December 14th)			
Velocity	30 cm/sec to 125 cm/sec	In areas where water velocity exceeds 125 cm/sec adult salmon require resting areas with a velocity of < 61 cm/s	sustained speeds > 61 cm/sec and maximum speed > 667 cm/sec
D.O.	> 5mg/L	4.5-5.0 mg/l	< 4.5mg/L
Temperature	14 – 20ºC	temperatures sometimes exceed 20oC but remain below 23ºC.	> 23ºC
Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts
Fisheries Interactions	Abundant diverse populations of indigenous fish species	Abundant diverse populations of indigenous fish species, low quantities of non-native species present	Limited abundance and diversity of indigenous fish species, abundant populations of non-native species
E) Juvenile Migration: (April 15th - June 14th)			
Temperature	8 - 11oC	5 - 11ºC.	< 5oC or > 11oC
pH	> 6	5.5 - 6.0	< 5.5
Passage	No anthropogenic causes that delay migration	Presence of anthropogenic causes that result in limited delays in migration	barriers to migration known to cause direct or indirect mortality of smolts

4.2.2 Factors Affecting Atlantic salmon and Critical Habitat

Threats Faced by Atlantic Salmon Throughout Their Range

Atlantic salmon face a number of threats to their survival, most of which are outlined in the Recovery Plan (NMFS and USFWS 2005) and the latest status review (Fay *et al.* 2006). We consider the following to be the most significant threats to the GOM DPS of Atlantic salmon:

- Dams
- Inadequacy of existing regulatory mechanisms for dams
- Continued low marine survival rates for U.S. stocks of Atlantic salmon
- Lack of access to spawning and rearing habitat due to dams and road-stream crossings
- Degraded water quality
- Aquaculture practices, which pose ecological and genetic risks
- Climate change
- Depleted diadromous fish communities
- Incidental capture of adults and parr by recreational anglers
- Introduced fish species that compete or prey on Atlantic salmon
- Poaching of adults
- Recovery hatchery program (potential for artificial selection/domestication)
- Sedimentation of spawning and rearing habitat
- Water extraction
- Diseases
- Predation
- Greenland Mixed Stock Fishery.

A wide variety of activities have focused on protecting Atlantic salmon and restoring the GOM DPS, including (but not limited to) hatchery supplementation; removing dams or providing fish passage; improving road crossings that block passage or degrade stream habitat; protecting riparian corridors along rivers; reducing the impact of irrigation water withdrawals; limiting effects of recreational and commercial fishing; reducing the effects of finfish aquaculture; outreach and education activities; and research focused on better understanding the threats to Atlantic salmon and developing effective restoration strategies.

Starting in the 1960s, Greenland implemented a mixed stock Atlantic salmon fishery off its western coast (Sheehan *et al.* 2015). The fishery primarily takes 1 sea winter (1 SW) North American and European origin Atlantic salmon that would potentially return to natal waters as mature, 2 SW spawning adults or older. Because of international concerns that the fishery would have deleterious on the contributing stock complexes, a quota system was agreed upon and implemented in 1976, and since 1984, catch regulations have been established by the North Atlantic Salmon Conservation Organization (NASCO) (Sheehan *et al.* 2015). In recent years, Greenland had limited the mixed stock salmon fishery for internal consumption only, which in the past has been estimated at 20 metric tons.

In 2015, Greenland unilaterally set a 45 ton quota for a mixed stock Atlantic salmon fishery for 2015, 2016, and 2017 (Sheehan *et al.* 2015). Based on historic harvest estimates, it is estimated that on average, approximately 100 U.S. origin adult Atlantic salmon will be harvested annually under a 45 ton quota. With recent U.S. returns of Atlantic salmon averaging less than 1,500 individuals per year, the majority of which originated from hatcheries, this harvest constitutes a substantial threat to the survival and recovery of the GOM DPS. The U.S. continues to negotiate with the government of Greenland and participants of the fishery both within and outside of NASCO to ultimately establish agreed upon measures that will curtail the impact of the fishery on U.S. origin fish.

The final rule designating critical habitat for the GOM DPS identifies a number of activities that have and will likely continue to impact the biological and physical features of spawning, rearing, and migration habitat for Atlantic salmon. These include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-crossings and other instream activities (such as alternative energy development), mining, dams, dredging, and aquaculture. Most of these activities have or still do occur, at least to some extent, throughout the Gulf of Maine.

4.3 Shortnose Sturgeon

Shortnose sturgeon are fish that occur in rivers and estuaries along the East Coast of the U.S. and Canada (SSSRT 2010). They have a head covered in bony plates, as well as protective armor called scutes extending from the base of the skull to the caudal peduncle. Other distinctive features include a subterminal, protractile tube-like mouth, and chemosensory barbels for benthic foraging (SSSRT 2010). Sturgeon have been present in North America since the Upper Cretaceous period, more than 66 million years ago. The information below is a summary of available information on the species. More thorough discussions can be found in the cited references as well as the SSSRT's Biological Assessment (2010). Information on the populations that occur in the action area is provided in section 4.3.3, while details on activities that impact individual shortnose sturgeon in the action area can be found in the Environmental Baseline (section 5.0).

4.3.1 Life History and General Habitat Use

There are differences in life history, behavior, and habitat use across the range of the species. Current research indicates that these differences are adaptations to unique features of the rivers where these populations occur. For example, there are differences in larval dispersal patterns in the Connecticut River (MA) and Savannah River (GA) (Parker 2007). There are also morphological and behavioral differences. Growth and maturation occurs more quickly in southern rivers but fish in northern rivers grow larger and live longer. We provide general life history attributes in Table 6.

Table 6: Shortnose sturgeon general life history for the species throughout its range

Stage	Size (mm)	Duration	Behaviors/Habitat Used
Egg	3-4	13 days post spawn	stationary on bottom; Cobble and rock, fresh, fast flowing water
Yolk Sac Larvae	7-15	8-12 days post hatch	Photonegative; swim up and drift behavior; form aggregations with other YSL; Cobble and rock, stay at bottom near spawning site
Post Yolk Sac	15 - 57	12-40 days	Free swimming; feeding; Silt bottom,

Larvae		post hatch	deep channel; fresh water
Young of Year	57 – 140 (north); 57-300 (south)	From 40 days post-hatch to one year	Deep, muddy areas upstream of the saltwedge
Juvenile	140 to 450-550 (north); 300 to 450-550 (south)	1 year to maturation	Increasing salinity tolerance with age; same habitat patterns as adults
Adult	450-1100 average; (max recorded 1400)	Post-maturation	Freshwater to estuary with some individuals making nearshore coastal migrations

Shortnose sturgeon live on average for 30-40 years (Dadswell *et al.* 1984). Males mature at approximately 5-10 years and females mature between age 7 and 13, with later maturation occurring in more northern populations (Dadswell *et al.* 1984). Females typically spawn for the first time 5 years post-maturation (age 12-18; Dadswell 1979; Dadswell *et al.* 1984) and then spawn every 3-5 years (Dadswell 1979; Dadswell *et al.* 1984;). Males spawn for the first time approximately 1-2 years after maturity with spawning typically occurring every 1-2 years (Kieffer and Kynard 1996; NMFS 1998; Dadswell *et al.* 1984). Shortnose sturgeon are iteroparous (spawning more than once during their life) and females release eggs in multiple “batches” during a 24 to 36-hour period (total of 30,000-200,000 eggs). Multiple males are likely to fertilize the eggs of a single female.

Cues for spawning are thought to include water temperature, day length and river flow (Kynard 2012). Shortnose sturgeon spawn in freshwater reaches of their natal rivers when water temperatures reach 9–15°C in the spring (Dadswell 1979; Taubert 1980a and b; Kynard 1997). Spawning occurs over gravel, rubble, and/or cobble substrate (Dadswell 1979, Taubert 1980a and b; Buckley and Kynard 1985b; Kynard 1997) in areas with average bottom velocities between 0.4 and 0.8 m/s. Depths at spawning sites are variable, ranging from 1.2 - 27 m (multiple references in SSSRT 2010). Eggs are small and demersal and stick to the rocky substrate where spawning occurs.

Shortnose sturgeon occur in waters between 0-34°C (Dadswell *et al.* 1984; Heidt and Gilbert 1978); with temperatures above 28°C considered to be stressful. Depths used are highly variable, ranging from shallow mudflats while foraging to deep channels up to 30 m (Dadswell *et al.* 1984; Dadswell 1979). Salinity tolerance increases with age; while young of the year must remain in freshwater, adults have been documented in the ocean with salinities of up 30 parts-per-thousand (ppt) (Holland and Yeverton 1973; Saunders and Smith 1978). Dissolved oxygen affects distribution, with preference for DO levels at or above 5mg/l and adverse effects anticipated for prolonged exposure to DO less than 3.2mg/L.

Shortnose sturgeon feed on benthic insects, crustaceans, mollusks, and polychaetes (Dadswell *et al.* 1984). Both juvenile and adult shortnose sturgeon primarily forage over sandy-mud bottoms, which support benthic invertebrates (Carlson and Simpson 1987; Kynard 1997). Shortnose sturgeon have also been observed feeding off plant surfaces (Dadswell *et al.* 1984).

Following spawning, adult shortnose sturgeon disperse quickly down river to summer foraging grounds areas and remain in areas downstream of their spawning grounds throughout the remainder of the year (Buckley and Kynard 1985, Dadswell *et al.* 1984; Buckley and Kynard 1985; O'Herron *et al.* 1993).

In northern rivers, shortnose aggregate during the winter months in discrete, deep (3-10m) freshwater areas with minimal movement and foraging (Kynard *et al.* 2012; Buckley and Kynard 1985a; Dadswell 1979, Li *et al.* 2007; Dovel *et al.* 1992; Bain *et al.* 1998a and b). In the winter, adults in southern rivers spend much of their time in the slower moving waters downstream near the salt-wedge and forage widely throughout the estuary (Collins and Smith 1993, Weber *et al.* 1998). Pre-spawning sturgeon in some northern and southern systems migrate into an area in the upper tidal portion of the river in the fall and complete their migration in the spring (Rogers and Weber 1995). Older juveniles typically occur in the same overwintering areas as adults while young of the year remain in freshwater (Jenkins *et al.* 1993, Jarvis *et al.* 2001).

4.3.2 Listing History
Shortnose sturgeon were listed as endangered in 1967 (32 FR 4001), and the species remained on the endangered species list with the enactment of the ESA in 1973. Shortnose sturgeon are thought to have been abundant in nearly every large East Coast river prior to the 1880s (see Catesby 1734; McDonald 1887; Smith and Clugston 1997). Pollution and overfishing, including bycatch in the shad fishery, were listed as principal reasons for the species' decline. The species remains listed as endangered throughout its range. While the 1998 Recovery Plan refers to Distinct Population Segments (DPS), the process to designate DPSs for this species has not been undertaken. The SSSRT published a Biological Assessment for shortnose sturgeon in 2010. The report summarized the status of shortnose sturgeon within each river and identified stressors that continue to affect the abundance and stability of these populations.

4.3.3 Current Status
There is no current total population estimate for shortnose sturgeon rangewide. Information on populations and metapopulations is presented below. In general, populations in the Northeast are larger and more stable than those in the Southeast (SSSRT 2010). Population size throughout the species' range is considered to be stable; however, most riverine populations are below the historic population sizes and most likely are below the carrying capacity of the river (Kynard 1996).

Population Structure
There are 19 documented populations of shortnose sturgeon ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Minas Basin in Nova Scotia, Canada. There is a large gap in the middle of the species range with individuals present in the Chesapeake Bay separated from populations in the Carolinas by a distance of more than 400 km. Currently, there are significantly more shortnose sturgeon in the northern portion of the range.

Developments in genetic research as well as differences in life history support the grouping of shortnose sturgeon into five genetically distinct groups, all of which have unique geographic adaptations (see Grunwald *et al.* 2008; Grunwald *et al.* 2002; King *et al.* 2001; Waldman *et al.* 2002b; Walsh *et al.* 2001; Wirgin *et al.* 2009; Wirgin *et al.* 2002; SSSRT 2010). These groups are: 1) Gulf of Maine; 2) Connecticut and Housatonic Rivers; 3) Hudson River; 4) Delaware River and Chesapeake Bay; and 5) Southeast. The Gulf of Maine, Delaware/Chesapeake Bay and Southeast groups function as metapopulations[6]. The other two groups (Connecticut/Housatonic and the Hudson River) function as independent populations.

While there is migration within each metapopulation (i.e., between rivers in the Gulf of Maine and between rivers in the Southeast) and occasional migration between populations (e.g., Connecticut and Hudson), interbreeding between river populations is limited to very few individuals per generation; this results in morphological and genetic variation between most river populations (see Walsh *et al.* 2001; Grunwald *et al.* 2002; Waldman *et al.* 2002; Wirgin *et al.* 2005). Indirect gene flow estimates from mtDNA indicate an effective migration rate of less than two individuals per generation. This means that while individual shortnose sturgeon may move between rivers, very few sturgeon are spawning outside their natal river; it is important to remember that the result of physical movement of individuals is rarely genetic exchange.

Summary of Status of Northeast Rivers
In our Greater Atlantic Region, shortnose sturgeon are known to spawn in the Kennebec, Androscoggin, Merrimack, Connecticut, Hudson and Delaware Rivers. Shortnose sturgeon are also known to occur in the Penobscot and Potomac Rivers; although it is unclear if spawning is currently occurring in those systems.

Gulf of Maine Metapopulation
Tagging and telemetry studies indicate that shortnose sturgeon are present in the Penobscot, Kennebec, Androscoggin, Sheepscot and Saco Rivers. Individuals have also been documented in smaller coastal rivers; however, the duration of presence has been limited to hours or days and the smaller coastal rivers are thought to be only used occasionally (Zydlewski *et al.* 2011).

Since the removal of the Veazie and Great Works Dams (2013 and 2012, respectively), in the Penobscot River, shortnose sturgeon range from the Bay to the Milford Dam. Shortnose sturgeon now have access to their full historical range. Adult and large juvenile sturgeon have been documented to use the river. While potential spawning sites have been identified, no spawning has been documented. Foraging and overwintering are known to occur in the river. Nearly all pre-spawn females and males have been documented to return to the Kennebec or Androscoggin Rivers. Robust design analysis with closed periods in the summer and late fall estimated seasonal adult abundance ranging from 636-1285 (weighted mean), with a low estimate of 602 (95%CI: 409.6-910.8) and a high of 1306 (95% CI: 795.6-2176.4) (Fernandes 2008; Fernandes *et al.* 2010; Dionne 2010 in Maine DMR 2010).

Kennebec/Androscoggin/Sheepscot
The estimated size of the adult population (>50cm TL) in this system, based on a tagging and

[6] A metapopulation is a group of populations in which distinct populations occupy separate patches of habitat separated by unoccupied areas (Levins 1969). Low rates of connectivity through dispersal, with little to no effective movement, allow individual populations to remain distinct as the rate of migration between local populations is low enough not to have an impact on local dynamics or evolutionary lineages (Hastings and Harrison 1994). This interbreeding between populations, while limited, is consistent, and distinguishes metapopulations from other patchy populations.

recapture study conducted between 1977-1981, was 7,200 (95% CI = 5,000 - 10,800; Squiers *et al.* 1982). A population study conducted 1998-2000 estimated population size at 9,488 (95% CI = 6,942 -13,358; Squiers 2003) suggesting that the population exhibited significant growth between the late 1970s and late 1990s. Spawning is known to occur in the Androscoggin and Kennebec Rivers. In both rivers, there are hydroelectric facilities located at the base of natural falls thought to be the natural upstream limit of the species. The Sheepscot River is used for foraging during the summer months.

Merrimack River

The historic range in the Merrimack extended to Amoskeag Falls (Manchester, NH, RKM 116; Piotrowski 2002); currently shortnose sturgeon cannot move past the Essex Dam in Lawrence, MA (RKM 46). A current population estimate for the Merrimack River is not available. Based on a study conducted 1987-1991, the adult population was estimated at 32 adults (20–79; 95% confidence interval; B. Kynard and M. Kieffer unpublished information). However, recent gill-net sampling efforts conducted by Kieffer indicate a dramatic increase in the number of adults in the Merrimack River. Sampling conducted in the winter of 2009 resulted in the capture of 170 adults. Preliminary estimates suggest that there may be approximately 2,000 adults using the Merrimack River annually. Spawning, foraging and overwintering all occur in the Merrimack River.

Tagging and tracking studies demonstrate movement of shortnose sturgeon between rivers within the Gulf of Maine, with the longest distance traveled between the Penobscot and Merrimack rivers. Genetic studies indicate that a small, but statistically insignificant amount of genetic exchange likely occurs between the Merrimack River and these rivers in Maine (King *et al.* 2013). The Merrimack River population is genetically distinct from the Kennebec-Androscoggin-Penobscot population (SSSRT 2010). In the Fall of 2014, a shortnose sturgeon tagged in the Connecticut River in 2001 was captured in the Merrimack River. To date, genetic analysis has not been completed and we do not yet know the river of origin of this fish.

Connecticut River Population

The Holyoke Dam divides the Connecticut River shortnose population; there is currently limited successful passage downstream of the Dam. No shortnose sturgeon have passed upstream of the dam since 1999 and passage between 1975-1999 was an average of four fish per year. The number of sturgeon passing downstream of the Dam is unknown. Despite this separation, the populations are not genetically distinct (Kynard 1997, Wirgin *et al.* 2005, Kynard *et al.*2012). The most recent estimate of the number of shortnose sturgeon upstream of the dam, based on captures and tagging from 1990-2005 is approximately 328 adults (CI = 188–1,264 adults; B. Kynard, USGS, unpubl. Data in SSSRT 2010); this compares to a previous Peterson mark-recapture estimate of 370–714 adults (Taubert 1980a). Using four mark-recapture methodologies, the longterm population estimate (1989-2002) for the lower Connecticut River ranges from 1,042-1,580 (Savoy 2004). Comparing 1989-1994 to 1996-2002, the population exhibits growth on the order of 65-138%. The population in the Connecticut River is thought to be stable, but at a small size.

The Turners Falls Dam is thought to represent the natural upstream limit of the species; however, in 2017, a shortnose sturgeon was confirmed above the Turners Falls Dam, and future research will investigate whether there is a larger population in that location. While limited spawning is thought to occur below the Holyoke Dam, successful spawning has only been documented upstream of the Holyoke Dam. Abundance of pre-spawning adults was estimated each spring between 1994–2001 at a mean of 142.5 spawning adults (CI =14–360 spawning adults) (Kynard *et al.* 2012). Overwintering and foraging occur in both the upper and lower portions of the river. Occasionally, sturgeon have been captured in tributaries to the Connecticut River including the Deerfield River and Westfield River. Additionally, a sturgeon tagged in the CT river was recaptured in the Housatonic River (T. Savoy, CT DEP, pers. comm.). Three individuals tagged in the Hudson were captured in the CT, with one remaining in the river for at least one year (Savoy 2004).

Hudson River Population

The Hudson River population of shortnose sturgeon is the largest in the United States. Studies indicated an extensive increase in abundance from the late 1970s (13,844 adults (Dovel *et al.* 1992), to the late 1990s (56,708 adults (95% CI 50,862 to 64,072; Bain *et al.* 1998). This increase is thought to be the result of high recruitment (31,000 – 52,000 yearlings) from 1986-1992 (Woodland and Secor 2007). Woodland and Secor examined environmental conditions throughout this 20-year period and determined that years in which water temperatures drop quickly in the fall and flow increases rapidly in the fall (particularly October), are followed by high levels of recruitment in the spring. This suggests that these environmental factors may index a suite of environmental cues that initiate the final stages of gonadal development in spawning adults. The population in the Hudson River exhibits substantial recruitment and is considered to be stable at high levels.

Delaware River-Chesapeake Bay Metapopulation

Shortnose sturgeon range from Delaware Bay up to at least Scudders Falls (RKM 223); there are no dams within the species’ range on this river. The population is considered stable (comparing 1981-1984 to 1999-2003) at around 12,000 adults (Hastings *et al.* 1987 and ERC 2006b). Spawning occurs primarily between Scudders Falls and the Trenton rapids. Overwintering and foraging also occur in the river. Shortnose sturgeon have been documented to use the Chesapeake-Delaware Canal to move from the Chesapeake Bay to the Delaware River.

The current abundance of shortnose sturgeon in the Chesapeake Bay is unknown. Incidental capture of shortnose sturgeon was reported to the USFWS and MDDNR between 1996-2008 as part of an Atlantic Sturgeon Reward Program. During this time, 80 shortnose sturgeon were documented in the Maryland waters of the Bay and in several tidal tributaries. To date, no shortnose sturgeon have been recorded in Virginia waters of the Bay.

Spawning has not been documented in any tributary to the Bay although suitable spawning habitat and two pre-spawning females with late stage eggs have been documented in the Potomac River. Current information indicates that shortnose sturgeon are present year round in the Potomac River with foraging and overwintering taking place there. Shortnose sturgeon captured in the Chesapeake Bay are not genetically distinct from the Delaware River population.

Southeast Metapopulation

There are no shortnose sturgeon between Maryland waters of the Chesapeake Bay and the

Carolinas. Shortnose sturgeon are only thought to occur in the Cape Fear River and Yadkin-Pee Dee River in North Carolina and are thought to be present in very small numbers.

The Altamaha River supports the largest known population in the Southeast with successful self-sustaining recruitment. The most recent population estimate for this river was 6,320 individuals (95% CI = 4,387-9,249; DeVries 2006). The population contains more juveniles than expected. Comparisons to previous population estimates suggest that the population is increasing; however, there is high mortality between the juvenile and adult stages in this river. This mortality is thought to result from incidental capture in the shad fishery, which occurs at the same time as the spawning period (DeVries 2006).

The only available estimate for the Cooper River is of 300 spawning adults at the Pinoplis Dam spawning site (based on 1996-1998 sampling; Cooke *et al.* 2004). This is likely an underestimate of the total number of adults as it would not include non-spawning adults. Estimates for the Ogeechee River were 266 (95%CI=236-300) in 1993 (Weber 1996, Weber *et al.* 1998); a more recent estimate (sampling from 1999-2004; Fleming *et al.* 2003) indicates a population size of 147 (95% CI = 104-249). While the more recent estimate is lower, it is not significantly different than the previous estimate. Available information indicates the Ogeechee River population may be experiencing juvenile mortality rates greater than other southeastern rivers.

Spawning is also occurring in the Savannah River, the Congaree River, and the Yadkin-Pee Dee River. There are no population estimates available for these rivers. Occurrence in other southern rivers is limited, with capture in most other rivers limited to fewer than five individuals. They are thought to be extremely rare or possibly extirpated from the St. Johns River in Florida as only a single specimen was found by the Florida Fish and Wildlife Conservation Commission during extensive sampling of the river in 2002/2003. In these river systems, shortnose sturgeon occur in nearshore marine, estuarine, and riverine habitat.

4.3.4 Threats

Because sturgeon are long-lived and slow growing, stock productivity is relatively low; this can make the species vulnerable to rapid decline and slow recovery (Musick 1999). In well studied rivers (e.g., Hudson, upper Connecticut), researchers have documented significant year to year recruitment variability (up to 10 fold over 20 years in the Hudson and years with no recruitment in the CT). However, this pattern is not unexpected given the life history characteristics of the species and natural variability in hydrogeologic cues relied on for spawning.

The small amount of effective movement between populations means recolonization of currently extirpated river populations is expected to be very slow and any future recolonization of any rivers that experience significant losses of individuals would also be expected to be very slow. Despite the significant decline in population sizes over the last century, gene diversity in shortnose sturgeon is moderately high in both mtDNA (Quattro *et al.* 2002; Wirgin *et al.* 2005; Wirgin *et al.* 2000) and nDNA (King *et al.* 2001) genomes.

A population of sturgeon can go extinct as a consequence of demographic stochasticity (fluctuations in population size due to random demographic events); the smaller the metapopulation (or population); the more prone it is to extinction. Anthropogenic impacts acting on top of demographic stochasticity further increase the risk of extinction.

All shortnose sturgeon populations are highly sensitive to increases in juvenile mortality that would result in reductions in the number of adult spawners (Anders *et al.* 2002; Gross *et al.* 2002; Secor 2002). Populations of shortnose sturgeon that do not have reliable natural recruitment are at increased risk of experiencing population decline leading to extinction (Secor *et al.* 2002). Elasticity studies of shortnose sturgeon indicate that the highest potential for increased population size and stability comes from YOY and juveniles as compared to adults (Gross *et al.* 2002); that is, increasing the number of YOY and juveniles has a more significant long term impact to the population than does increasing the number of adults or the fecundity of adults.

The Shortnose Sturgeon Recovery Plan (NMFS 1998) and the Shortnose Sturgeon Status Review Team's Biological Assessment of shortnose sturgeon (2010) identify habitat degradation or loss and direct mortality as principal threats to the species' survival. Natural and anthropogenic factors continue to threaten the recovery of shortnose sturgeon and include: poaching, bycatch in riverine fisheries, habitat alteration resulting from the presence of dams, in-water and shoreline construction, including dredging; degraded water quality which can impact habitat suitability and result in physiological effects to individuals including impacts on reproductive success; direct mortality resulting from dredging as well as impingement and entrainment at water intakes; and, loss of historical range due to the presence of dams. Shortnose sturgeon are also occasionally killed as a result of research activities. The total number of sturgeon affected by these various threats is not known. Climate change, particularly shifts in seasonal temperature regimes and changes in the location of the salt wedge, may impact shortnose sturgeon in the future (more information on Climate Change is presented in Section 6.0). More information on threats experienced in the action area is presented in the Environmental Baseline section of this Opinion.

Survival and Recovery

The 1998 Recovery Plan outlines the steps necessary for recovery and indicates that each population may be a candidate for downlisting (i.e., to threatened) when it reaches a minimum population size that is large enough to prevent extinction and will make the loss of genetic diversity unlikely; the minimum population size for each population has not yet been determined. The Recovery Outline contains three major tasks: (1) establish delisting criteria; (2) protect shortnose sturgeon populations and habitats; and, (3) rehabilitate habitats and population segments. We know that in general, to recover, a listed species must have a sustained positive trend of increasing population over time. To allow that to happen for sturgeon, individuals must have access to enough habitat in suitable condition for foraging, resting and spawning. In many rivers, particularly in the Southeast, habitat is compromised and continues to impact the ability of sturgeon populations to recover. Conditions must be suitable for the successful development of early life stages. Mortality rates must be low enough to allow for recruitment to all age classes so that successful spawning can continue over time and over generations. There must be enough suitable habitat for spawning, foraging, resting and migrations of all individuals. Habitat connectivity must also be maintained so that individuals can migrate between important habitats without delays that impact their fitness. The loss of any population or metapopulation would result in the loss of biodiversity and would create (or widen) a gap in the species' range.

4.3.5 Summary of Status

Shortnose sturgeon remain listed as endangered throughout their range, with populations in the Northeast being larger and generally more stable than populations in the Southeast. All populations are affected by mortality incidental to other activities, including dredging, power plant intakes and shad fisheries where those still occur, and impacts to habitat and water quality that affect the ability of sturgeon to use habitats and impacts individuals that are present in those habitats. While the species is overall considered to be stable (i.e., its trend has not changed recently, and we are not aware of any new or emerging threats that would change the trend in the future), we lack information on abundance and population dynamics in many rivers. We also do not fully understand the extent of coastal movements and the importance of habitat in non-natal rivers to migrant fish. While the species has high levels of genetic diversity, the lack of effective movement between populations increases the vulnerability of the species should there be a significant reduction in the number of individuals in any one population or metapopulation as recolonization is expected to be very slow. All populations, regardless of size, are faced with threats that result in the mortality of individuals and/or affect the suitability of habitat and may restrict the further growth of the population. Additionally, there are several factors that combine to make the species particularly sensitive to existing and future threats; these factors include: the small size of many populations, existing gaps in the range, late maturation, the sensitivity of adults to very specific spawning cues which can result in years with no recruitment, and the impact of losses of young of the year and juveniles to population persistence and stability.

4.4 Status of Atlantic sturgeon

The section below describes the Atlantic sturgeon listing, provides life history information that is relevant to all DPSs of Atlantic sturgeon and then provides information specific to the status of each DPS of Atlantic sturgeon. Below, we also provide a description of which Atlantic sturgeon DPSs likely occur in the action area and provide information on the use of the action area by Atlantic sturgeon (see Environmental Baseline, section 5.0).

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) is a subspecies of sturgeon distributed along the eastern coast of North America from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida, USA (Scott and Scott, 1988; ASSRT, 2007; T. Savoy, CT DEP, pers. comm.). We have delineated U.S. populations of Atlantic sturgeon into five DPSs (77 FR 5880 and 77 FR 5914, February 6, 2012). These are: the Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs (see Figure 10). The results of genetic studies suggest that natal origin influences the distribution of Atlantic sturgeon in the marine environment (Wirgin and King, 2011). However, genetic data as well as tracking and tagging data demonstrate sturgeon from each DPS and Canada occur throughout the full range of the subspecies. Therefore, sturgeon originating from any of the five DPSs can be affected by threats in the marine, estuarine and riverine environment that occur far from natal spawning rivers.

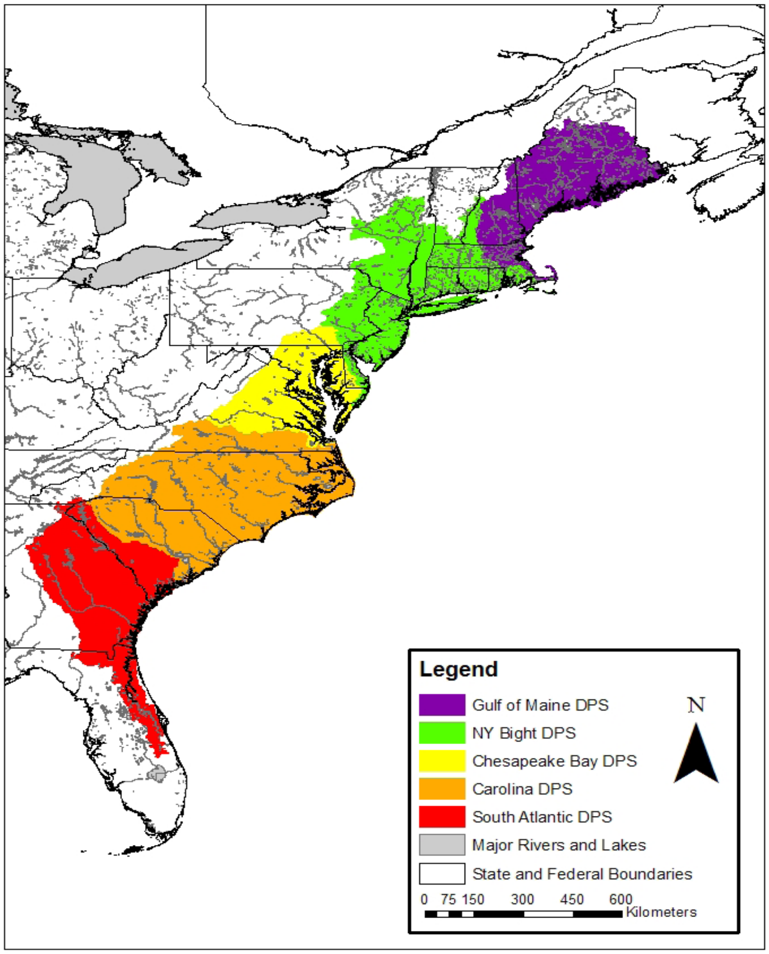

Figure 10: Map Depicting the five Atlantic sturgeon DPSs

The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs are listed as endangered, and the Gulf of Maine DPS is listed as threatened (77 FR 5880 and 77 FR 5914, February 6, 2012). The effective date of the listings was April 6, 2012. The DPSs do not include Atlantic sturgeon spawned in Canadian rivers. Therefore, Canadian spawned fish are not included in the listings.

As described below, only individuals from the Gulf of Maine DPS are expected to occur in the action area.

4.4.1 Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. The distribution of Atlantic sturgeon is influenced by geography, with Atlantic sturgeon from a particular DPS becoming less common the further from the river of origin one moves. Areas that are geographically close are expected to have a similar composition of individuals. We have considered the best available information to determine from which DPSs individuals in the action area are likely to have originated.

There is currently no mixed stock analysis for the Androscoggin River or Kennebec Rivers.

Mixed stock analysis is available for the Bay of Fundy. Given the geographic proximity of the Bay of Fundy to the action area, it is reasonable to anticipate similar distribution in these two areas (93% Gulf of Maine DPS (60% St. John, 40% Kennebec) and 7% New York Bight DPS). However, in the action area we would expect a higher frequency of Androscoggin and Kennebec River origin individuals than St. John River individuals. As such, in the Kennebec River System (including the Androscoggin River) we expect Atlantic sturgeon to occur at the following frequencies: Gulf of Maine 93% (60-100% Androscoggin and Kennebec and up to 40% St. John (Canada)) and 7% New York Bight. These occurrences are supported by preliminary genetic analyses of fish caught in the Gulf of Maine (see Damon-Randall *et al.* 2013). The genetic assignments have a plus/minus 5% confidence interval; however, for purposes of section 7 consultation we have selected the reported values above, which approximate the mid-point of the range, as a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail by Damon-Randall *et al.* (2013).

As we will discuss in the Environmental Baseline (section 5.6), we only expect spawning adult Atlantic sturgeon to travel to the action area. While adult Atlantic sturgeon do enter non-natal rivers, we only expect natal fish to occur on the spawning grounds during the spawning season. As such, all Atlantic sturgeon in the action area will be from the Gulf of Maine DPS (ASSRT 2007).

4.4.2 Atlantic sturgeon life history

Atlantic sturgeon are long lived (approximately 60 years), late maturing, estuarine dependent, anadromous[7] fish (Bigelow and Schroeder, 1953; Vladykov and Greeley 1963; Mangin, 1964; Pikitch *et al.*, 2005; Dadswell, 2006; ASSRT, 2007).

The life history of Atlantic sturgeon can be divided up into five general categories as described in the table below (adapted from ASSRT 2007).

Table 7: Descriptions of Atlantic sturgeon life history stages

Age Class	Size	Duration	Description
Egg	~2mm – 3 mm diameter (Van Eenannnam *et al.* 1996, p. 773)	Hatching occurs ~3-6 days after egg deposition and fertilization (ASSRT 2007, p. 4)	Fertilized or unfertilized
Yolk-sac larvae (YSL)	~6mm – 14 mm (Bath *et al.* 1981, pp. 714-715)	8-12 days post hatch (ASSRT 2007, p.4)	Negative photo-taxic, nourished by yolk sac

[7] Anadromous refers to a fish that is born in freshwater, spends most of its life in the sea, and returns to freshwater to spawn (NEFSC FAQ's, available at http://www.nefsc.noaa.gov/faq/fishfaq1a.html, modified June 16, 2011)

Age Class	Size	Duration	Description
Post yolk-sac larvae (PYSL)	~14mm – 37mm (Bath *et al.* 1981, pp. 714-715)	12-40 days post hatch	Free swimming; feeding; Silt/sand bottom, deep channel; fresh water
Young of Year (YOY)	0.3 grams <410mm TL	From 40 days to 1 year	Fish that are > 40 days and < one year; capable of capturing and consuming live food
Juveniles	>410mm and <760mm TL	1 year to time at which first coastal migration is made	Fish that are at least age 1 and are not sexually mature and do not make coastal migrations.
Subadults	>760 mm and <1500 mm TL	From first coastal migration to sexual maturity	Fish that are not sexually mature but make coastal migrations
Adults	>1500 mm TL	Post-maturation	Sexually mature fish

Atlantic sturgeons are bottom feeders that suck food into a ventrally-located protruding mouth (Bigelow and Schroeder, 1953). Four barbels in front of the mouth assist the sturgeon in locating prey (Bigelow and Schroeder, 1953). Diets of adult and migrant subadult Atlantic sturgeon include mollusks, gastropods, amphipods, annelids, decapods, isopods, and fish such as sand lance (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007; Savoy, 2007). Juvenile Atlantic sturgeon feed on aquatic insects, insect larvae, and other invertebrates (Bigelow and Schroeder, 1953; ASSRT, 2007; Guilbard *et al.*, 2007).

Rate of maturation is affected by water temperature and gender. In general: (1) Atlantic sturgeon that originate from southern systems grow faster and mature sooner than Atlantic sturgeon that originate from more northern systems; (2) males grow faster than females; (3) fully mature females attain a larger size (i.e. length) than fully mature males; and (4) the length of Atlantic sturgeon caught since the mid-late 20th century have typically been less than 3 meters (m) (Smith *et al.*, 1982; Smith *et al.*, 1984; Smith, 1985; Scott and Scott, 1988; Young *et al.*, 1998; Collins *et al.*, 2000; Caron *et al.*, 2002; Dadswell, 2006; ASSRT, 2007; Kahnle *et al.*, 2007; DFO, 2011). The largest recorded Atlantic sturgeon was a female captured in 1924 that measured approximately 4.26 m (Vladykov and Greeley, 1963). Dadswell (2006) reported seeing seven fish of comparable size in the St. John River estuary from 1973 to 1995. Observations of large-sized sturgeon are particularly important given that egg production is correlated with age and body size (Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Dadswell, 2006). However, while females are prolific with egg production ranging from 400,000 to 4 million eggs per spawning year, females spawn at intervals of 2-5 years (Vladykov and Greeley, 1963; Smith *et al.*, 1982; Van Eenennaam *et al.*, 1996; Van Eenennaam and Doroshov, 1998; Stevenson and Secor, 1999; Dadswell, 2006). Given spawning periodicity and a female's relatively late age to maturity, the age at which 50 percent of the maximum lifetime egg production is achieved is estimated to be 29 years (Boreman, 1997). Males exhibit spawning periodicity of 1-5 years (Smith, 1985; Collins *et al.*, 2000; Caron *et al.*, 2002). While long-lived, Atlantic sturgeon are exposed to a multitude of threats prior to achieving maturation and have a limited number of spawning opportunities once mature.

Water temperature plays a primary role in triggering the timing of spawning migrations (ASMFC, 2009). Spawning migrations generally occur during February-March in southern systems, April-May in Mid-Atlantic systems, and May-July in Canadian systems (Murawski and Pacheco, 1977; Smith, 1985; Bain, 1997; Smith and Clugston, 1997; Caron *et al.*, 2002). Male sturgeon begin upstream spawning migrations when waters reach approximately 6° C (43° F) (Smith *et al.*, 1982; Dovel and Berggren, 1983; Smith, 1985; ASMFC, 2009), and remain on the spawning grounds throughout the spawning season (Bain, 1997). Females begin spawning migrations when temperatures are closer to 12° C to 13° C (54° to 55° F) (Dovel and Berggren, 1983; Smith, 1985; Collins *et al.*, 2000), make rapid spawning migrations upstream, and quickly depart following spawning (Bain, 1997).

While the exact spawning locations in all rivers are not known, the habitat characteristics of spawning areas have been identified based on historical accounts of where fisheries occurred, tracking and tagging studies of spawning sturgeon, and physiological needs of early life stages. Spawning is believed to occur in flowing water between the salt front of estuaries and the fall line of large rivers, when and where optimal flows are 46-76 cm/s and depths are 3-27 m (Borodin, 1925; Dees, 1961; Leland, 1968; Scott and Crossman, 1973; Crance, 1987; Shirey *et al.* 1999; Bain *et al.*, 2000; Collins *et al.*, 2000; Caron *et al.* 2002; Hatin *et al.* 2002; ASMFC, 2009). Sturgeon eggs are deposited on hard bottom substrate such as cobble, coarse sand, and bedrock (Dees, 1961; Scott and Crossman, 1973; Gilbert, 1989; Smith and Clugston, 1997; Bain *et al.* 2000; Collins *et al.*, 2000; Caron *et al.*, 2002; Hatin *et al.*, 2002; Mohler, 2003; ASMFC, 2009), and become adhesive shortly after fertilization (Murawski and Pacheco, 1977; Van den Avyle, 1983; Mohler, 2003). Incubation time for the eggs increases as water temperature decreases (Mohler, 2003). At temperatures of 20° and 18° C, hatching occurs approximately 94 and 140 hours, respectively, after egg deposition (ASSRT, 2007).

Larval Atlantic sturgeon (i.e. less than 4 weeks old, with total lengths (TL) less than 30 mm; Van Eenennaam *et al.* 1996) are assumed to undertake a demersal existence and inhabit the same riverine or estuarine areas where they were spawned (Smith *et al.*, 1980; Bain *et al.*, 2000; Kynard and Horgan, 2002; ASMFC, 2009). Studies suggest that age-0 (i.e., young-of-year), age-1, and age-2 juvenile Atlantic sturgeon occur in low salinity waters of the natal estuary (Haley, 1999; Hatin *et al.*, 2007; McCord *et al.*, 2007; Munro *et al.*, 2007) while older fish are more salt tolerant and occur in higher salinity waters as well as low salinity waters (Collins *et al.*, 2000). Atlantic sturgeon remain in the natal estuary for months to years before emigrating to open ocean as subadults (Holland and Yelverton, 1973; Dovel and Berggren, 1983; Waldman *et al.*, 1996;

Dadswell, 2006; ASSRT, 2007).

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 (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Welsh *et al.*, 2002; Savoy and Pacileo, 2003; Stein *et al.*, 2004; Laney *et al.*, 2007; Dunton *et al.*, 2010; Erickson *et al.*, 2011; Wirgin and King, 2011). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast. Satellite-tagged adult sturgeon from the Hudson River concentrated in the southern part of the Mid-Atlantic Bight at depths greater than 20 m during winter and spring, and in the northern portion of the Mid-Atlantic Bight at depths less than 20 m in summer and fall (Erickson *et al.*, 2011). Shirey (Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009) found a similar movement pattern for subadult Atlantic sturgeon based on recaptures of fish originally tagged in the Delaware River. After leaving the Delaware River estuary during the fall, subadult Atlantic sturgeon were recaptured by commercial fishermen in nearshore waters along the Atlantic coast as far south as Cape Hatteras, North Carolina from November through early March. In the spring, a portion of the tagged fish re-entered the Delaware River estuary. However, many fish continued a northerly coastal migration through the Mid-Atlantic as well as into southern New England waters where they were recovered throughout the summer months. Movements as far north as Maine were documented. A southerly coastal migration was apparent from tag returns reported in the fall. The majority of these tag returns were reported from relatively shallow near shore fisheries with few fish reported from waters in excess of 25 m (C. Shirey, Delaware Department of Fish and Wildlife, unpublished data reviewed in ASMFC, 2009). Areas where migratory Atlantic sturgeon commonly aggregate include the Bay of Fundy (e.g., Minas and Cumberland Basins), Massachusetts Bay, Connecticut River estuary, Long Island Sound, New York Bight, Delaware Bay, Chesapeake Bay, and waters off of North Carolina from the Virginia/North Carolina border to Cape Hatteras at depths up to 24 m (Dovel and Berggren, 1983; Dadswell *et al.*, 1984; Johnson *et al.*, 1997; Rochard *et al.*, 1997; Kynard *et al.*, 2000; Eyler *et al.*, 2004; Stein *et al.*, 2004; Wehrell, 2005; Dadswell, 2006; ASSRT, 2007; Laney *et al.*, 2007). These sites may be used as foraging sites and/or thermal refuge.

4.4.3 Distribution and Abundance

In the mid to late 19th century, Atlantic sturgeon underwent significant range-wide declines from historical abundance levels due to overfishing for the caviar market (Scott and Crossman 1973; Taub 1990; Smith and Clugston 1997; Dadswell 2006; ASSRT 2007). Abundance of spawning-aged females prior to this period of exploitation was predicted to be greater than 100,000 for the Delaware River, and at least 10,000 females for other spawning stocks (Secor and Waldman 1999; Secor 2002). Historical records suggest that Atlantic sturgeon spawned in at least 35 rivers prior to this period. Currently, only 17 U.S. rivers are known to support spawning (i.e., presence of young-of-year or gravid Atlantic sturgeon documented within the past 15 years) (ASSRT 2007). While there may be other rivers supporting spawning for which definitive evidence has not been obtained (e.g., in the Penobscot and York Rivers), the number of rivers supporting spawning of Atlantic sturgeon are approximately half of what they were historically. In addition, only five rivers (Kennebec, Androscoggin, Hudson, Delaware, James) are known to currently support spawning from Maine through Virginia, where historical records show that there used to be 15 spawning rivers (ASSRT 2007). Currently, there are substantial gaps between Atlantic sturgeon spawning rivers among northern and Mid-Atlantic states which could slow the rate of recolonization of extirpated populations.

At the time of the listing, there were no current, published population abundance estimates for any of the currently known spawning stocks or for any of the five DPSs of Atlantic sturgeon. An estimate of 863 mature adults per year (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data collected from 1985 to 1995 (Kahnle *et al.*, 2007). An estimate of 343 spawning adults per year is available for the Altamaha River, GA, based on fishery-independent data collected in 2004 and 2005 (Schueller and Peterson 2006). Using the data collected from the Hudson and Altamaha Rivers to estimate the total number of Atlantic sturgeon in either subpopulation is not possible, since mature Atlantic sturgeon may not spawn every year (Vladykov and Greeley 1963; Smith 1985; Van Eenennaam *et al.* 1996; Stevenson and Secor 1999; Collins *et al.* 2000; Caron *et al.* 2002), the age structure of these populations is not well understood, and stage-to-stage survival is unknown. In other words, the information that would allow us to take an estimate of annual spawning adults and expand that estimate to an estimate of the total number of individuals (e.g., yearlings, subadults, and adults) in a population is lacking. The ASSRT presumed that the Hudson and Altamaha rivers had the most robust of the remaining U.S. Atlantic sturgeon spawning populations and concluded that the other U.S. spawning populations were likely less than 300 spawning adults per year (ASSRT 2007).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NEFSC developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (see Kocik *et al.* 2013). The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (see Table 8 and Table 9). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the United States Fish and Wildlife Service (USFWS) sturgeon tagging database[8], and federal fishery discard estimates from 2006 to 2010 to produce a virtual population.

In additional to the ASPI, a population estimate was derived from the Northeast Area Monitoring and Assessment Program (NEAMAP) (Table 8 and Table 9). NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall and spring. Fall surveys have been ongoing since 2007 and spring surveys since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

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8 The USFWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag, release, and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

Table 8: Description of the ASPI model and NEAMAP survey based area estimate method

Model Name	Model Description
A. ASPI	Uses tag-based estimates of recapture probabilities from 1999 to 2009. Natural mortality based on Kahnle *et al.* (2007) rather than estimates derived from tagging model. Tag recaptures from commercial fisheries are adjusted for non-reporting based on recaptures from observers and researchers. Tag loss assumed to be zero.
B. NEAMAP Swept Area	Uses NEAMAP survey-based swept area estimates of abundance and assumed estimates of gear efficiency. Estimates based on average of ten surveys from fall 2007 to spring 2012.

Table 9: Modeled Results

Model Run	**Model Years**	**95% low**	**Mean**	**95% high**
A. ASPI	1999-2009	165,381	417,934	744,597
B.1 NEAMAP Survey, swept area assuming 100% efficiency	2007-2012	8,921	33,888	58,856
B.2 NEAMAP Survey, swept area assuming 50% efficiency	2007-2012	13,962	67,776	105,984
B.3 NEAMAP Survey, swept area assuming 10% efficiency	2007-2012	89,206	338,882	588,558

The information from the NEAMAP survey can be used to calculate minimum swept area population estimates within the strata swept by the survey. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 10). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e. net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e. net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species. The ratio of total sturgeon habitat to area sampled by the NEAMAP survey is unknown, but is certainly greater than one (i.e. the NEAMAP survey does not survey 100% of the Atlantic sturgeon habitat).

Table 10: Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall from the Northeast Area Monitoring and Assessment Program survey. Estimates assume 100% net efficiencies. Estimates provided by Dr. Chris Bonzek (VIMS)

Year	Fall Number	CV	Spring Number	CV
2007	6,981	0.015		
2008	33,949	0.322	25,541	0.391
2009	32,227	0.316	41,196	0.353
2010	42,164	0.566	52,992	0.265
2011	22,932	0.399	52,840	0.480
2012			28,060	0.652

Available data do not support estimation of true catchabilty (i.e., net efficiency X availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, the NEAMAP swept area biomass estimates were produced and presented in Kocik *et al.* (2013) for catchabilities from 5 to 100%. In estimating the efficiency of the sampling net, we consider the likelihood that an Atlantic sturgeon in the survey area is likely to be captured by the trawl. Assuming the NEAMAP surveys have been 100% efficient would require the unlikely assumption that the survey gear captures all Atlantic sturgeon within the path of the trawl and all sturgeon are within the sampling area of the NEAMAP survey. In estimating the fraction of the Atlantic sturgeon population within the sampling area of the NEAMAP, we consider that the NEAMAP-based estimates do not include young of the year fish and juveniles in the rivers where the NEAMAP survey does not sample. Although the NEAMAP surveys are not conducted in the Gulf of Maine or south of Cape Hatteras, NC, the NEAMAP surveys are conducted from Cape Cod to Cape Hatteras at depths up to 18.3 meters (60 feet), which includes the preferred depth ranges of subadult and adult Atlantic sturgeon. NEAMAP surveys take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. The NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon based on sampling in a large portion of the marine range of the five DPSs, in known sturgeon coastal migration areas during times that sturgeon are expected to be migrating north and south.

Based on the above, we consider that the NEAMAP samples an area utilized by Atlantic sturgeon, but does not sample all the locations and times where Atlantic sturgeon are present and the trawl net captures some, but likely not all, of the Atlantic sturgeon present in the sampling area. Therefore, we assumed that net efficiency and the fraction of the population exposed to the NEAMAP survey in combination result in a 50% catchability. The 50% catchability assumption seems to reasonably account for the robust, yet not complete sampling of the Atlantic sturgeon oceanic temporal and spatial ranges and the documented high rates of encounter with NEAMAP survey gear and Atlantic sturgeon.

The ASPI model projects a mean population size of 417,934 Atlantic sturgeon and the NEAMAP Survey projects mean population sizes ranging from 33,888 to 338,882 depending on the assumption made regarding efficiency of that survey (see Table 9). The ASPI model uses estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U. S. Fish and Wildlife Service (USFWS) sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The NEAMAP estimate, in contrast, does not depend on as many assumptions. For the purposes of this Opinion, we consider the NEAMAP estimate resulting from the 50% catchability rate, as the best available information on the number of subadult and adult Atlantic sturgeon in the ocean.

The ocean population abundance of 67,776 fish estimated from the NEAMAP survey assuming 50% efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence (Table 11) in the sampled area. Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

*Table 11: Summary of calculated population estimates based upon the NEAMAP Survey swept area**

DPS	**Estimated Ocean Population Abundance**	**Estimated Ocean Population of Adults**	**Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)**
GOM	7,455	1,864	5,591
NYB**	34,566	8,642	25,925
CB	8,811	2,203	6,608
Carolina	1,356	339	1,017
SA	14,911	3,728	11,183
Canada	678	170	509

* Summary of calculated population estimates based upon the NEAMAP Survey swept area assuming 50% efficiency (based on net efficiency and area sampled) derived from applying the Mixed Stock Analysis to the total estimate of Atlantic sturgeon in the Ocean and the 1:3 ratio of adults to subadults)

** Genetic testing conducted on Atlantic sturgeon sampled by the NEFOP indicates that approximately 91% of the NYB Atlantic Sturgeon originate from the Hudson River.

The ASMFC released a new Atlantic sturgeon stock assessment in October 2017. The assessment used both fishery-dependent and fishery-independent data, as well as biological and life history information. Fishery-dependent data came from commercial fisheries that formerly targeted Atlantic sturgeon (before the moratorium), as well as fisheries that catch sturgeon incidentally. Fishery-independent data were collected from scientific research and survey programs.

Table 12: Stock status determination for the coastwide stock and DPSs (from ASMFC's Atlantic Sturgeon Stock Assessment Overview, October 2017)

	Mortality Status	Biomass/Abundance Status	
Population	Probability that $Z > Z_{50\%EPR}$ 80%	Relative to Historical Levels	Average probability of terminal year of indices > 1998* value
Coastwide	7%	Depleted	95%
Gulf of Maine	74%	Depleted	51%
New York Bight	31%	Depleted	75%
Chesapeake Bay	30%	Depleted	36%
Carolina	75%	Depleted	67%
South Atlantic	40%	Depleted	Unknown (no suitable indices)

*For indices that started after 1998, the first year of the index was used as the reference value.

At the coastwide and DPS levels, the stock assessment concluded that Atlantic sturgeon are depleted relative to historical levels. The low abundance of Atlantic sturgeon is not due solely to effects of historic commercial fishing, so the 'depleted' status was used instead of 'overfished.' This status reflects the array of variables preventing Atlantic sturgeon recovery (e.g., bycatch, habitat loss, and ship strikes).

As described in the Assessment Overview, Table 12 shows "the stock status determination for the coastwide stock and DPSs based on mortality estimates and biomass/abundance status relative to historic levels, and the terminal year (i.e., the last year of available data) of indices relative to the start of the moratorium as determined by the ARIMA[9] analysis."

Despite the depleted status, the assessment did include signs that the coastwide index is above the 1998 value (95% chance). The Gulf of Maine DPS, New York Bight DPS, and Carolina DPS indices also all had a greater than 50% chance of being above their 1998 value; however, the index from the Chesapeake Bay DPS (highlighted red) only had a 36% chance of being above the 1998 value. There were no representative indices for the South Atlantic DPS. Total mortality from the tagging model was very low at the coastwide level. Small sample sizes made mortality estimates at the DPS level more difficult. The New York Bight, Chesapeake Bay, and South Atlantic DPSs all had a less than 50% chance of having a mortality rate higher than the threshold. The Gulf of Maine and Carolina DPSs (highlighted red) had 74-75% probability of being above the mortality threshold (ASMFC 2017).

[9] "The ARIMA (Auto-Regressive Integrated Moving Average) model uses fishery-independent indices of abundance to estimate how likely an index value is above or below a reference value" (ASMFC 2017).

4.4.4 Threats faced by Atlantic sturgeon throughout their range

Atlantic sturgeon are susceptible to over exploitation given their life history characteristics (e.g., late maturity, dependence on a wide-variety of habitats). Similar to other sturgeon species (Vladykov and Greeley, 1963; Pikitch *et al.*, 2005), Atlantic sturgeon experienced range-wide declines from historical abundance levels due to overfishing (for caviar and meat) and impacts to habitat in the 19th and 20th centuries (Taub, 1990; Smith and Clugston, 1997; Secor and Waldman, 1999).

Because a DPS is a group of populations, the stability, viability, and persistence of individual populations that make up the DPS can affect the persistence and viability of the larger DPS. The loss of any population within a DPS could 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) loss of unique haplotypes; (5) loss of adaptive traits; and (6) reduction in total number. The persistence of individual populations, and in turn the DPS, depends on successful spawning and rearing within the freshwater habitat, emigration to marine habitats to grow, and return of adults to natal rivers to spawn.

Based on the best available information, we have concluded that unintended catch of Atlantic sturgeon in fisheries, vessel strikes, poor water quality, water availability, dams, lack of regulatory mechanisms for protecting the fish, and dredging are the most significant threats to Atlantic sturgeon (77 FR 5880 and 77 FR 5914; February 6, 2012). While all of the threats are not necessarily present in the same area at the same time, given that Atlantic sturgeon subadults and adults use ocean waters from the Labrador, Canada to Cape Canaveral, FL, as well as estuaries of large rivers along the U.S. East Coast, activities affecting these water bodies are likely to impact more than one Atlantic sturgeon DPS. In addition, given that Atlantic sturgeon depend on a variety of habitats, every life stage is likely affected by one or more of the identified threats.

An ASMFC interstate fishery management plan for sturgeon (Sturgeon FMP) was developed and implemented in 1990 (Taub, 1990). In 1998, the remaining Atlantic sturgeon fisheries in U.S. state waters were closed per Amendment 1 to the Sturgeon FMP. Complementary regulations were implemented by NMFS in 1999 that prohibit fishing for, harvesting, possessing or retaining Atlantic sturgeon or its parts in or from the Exclusive Economic Zone in the course of a commercial fishing activity.

Commercial fisheries for Atlantic sturgeon still exist in Canadian waters (DFO, 2011). Sturgeon belonging to one or more of the DPSs may be harvested in the Canadian fisheries. In particular, the Bay of Fundy fishery in the Saint John estuary may capture sturgeon of U.S. origin given that sturgeon from the Gulf of Maine and the New York Bight DPSs have been incidentally captured in other Bay of Fundy fisheries (DFO, 2011; Wirgin and King, 2011). Because Atlantic sturgeon are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES), the U.S. and Canada are currently working on a conservation strategy to address the potential for captures of U.S. fish in Canadian directed Atlantic sturgeon fisheries and of Canadian fish incidentally in U.S. commercial fisheries. At this time, there are no estimates of the number of individuals from any of the DPSs that are captured or killed in Canadian fisheries each year.

Based on geographic distribution, most U.S. Atlantic sturgeon that are intercepted in Canadian fisheries are likely to originate from the Gulf of Maine DPS, with a smaller percentage from the New York Bight DPS.

Individuals from all 5 DPSs are caught as bycatch in fisheries operating in U.S. waters. At this time, we have an estimate of the number of Atlantic sturgeon captured and killed in sink gillnet and otter trawl fisheries authorized by Federal FMPs (NEFSC 2011) in the Northeast Region but do not have a similar estimate for Southeast fisheries. We also do not have an estimate of the number of Atlantic sturgeon captured or killed in state fisheries. At this time, we are not able to quantify the effects of other significant threats (e.g., vessel strikes, poor water quality, water availability, dams, and dredging) in terms of habitat impacts or loss of individuals. While we have some information on the number of mortalities that have occurred in the past in association with certain activities (e.g., mortalities in the Delaware and James rivers that are thought to be due to vessel strikes), we are not able to use those numbers to extrapolate effects throughout one or more DPS. This is because of (1) the small number of data points and, (2) lack of information on the percent of incidences that the observed mortalities represent.

As noted above, the NEFSC prepared an estimate of the number of encounters of Atlantic sturgeon in fisheries authorized by Northeast FMPs (NEFSC 2011). The analysis prepared by the NEFSC estimates that from 2006 through 2010 there were 2,250 to 3,862 encounters per year in observed gillnet and trawl fisheries, with an average of 3,118 encounters. Mortality rates in gillnet gear are approximately 20%. Mortality rates in otter trawl gear are believed to be lower at approximately 5%.

Based on the results of our NEFSC's climate vulnerability analysis, diadromous fish are amongst the functional groups with the highest overall climate vulnerability (data quality is moderate; Hare *et al.* 2016a). Specifically, the overall vulnerability of Atlantic sturgeon to climate change is very high (Hare *et al.*, 2016a). The contributing factors to climate exposure included ocean surface temperature, air temperature and ocean acidification, and contributing biological sensitivity attributes included stock status, population growth rate, habitat specialization, and dispersal and early life history (Hare *et al.*, 2016a). Hare *et al.* (2016a) noted some of the following studies related to climate change effects on abundance and distribution: 1) juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature (Secor and Gunderson; 1998); and 2) a 1^{o}C temperature increase reduced productivity by 65% when a multivariable bioenergetics and survival model was used to generate spatially explicit maps of potential production in the Chesapeake Bay (Niklitschek and Secor, 2005). We further discuss the effects of climate change below in Section 6.0.

4.5 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine DPS includes the following: all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, MA. Within this range, Atlantic sturgeon historically spawned in at least the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT, 2007). Spawning habitat is available and accessible in the Penobscot, Androscoggin, Kennebec, Merrimack, and Piscataqua (inclusive of the

Cocheco and Salmon Falls rivers) rivers. Spawning has been documented in the Kennebec River. In the Androscoggin River, captures of adult Atlantic sturgeon, including a ripe male, over suitable spawning grounds during the spawning season confirm likely spawning; however Atlantic sturgeon eggs and larvae have not yet been recovered in the Androscoggin (Wippelhauser pers. comm. 2018). Despite the availability of suitable habitat and the presence of Atlantic sturgeon in the remaining rivers, there is currently no evidence spawning activity in these rivers.

Studies are on-going to determine whether Atlantic sturgeon are spawning in these rivers. Atlantic sturgeons that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT, 2007). The movement of subadult and adult sturgeon between rivers, including to and from the Kennebec River and the Penobscot River, demonstrates that coastal and marine migrations are key elements of Atlantic sturgeon life history for the Gulf of Maine DPS as well as likely throughout the entire range (ASSRT, 2007; Fernandes, *et al.* 2010).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (Squiers *et al.*, 1981; ASMFC, 1998; NMFS and USFWS, 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) capture of 31 adult Atlantic sturgeon from June 15, 1980, through July 26, 1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least 4 ripe males and 1 ripe female captured on July 26,1980; and, (3) capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, ME (NMFS and USFWS, 1998; ASMFC 2007). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Several threats play a role in shaping the current status of Gulf of Maine DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17^{th} century (Squiers *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon by-catch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries occurring in state and federal waters still occurs. In the marine range, Gulf of Maine DPS Atlantic sturgeon are incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast FMPs. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the Gulf of Maine DPS have navigation channels that are maintained by dredging. Dredging outside of Federal channels and in-water construction occurs throughout the Gulf of Maine DPS. While some dredging projects operate with observers present to document fish mortalities, many do not. To date we have not received any reports of Atlantic sturgeon killed during dredging projects in the Gulf of Maine region; however, as noted above, not all projects are monitored for interactions with fish. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects. We are also not able to quantify any effects to habitat.

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin and Saco Rivers, these dams are near the site of natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon are known to occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. While not expected to be killed or injured during passage at a dam, the extent that Atlantic sturgeon are affected by the existence of dams and their operations in the Gulf of Maine region is currently unknown. The tracking of spawning condition Atlantic sturgeon downstream of the Brunswick Dam in the Androscoggin River suggests however, that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. Until it was breached in July 2013, the range of Atlantic sturgeon in the Penobscot River was limited by the presence of the Veazie Dam. Since the removal of the Veazie Dam and the Great Works Dam, sturgeon can now travel as far upstream as the Milford Dam. While Atlantic sturgeon are known to occur in the Penobscot River, there is no evidence of spawning currently occurring. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. Like the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning occurring in this river.

Gulf of Maine DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006; EPA, 2008). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from industrial discharges from pulp and paper mills. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds as developing eggs and larvae are particularly susceptible to exposure to contaminants.

Other than the ASPI and NEAMAP based estimates presented above, there are no empirical abundance estimates for the Gulf of Maine DPS. The Atlantic sturgeon SRT (2007) presumed that the Gulf of Maine DPS was comprised of less than 300 spawning adults per year, based on abundance estimates for the Hudson and Altamaha River riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers, 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies.

Summary of the Gulf of Maine DPS

Spawning for the Gulf of Maine DPS is known to occur in two rivers (Kennebec and Androscoggin). Spawning may be occurring in other rivers, such as the Penobscot, but has not been confirmed. There are indications of increasing abundance of Atlantic sturgeon belonging to the Gulf of Maine DPS. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., the Saco, Presumpscot, and Charles rivers). These observations suggest that abundance of the Gulf of Maine DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the Gulf of Maine DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999). There are strict regulations on the use of fishing gear in Maine state waters that incidentally catch sturgeon. In addition, there have been reductions in fishing effort in state and federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC, 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, MA, with only 8 percent (e.g., 7 of the 84 fish) of interactions observed in the Mid Atlantic/Carolina region being assigned to the Gulf of Maine DPS (Wirgin and King, 2011). Tagging results also indicate that Gulf of Maine DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south. However, data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35 percent originated from the Gulf of Maine DPS (Wirgin *et al.*, in draft).

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman, 1997; ASMFC, 2007; Kahnle *et al.*, 2007; Brown and Murphy, 2010). We have determined that the Gulf of Maine DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

4.6 Critical Habitat Designated for the GOM DPS of Atlantic Sturgeon

On August 17, 2017, we issued a final rule to designate critical habitat for the threatened Gulf of Maine DPS of Atlantic sturgeon, the endangered New York Bight DPS of Atlantic sturgeon, the endangered Chesapeake Bay DPS of Atlantic sturgeon, the endangered Carolina DPS of Atlantic sturgeon, and the endangered South Atlantic DPS of Atlantic sturgeon (82 FR 39160).
The rule was effective on September 18, 2017. The action area overlaps with the Androscoggin River critical habitat unit designated for the Gulf of Maine DPS.

The conservation objective identified in the final rule is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. We designated five critical habitat units to achieve this objective for the Gulf of Maine DPS: (1) Penobscot River main stem from the Milford Dam downstream for 53 river kilometers (rkms) to where the main stem river discharges at its mouth into Penobscot Bay; (2) Kennebec River main stem from the Ticonic Falls/Lockwood Dam downstream for 103 rkms to where the main stem river discharges at its mouth into the Atlantic Ocean; (3) Androscoggin River main stem from the Brunswick Dam downstream for 10 rkms to where the main stem river discharges at its mouth into Merrymeeting Bay; (4) Piscataqua River from its confluence with the Salmon Falls and Cocheco rivers downstream for 19 rkms to where the main stem river discharges at its mouth into the Atlantic Ocean as well as the waters of the Cocheco River from its confluence with the Piscataqua River and upstream 5 rkms to the Cocheco Falls Dam, and waters of the Salmon Falls River from its confluence with the Piscataqua River and upstream 6 rkms to the Route 4 Dam; and, (5) Merrimack River from the Essex Dam (also known as the Lawrence Dam) downstream for 48 rkms to where the main stem river discharges at its mouth into the Atlantic Ocean. In total, these designations encompass approximately 244 kilometers (152 miles) of aquatic habitat.

As identified in the final rule, the physical features that are essential to the conservation of the species and that may require special management considerations or protection are:

1) Hard bottom substrate (*e.g.*, rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.*, 0.0 to 0.5 parts per thousand (ppt) range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
2) Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.*, sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;
3) Water of appropriate depth and absent physical barriers to passage (*e.g.*, locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support:
   (i) Unimpeded movement of adults to and from spawning sites;
   (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and
   (iii) Staging, resting, or holding of subadults or spawning condition adults.

   Water depths in main river channels must also be deep enough (*e.g.*, at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.

4) Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support:
   (i) Spawning;
   (ii) Annual and interannual adult, subadult, larval, and juvenile survival; and
   (iii) Larval, juvenile, and subadult growth, development, and recruitment (*e.g.*,13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and 6 milligrams per liter (mg/L) dissolved oxygen (DO) or greater for juvenile rearing habitat).

The paragraphs that follow are excerpted from the ESA Section 4(b)(2) Report for Atlantic sturgeon critical habitat (NMFS 2017). That document provides background information on the current status and function of the four critical habitat units designated for the Gulf of Maine DPS, and summarizes their ability to support reproduction, survival, and juvenile development, and recruitment. Additional information on the status of the Gulf of Maine DPS relevant to the current status and function of critical habitat can be found in Section 4.5.

> The Kennebec River was the only known spawning river for the Gulf of Maine DPS when the DPS was listed as threatened (ASSRT, 2007; 77 FR 5880, February 6, 2012). Spawning has since been confirmed in the Androscoggin River (Wippelhauser, 2012). The Brunswick Dam is the upstream limit of Atlantic sturgeon distribution in the Androscoggin River, and the likely historical upstream limit given the dam is built at the head of tide at Pejepscot Falls, a natural barrier to sturgeon passage. The Brunswick Dam is located approximately 10 RKMs upstream of the confluence of the Kennebec and Androscoggin rivers (ASMFC, 1998; ASSRT, 2007; NMFS, 2013; Wippelhauser and Squiers, 2015). The Lockwood Dam at RKM 103 is the current upstream limit for Atlantic sturgeon in the Kennebec River and is also located at the site of a natural falls; considered the historic upstream limit for Atlantic sturgeon on the River (ASSRT, 2007). From 1837 to 1999, the Edwards Dam was the upstream limit of Atlantic sturgeon in the Kennebec River. Located near the head of tide, approximately 29 RKMs downstream of the Lockwood Dam, the Edwards Dam (formerly at RKM 74) prevented Atlantic sturgeon from accessing historical habitat. Sturgeon were sighted above the former Edwards Dam site after removal of the dam. In June 2005, an Atlantic sturgeon was incidentally captured as far upriver as RKM 102 (ASSRT, 2007; Wippelhauser, 2012).
>
> Substrate type in the Kennebec estuary is largely sand and bedrock (Fenster and Fitzgerald 1996; Moore and Reblin, 2008). Mesohaline waters occur upstream of Doubling Point (approximately RKM 16) during summer low flows, transitioning to oligohaline waters and then essentially tidal freshwater from Chops Point (the outlet of Merrymeeting Bay at approximately RKM 30) 10 upriver to the head of tide on the Kennebec and Androscoggin rivers (ASMFC, 1998; Kistner and Pettigrew, 2001; Moore and Reblin; 2008; Wippelhauser, 2012).
>
> During the period 1977-2001, Atlantic sturgeon in spawning condition (i.e., ripe males releasing milt) or of size presumed to be sexually mature adults (i.e., > 150 centimeter

total length) were caught between RKM 52.8 and RKM 74 of the Kennebec River during the months of June and July, the likely spawning season. From 2009 to 2011, 31 Atlantic sturgeon, including 6 ripe males, were caught in the Kennebec River between RKM 70 and RKM 75 (Wippelhauser, 2012; Wippelhauser and Squiers, 2015). Sturgeon in the Upper Kennebec Estuary (defined as RKM 45 to RKM 74 at head of tide in the cited document) repeatedly moved between RKM 48 and RKM 75 (Wippelhauser, 2012). An additional eight sturgeon, including one ripe male, were caught in the Androscoggin in June and July of 2009-2011 (Wippelhauser, 2012). Three larvae were captured in the Upper Kennebec Estuary, 1 to 1.6 RKMs upstream of the former Edwards Dam site (RKM 74) (Wippelhauser, 2012).

Merrymeeting Bay and the Lower Kennebec Estuary were used by post-spawn adults, juveniles, and other life stages at least as late as November 7. Tagging detections the following spring suggest that some subadult Atlantic sturgeon may have overwintered in Merrymeeting Bay (Wippelhauser, 2012). Sturgeon captured and tagged in the Saco and Penobscot rivers were also detected in the Kennebec Estuary, typically Merrymeeting Bay and downstream locations, although at least one male, captured in the Saco in 2010, was the single ripe male also captured in the Androscoggin (Wippelhauser, 2012). Genetic information to identify this Atlantic sturgeon to the river of origin is not available.

The Penobscot River estuary is about 51 RKMs long from the head of tide to Searsport, ME. During spring freshets tidal freshwater extends to Winterport (RKM 29), and during low flow months the salt front extends upstream as far as Hamden (RKM 40) (ASMFC, 1998). The two lowermost dams on the Penobscot River, Great Works Dam and Veazie Dam (at RKM 56), were removed in 2012 and 2013, respectively, opening up all known historical Atlantic sturgeon habitat in the Penobscot River, and access to more of the tidal freshwater habitat.

The upper part of the Penobscot River estuary (RKM 34 to RKM 43) is characterized as freshwater, with depths of 2.5 – 9 meters depending on tide and position in the river, and are predominantly cobble and gravel substrate. The middle part (RKM 26 to RKM 31) has an average water depth of 7.5 meters with maximum salinity of 2.5 ppt (i.e., oligohaline waters) in June, and muddy substrate with high levels of organic matter (mostly decaying wood chips and sawdust), whereas the lower part of the estuary (RKM 21 to RKM 24) has salinities of approximately 15 ppt during summer, and a predominance of sand substrate (Dzaugis, 2013).

The Piscataqua River is formed by the confluence of the Salmon Falls and Cocheco Rivers, and is part of the Great Bay Estuary. The Piscataqua River is tidal throughout it length, approximately 21 RKMs, to its mouth at Portsmouth Harbor. Head of tide occurs upriver of the confluence, at the location of the lowermost dams on the Salmon Falls and Cocheco Rivers (Short, 1992; SBCC, 2009). Salinity of the Piscataqua River ranges from polyhaline at the mouth of the river to oligohaline at the head of tide on the Salmon Falls and Cocheco rivers. Overall, the estuary is heavily influenced by the tidal flow. Dissolved oxygen is typically above 6.0 mg/L, and is very consistent throughout the water column in the Piscataqua River. The average depth at mid-tide is approximately 3.2 meters although this varies with both tide and topography. Substrate varies from soft mud to hard sand to gravel. (Short, 1992; ASMFC, 1998; Trowbridge, 2007). The 2007 Atlantic sturgeon status review provided information on directed effort to catch Atlantic sturgeon in the Piscataqua River, and incidental capture of a large, ripe female Atlantic sturgeon near the head of tide in the Salmon Falls River in 1990. Between 2010 and 2016, three Atlantic sturgeon were detected in the Piscataqua River using passive acoustic array (M. Kieffer, USGS, pers. comm.). There are no current directed studies for Atlantic sturgeon in the Piscataqua River or Great Bay Estuary other than the use of the passive acoustic receivers for a part of the year in some areas of the river.

In the 1800s, construction of the Essex Dam on the Merrimack River (at RKM 48) blocked Atlantic sturgeon access to about 58 percent of historical habitat (ASMFC, 1998; Oakley, 2003; ASSRT, 2007). Tidal influence extends to RKM 35. The salt front extends upriver to RKM 16 in summer at the lowest river discharges (Kieffer and Kynard 1993; ASMFC, 1998). The non-tidal section is dominated by sand and gravel and depths less than three meters. Thus, there is approximately 19 RKMs of tidal freshwater and 11 RKMs of freshwater habitat available for the early life stages of Atlantic sturgeon during the summer months. Atlantic sturgeon are regularly present in the Merrimack River. Although there are no recent reports of Atlantic sturgeon spawning in the Merrimack River, the success of shortnose sturgeon spawning in the river suggests Atlantic sturgeon spawning would be successful as well.

While there is no current evidence that Atlantic sturgeon are spawning in Gulf of Maine rivers other than the Kennebec and Androscoggin, captures of sturgeon in the Merrimack, Penobscot and Piscataqua/Salmon Falls/Cocheco rivers indicate that there is the potential for spawning to occur in these rivers.

Gulf of Maine DPS Atlantic sturgeon travel great distances in the marine environment, and their marine range includes waters under Canadian jurisdiction. Genetics information is available for Atlantic sturgeon captured in six specific areas of their marine range: Bay of Fundy, Connecticut River estuary and Long Island Sound, New York and New Jersey coast, Delaware coast, Long Island coast off of Rockaway, New York, and waters off of the Virginia/North Carolina border. The Gulf of Maine DPS comprised 0 to 14.5 percent of Atlantic sturgeon sampled in these areas with the exception of the Bay of Fundy collection where the Gulf of Maine DPS comprised 35 percent of the Atlantic sturgeon sampled (Laney *et al.*, 2007; Dunton *et al.*, 2012; Wirgin *et al.*, 2012; Waldman *et al.*, 2013; O'Leary *et al.*, 2014; Wirgin *et al.*, 2015a). The greater concentration of Gulf of Maine DPS Atlantic sturgeon in some parts of its marine range suggests certain marine habitats are more useful to and perhaps also essential to the Gulf of Maine DPS. As previously noted, we cannot designate critical habitat in areas outside of U.S. jurisdiction.

The action area for the proposed work considered in this Opinion covers approximately 27.4 acres of the Androscoggin River critical habitat unit. The critical habitat designation is bank-to-bank within the Androscoggin River. The action area is only a 1.2 rkm stretch in the freshwater reaches of the Androscoggin. It contains all three of the four PBFs; it does not contain PBF 2, aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.,* sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development. Information on the PBFs within the action area is contained in the Environmental Baseline section below (section 5.7).

5.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal 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 (50 CFR 402.02). The environmental baseline for this Opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: dredging operations, actions that impact water quality, scientific research, shipping and other vessel traffic, fisheries, and recovery activities associated with reducing those impacts.

5.1 Brunswick Dam

On July 19, 2013, we issued an Opinion to FERC on the impacts to listed species from operations of the Brunswick Hydroelectric Project pursuant to the terms of an Interim Species Protection Plan (ISPP) and associated license amendment proposed for implementation by FERC and FPL Energy Maine Hydro LLC for the Brunswick and Lewiston Falls Projects on the Androscoggin River. The purpose of the ISPP is to collect information on passage efficiency and survival of Atlantic salmon adults and smolts attempting to migrate past the Projects. Lewiston Falls does not have fishways, so passage efficiency studies were not proposed at that project. The ITS of the Opinion authorized take for the proposed studies, as well as for the effects of ongoing operations at the Project. The ISPP, and the Opinion, have a seven-year term (2013-2019), after which the Opinion and ITS will no longer be valid. At that point (2019), FPL Energy will put together a final SPP that contains additional protection measures for listed fish, and FERC will reinitiate formal consultation in order to obtain take authorization for the remainder of the projects' license terms. We concluded that the proposed action was not likely to jeopardize the continued existence of listed Atlantic salmon, Atlantic sturgeon, or shortnose sturgeon. The ITS accompanying the Opinion exempted incidental take for upstream and downstream fish passage studies, as well as for the operation of the Project over the term of the ISPP. It is anticipated that 61% of the salmon that are motivated to pass the Brunswick Project are expected to do so successfully but will be collected, captured, and trapped; 38.6% will be harassed as they will not be able to access potentially suitable spawning habitat upstream of the Project; and 0.4% will die. It is also expected that project operations will result in the injury or death of up to 7% of the total number of smolts in the project area and 15% of all kelts in the project area. At the Lewiston Falls Project, it is anticipated that one salmon could be stranded downstream of the Project during the period of the ISPP. This authorization expires at the end of the proposed ISPP (2019). The ITS also exempted incidental take of four trapped shortnose sturgeon and Atlantic sturgeon (four in the fishway and four stranded) at the Lockwood Project (license expires in 2036), and another four trapped of each species (four in the fishway and four stranded) at the Brunswick Project (license expires in 2029). Neither mortality nor major injuries of any sturgeon is anticipated or exempted.

5.2 Scientific Studies

MDMR is authorized under the USFWS' endangered species blanket permit (No. 697823) to conduct monitoring, assessment, and habitat restoration activities for listed Atlantic salmon populations in Maine. The extent of take from MDMR activities during any given year is not expected to exceed 2% of any life stage being impacted; for adults, it would be less than 1%. MDMR will continue to conduct Atlantic salmon research and management activities in the GOM DPS while the proposed action is carried out. The information gained from these activities will be used to further salmon conservation actions.

USFWS is also authorized under an ESA section 10 endangered species blanket permit to conduct the conservation hatchery program at the Craig Brook and Green Lake National Fish Hatcheries. The mission of the hatcheries is to raise Atlantic salmon parr and smolts for stocking into selected Atlantic salmon rivers in Maine. Over 90% of adult returns to the GOM DPS are currently provided through production at the hatcheries. Approximately 1,000 fry are stocked annually in the Androscoggin River. The hatcheries provide a significant buffer from extinction for the species.

The University of Maine holds a scientific research permit (No. 20347) to capture, tag, and sample genetic material from shortnose sturgeon and Atlantic sturgeon from 2017-2027. The University proposes to:

1. Combine acoustic telemetry, blood analysis, genetics and scute spine analysis to determine spawning periodicity for each sex and species and river of origin;
2. Compare aging of fin spines/rays and scute spines to determine if scute spines are an alternate means of ageing fish (fish (hereafter we refer to the first marginal pectoral-fin ray as a "fin spine" and the remainder as "fin rays"); and
3. Use mark-recapture and acoustic telemetry to identify critical habitat for juveniles, estimate annual juvenile recruitment, and movement within and between river systems.

Across Gulf of Maine rivers and coastal marine habitat, their objectives for Atlantic sturgeon include capturing a maximum of 845 adults/subadults, 138 juveniles, and 200 early life stages (ELS; eggs and larvae). All adults, subadults, and juveniles will be weighed, measured, examined for tags, examined with a borescope when appropriate, marked with PIT tags and T-bar or Floy tags, photographed, and sampled for genetic material (i.e. a fin clip) and blood prior to being released. Their objectives for shortnose sturgeon include capturing a maximum of 1,535 adults, 189 juveniles, and 210 ELS. All adults, sub-adults, and juveniles will be weighed, measured, examined for tags, examined with a borescope when appropriate, marked with PIT tags and T-bar or Floy tags, photographed, and sampled for genetic material (i.e. a fin clip) and blood prior to being released (hereafter "basic processing").

Specific to the Kennebec River System (including the Androscoggin River and the action area), they propose to capture and handle as many as 200 Atlantic sturgeon (all DPSs) and 400 shortnose sturgeon. They also propose to capture 100 Atlantic sturgeon eggs/larvae from the GOM DPS and 50 shortnose sturgeon eggs/larvae, resulting in mortality. Over the lifetime of the permit, they also expect the unintentional mortality of one Atlantic sturgeon adult/subadult (all DPSs), one Atlantic sturgeon juvenile (all DPSs), two shortnose sturgeon adults, and two shortnose sturgeon juveniles.

5.3 State or Private Activities in the Action Area

5.3.1 State of Maine stocking program

Competitive interactions between wild Atlantic salmon and other salmonid fishes, especially introduced species, are not well understood and in Maine. State managed programs supporting recreational fisheries often include stocking non-indigenous salmonid fish into rivers containing anadromous Atlantic salmon. Interactions between wild Atlantic salmon and other salmonids include; indigenous brook trout (*Salvelinus fontinalis*) and landlocked Atlantic salmon (*Salmo salar sebago*) and hatchery reared non-indigenous brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Competition plays an important role in habitat use by defining niches that are desirable for optimal feeding, sheltering and spawning. Limited resources may also increase competitive interactions which may act to limit the time and energy fish can spend obtaining nutrients essential to survival. This is most noticeable shortly after fry emerge from redds, when fry densities are at their highest (Hearn 1987) and food availability is limited. Prior residence of wild salmonids may infer a competitive advantage during this time over domesticated hatchery juveniles (Letcher 2002; Metcalfe 2003); even though the hatchery reared individuals may be larger (Metcalfe 2003). This may limit the success of hatchery cohorts stocked annually to support the recovery of Atlantic salmon. Annual population assessments and smolt trapping estimates conducted on GOM DPS rivers indicates stocking of hatchery reared Atlantic salmon fry and parr in areas where wild salmon exist could limit natural production and may not increase the overall population level in freshwater habitats. The amount of quality habitat available to wild Atlantic salmon may also increase inter and intra-specific interactions between species due to significant overlap of habitat use during periods of poor environmental conditions such as during drought or high water temperatures. These interactions may impact survival and cause Atlantic salmon, brook and brown trout populations to fluctuate from year to year. However, since brook trout and Atlantic salmon co-evolved, wild populations should be able to co-exist with minimal long-term effects (Hearn 1987; Fausch 1988). Domesticated Atlantic salmon produced by the commercial aquaculture industry that escape from hatcheries or net pens also compete with wild Atlantic salmon for food, space and mates.

5.3.2 Private Recreational Boating and Fishing

The boat launch MaineDOT has proposed to use for launching project vessels is a public boat launch for recreational boating at the end of Water Street in Brunswick. According to the Brunswick Parks and Recreation Department (pers. comm. March 28, 2018), this boat launch is a paved facility with a float system for motorized boats and an additional float for members of the Merrymeeting Community Rowing Association. The parking area accommodates 13 vehicles with rigs, and may be at capacity in the spring during heavy runs of striped bass; however, this has not been the case in recent years, and during peak summer use, they typically see between 5 and 8 vehicles with rigs in the parking lot. Users are a combination of fishermen and pleasure boaters accessing the river downstream of the existing bridge to Merrymeeting Bay.

Slightly upstream is another gravel access, hand carry launch below the intersection of Water Street and Industry Road. This launch is primarily used by individuals with canoes and kayaks. This launch area accommodates 5 vehicles at a time, but is rarely full during the peak summer season. In the winter, this location is an access point for as many as 20 smelt camps placed on the ice by local fishermen.

Therefore, based on the best available information, we estimate that from the spring through the fall, the action area may be support the use of 5-13 recreational motor boats, as well as 5 or more non-motorized recreational vessels from the two launch sites. We do not expect recreational vessels in the action area during the winter months.

5.4 Status of Atlantic Salmon and Critical Habitat in the Action Area

A summary of the status of the species rangewide and designated critical habitat in its entirety was provided above. This section will focus on the status of Atlantic salmon and designated critical habitat in the action area. The Androscoggin River watershed supports a run of Atlantic salmon and a modest fry stocking program.

The Androscoggin River originates at Umbagog Lake near Errol, New Hampshire and flows roughly 260 km past several towns including, Rumford, Dixfield, Jay, Livermore Falls, and Brunswick as well as the city of Lewiston-Auburn (MDEP 1999). The upper portions of the Androscoggin are high gradient. The Androscoggin River drops over 305 meters from its headwaters to where it meets the sea, with an average gradient of 3.9 meters per kilometer. In the Androscoggin watershed, Rumford Falls was the historic upper extent of Atlantic salmon migration, while Lewiston Falls was believed to be the upper extent of alewife and shad migrations (Foster and Atkins 1867). The Little Androscoggin River is the largest major sub-basin of the Androscoggin with historically important salmon habitat that was accessible as far up as Snow’s Falls located 3.2 km outside of West Paris (Foster and Atkins 1867). Prior to its damming, the Androscoggin River provided access to a large and diverse aquatic habitat for great numbers of diadromous and resident fish species (Foster and Atkins 1867).

5.4.1 Upstream Migrating Adults

Based on historic reports, Atlantic salmon were abundant in the Androscoggin River. Adult returns have dwindled and native stocks of Atlantic salmon are considered extirpated south of the Androscoggin River watershed. Dams, pollution, and over-fishing have contributed to the decline of Atlantic salmon in the Androscoggin River. The returns of adult Atlantic salmon to the Androscoggin River in recent years have been small, and mostly comprised of stray, hatchery origin fish from active restoration programs on other rivers (USASAC 2017, Table 13).

Table 13: Adult Atlantic salmon returns by origin to the Androscoggin River recorded from 1983 to 2016 at the Brunswick Project (USASAC 2017)

	Hatchery Origin				Wild Origin				
Androscoggin	**1SW**	**2SW**	**3SW**	**Repeat**	**1SW**	**2SW**	**3SW**	**Repeat**	**Total**
1983-2006	37	532	6	2	6	84	0	1	**668**
2007	6	11	0	0	0	2	0	0	**20**
2008	8	5	0	0	1	1	0	0	**16**
2009	2	19	0	0	2	3	0	0	**24**
2010	2	5	0	0	0	2	0	0	**9**
2011	2	27	0	0	1	14	0	0	**44**
2012	0	0	0	0	0	0	0	0	**0**
2013	0	1	0	0	0	1	0	0	**2**
2014	0	2	0	0	0	1	0	0	**3**
2015	0	0	0	0	0	1	0	0	**1**
2016	0	0	0	0	0	6	0	0	**6**
Total	**57**	**602**	**6**	**2**	**10**	**115**	**0**	**1**	**793**

Prior to 2007, MDMR stated that there were no indications that the Androscoggin River had a reproducing population of Atlantic salmon (letter from MDMR to FERC dated March 25, 2010). Documented annual runs of returning adult salmon consisted primarily (98%) of fish originating as hatchery smolts released into Maine rivers. In 2007 and 2008 several returning adults captured at the Brunswick fishway were determined to be fry-stocked or naturally reared fish. Salmon returning to the Merrymeeting Bay SHRU are generally considered naturally-reared, as production occurs primarily in the form of egg planting and fry stocking activities, in addition to a small proportion of natural reproduction. Because there is currently no reliable method to distinguish adults of natural origin versus those that were produced via egg planting or fry stocking, there is no estimate of the proportionality of those modes of production. As stocking efforts in other DPS rivers increase so does the amount of strays captured at the Brunswick Dam.

Adult Atlantic salmon are released above the Brunswick Dam to continue upstream migration after biological data (e.g., length) are collected. The mean fork length of returning adults was 603 mm in 2008 and 735 in 2009 (MDMR 2010). Several adult salmon have been captured at the Brunswick fishway with fin-clips or tags, indicating that these fish are strays or stocked landlocked salmon from other rivers (MDMR 2010). The Maine Atlantic Salmon Technical Advisory Committee (MASTAC) collects fin-clips for genetic samples in an attempt to identify the origin of returning salmon (MDMR 2010). The MASTAC plans to conduct future analyses to determine the origin of these and all other adult Atlantic salmon captured at the Brunswick fishway (MDMR 2010).

The next two dams encountered on the Androscoggin River upstream of the Brunswick Dam are the Pejepscot and Worumbo Dams. Both projects have upstream passage facilities designed for anadromous species. With passage at the first three dams on the river, Atlantic salmon have access up to Lewiston Falls (Fay *et al.* 2006, MDMR 2010). This available habitat represents approximately 27 miles of accessible water in the lower Androscoggin River from the Brunswick Project to Lewiston Falls. Atlantic salmon habitat is quantified in the GOM DPS by mapping Hydrologic Unit Codes 10 scale (HUC10) to define suitable Atlantic salmon habitat units (NMFS 2009). Each habitat unit equals 100 square meters. The Androscoggin River consists of 70,249 historic HUC10 habitat units. An estimated 24% (16,978 units) of these historic habitat units within the Androscoggin River system are considered to be occupied and occur in the lower Androscoggin River drainage (NMFS 2009). Atlantic salmon habitat quality is measured in HUC10s based on the suitability of several parameters using a scale from zero to three, which include temperature, biological communities, water quality, and substrate and cover. Low quality habitat scores have been assigned to the lower Androscoggin River where the Brunswick Project is located, while high scores were determined in the upper inaccessible reaches of the river (NMFS 2009).

Fay *et al.* (2006) report that "...practically all suitable rearing habitat in the Androscoggin River watershed is not currently accessible to Atlantic salmon." The availability of suitable spawning habitat is unknown; no documentation of successful spawning in the Androscoggin River exists although naturally reared fish have been documented to occur in the river (MDMR 2012). In 2011, HDR evaluated the spawning habitat in the Little River, 800 meters downriver of the Worumbo Project, and found numerous barriers and poor substrates. However, MDMR indicates that there is a significant amount of habitat in the Little River and that it could hold “tens of thousands of eggs” (MDMR 2012b). During the 2011 telemetry study, MDMR documented a radio tagged female Atlantic salmon moving throughout the Little River, and it is thought that it may have spawned in Gillespie Brook, one of its tributaries (MDMR 2012b). The mainstem Androscoggin River is expected to provide minimal spawning habitat due to the existing impoundments and/or unsuitable substrates. No suitable spawning habitat exists in the action area.

There have been few studies of Atlantic salmon in the Androscoggin River. In 2011, MDMR radio tagged 21 adult salmon (12 wild and 9 hatchery raised) when they were trapped at the Brunswick Dam (MDMR 2012b). 29% (6 out of 21) of these fish dropped out of the Androscoggin soon after they were released, and at least four of these continued their migration in the Kennebec River. 43% (9 out of 21) of the tagged fish successfully migrated past the Pejepscot Project, whereas fewer than 10% (2 out of 21) successfully passed all three dams in the lower Androscoggin (MDMR 2012b). The remaining 29% (6 out of 21) passed the Brunswick Project but did not migrate any further in the River. The study showed minimal use of tributaries in the system, although many fish were detected in the mainstem, holding in the vicinity of cool water tributaries during the summer months (Little River and Meadow Brook downstream of the Worumbo project; Gerrish Brook upstream of the Worumbo Project; and Simpson Brook downstream of the Pejepscot Project). One female Atlantic salmon was detected several times in the Little River, and may have spawned with an untagged male in one of its tributaries. Likewise, one tagged male was detected in the bypass reach of Lower Barker Dam and may have spawned with an untagged female (MDMR 2012b).

The fact that only 10% (2 out of 21) of the tagged adult Atlantic salmon successfully migrated past all three of the lower dams in 2011 may indicate poor passage efficiencies at the Pejepscot and Worumbo Projects, but likely also suggests that the salmon are poorly motivated to seek out upstream habitat. This conclusion is further supported by the fact that nearly one third of the salmon dropped out of the river soon after release in the Brunswick headpond and did not return. Overall, this study appears to support the conclusion that the majority of Atlantic salmon that enter the Androscoggin are strays that were stocked in other GOM DPS rivers.

The Androscoggin River is considered within the same Ecological Drainage Unit (EDU) as the Penobscot and Kennebec Rivers (Fay *et al.* 2006), which was considered in the decision to expand the GOM DPS in 2009 (USFWS and NMFS 2009). While salmon migration and habitat use studies are limited in the Androscoggin River, a number of studies have been conducted in the Penobscot River that may be relevant to the Androscoggin River. Specifically, adult Atlantic salmon returns are most common in June on the Penobscot River (MDMR 2007, 2008), and have been tracked with telemetry and observed to stop migration and seek thermal refuge when temperatures exceed 22°C (Holbrook 2007). Adult salmon have also been observed falling back and out of the river during periods of very high water temperatures (Shepard 1995, Holbrook 2007). After spawning, kelts have been observed in the lower Penobscot River in November (USASAC 2007).

5.4.2 Juveniles

Atlantic salmon stocking practices are common in the region for the Gulf of Maine DPS stock enhancement program, although the Androscoggin River has been stocked with fewer fish than any other river with a stocking program for anadromous Atlantic salmon. A total of 18,500 fry have been stocked in the Androscoggin River since stocking commenced in 2001 (USASAC 2016). The total number of juvenile salmon stocked in the Androscoggin River (fry only) was 1,500 individuals in 2013, 1,000 in 2014 and 2,000 in 2015 (USASAC 2016). These numbers are most likely estimates of the amount of fry stocked into the Little River by school groups participating in salmon outreach programs (MDMR 2010). In comparison, other major GOM rivers were stocked at the following levels in 2015 (number of juveniles indicated in parenthesis): the Penobscot (1.24 million), Machias (552,732), Dennys (110,000), and Kennebec (276,587) rivers (USASAC 2016).

Based on NMFS Penobscot River smolt trapping studies in 2000 - 2005, smolts migrate from the Penobscot between late April and early June with a peak in early May (Fay *et al.* 2006). These data also demonstrate that the majority of the smolt migration appears to take place over a two-week period after water temperatures rise to 10°C. Timing of smolt migrations may differ amongst rivers within the GOM DPS (Figure 11). In 2015, smolt trapping studies on the Sheepscot River in the Merrymeeting Bay SHRU indicated a median migration date of May 12 with a migration duration of 33 days (USASAC 2016).

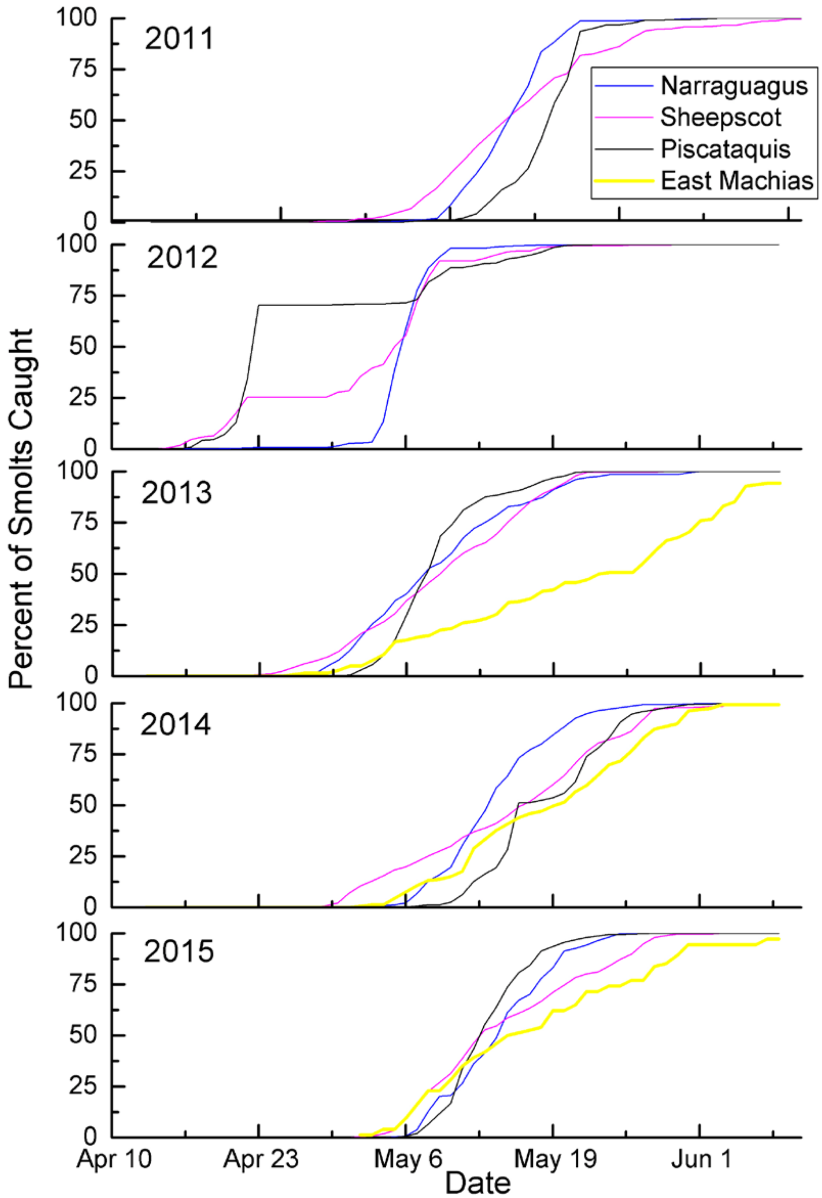

Figure 11: Cumulative percent smolt capture of all origins by date (run timing) on the Narraguagus (blue line), Sheepscot (pink line), Piscataquis (black line), and East Machias (yellow line) rivers, Maine (2011-2015) (USASAC 2016)

5.4.3 Threats faced by Atlantic salmon within the Merrymeeting Bay SHRU

Dams and Hydroelectric Facilities

Within the Merrymeeting Bay SHRU there are roughly 104 dams of which 15 are FERC licensed mainstem dams used for power generation or storage, resulting in over 59 km of impounded river (MDEP 1999). Therefore, both the Kennebec and Androscoggin watersheds are major power producers. On the Androscoggin below Rumford (the upper extent of the range of Atlantic salmon), major Hydro-power facilities include the upper and lower stations at the Rumford Falls project in Rumford; Riley/Jay/Livermore Projects in Jay, Riley and Livermore; Gulf Island/Deer Rips project in Lewiston-Auburn; Lewiston Falls project in Lewiston/Auburn; the Worumbo Project in Lisbon/Durham; Worumbo in Topsham/Brunswick; and the Brunswick project in Brunswick/Topsham. Today, the upper extent of fish passage in the Androscoggin River is Lewiston Falls, which is located 32 km upstream from Merrymeeting Bay.

Habitat Alteration

Dams have eliminated or degraded vast, but to date unquantified, reaches of suitable rearing habitat in the Androscoggin River watershed. The Androscoggin River consists of 70,249 historic habitat units, with 16,978 units considered to be occupied (NMFS 2009). Because Atlantic salmon cannot volitionally access habitat upstream of the Lewiston Falls Project on the mainstem or above the Barker Mill Dam on the Little Androscoggin, habitat in the upper areas of the Androscoggin River watershed are not accessible. Impoundments created by dams limit access to habitat, alter habitat, and degrade water quality through increased temperatures and lowered dissolved oxygen levels. Furthermore, because hydropower dams are typically constructed in reaches with moderate to high underlying gradients, significant areas of free-flowing habitat have been converted to impounded habitats in the Androscoggin River watershed. Coincidently, these moderate to high gradient reaches, if free-flowing, would likely constitute the highest value as Atlantic salmon spawning, nursery, and adult resting habitat within the context of all potential salmon habitat within these reaches.

Compared to a natural hydrograph, the operation of dams in a store-and-release mode in the upper reaches of the Androscoggin River watershed results in reduced spring runoff flows, less severe flood events, and augmented summer and early fall flows. Such operations in turn reduce sediment flushing and transport and physical scouring of substrates, and increase surface area and volume of summer and early fall habitat in the main stem. The extent to which these streamflow modifications in the upper Androscoggin River watershed impact salmon populations, habitat (including migratory corridors during applicable seasons), and restoration efforts is unknown. However, increased embeddedness of spawning and invertebrate colonization substrates, diminished flows during smolt and kelt outmigration, and enhanced habitat quantity and, potentially, “quality” for non-native predators such as smallmouth bass, are likely among the adverse impacts to salmon. Conversely, higher summer and early fall stream flows may provide some benefits to Atlantic salmon or their habitat within affected reaches, and may also help mitigate certain potential water quality impacts (e.g., dilution of harmful industrial and municipal discharges).

Habitat Connectivity

In 1982, Central Maine Power Company (CMP) reconstructed the hydroelectric facility in Brunswick-Topsham, the first upstream dam on the Androscoggin River (Brown *et al.* 2006). CMP installed a slot fishway with a trapping and sorting facility. At that time, the MDMR began the Anadromous Fish Restoration Program in the lower Androscoggin River main stem and tributaries below Lewiston Falls. In 1987, the Pejepscot Project, the second dam on the Androscoggin River, had upstream fish passage installed. In 1988, upstream passage facilities were installed at the Worumbo Project, the third upstream dam on the river. This provided an opportunity for anadromous species to migrate upstream as far as Lewiston Falls (Brown *et al.* 2006).

No upstream passage studies for Atlantic salmon have been conducted at the dams on the Androscoggin River, although annual counts of pre-spawn migrating Atlantic salmon trapped at the Brunswick and Worumbo Dams have been made since 1983. Few Atlantic salmon are known to migrate upriver of all three passable dams in the lower Androscoggin River. Between 3 and 44 Atlantic salmon per year (average of 12 fish) passed the Brunswick Dam between 2003 and 2015 (Table 14). Of these, an average of 22% (range between 0% and 56%) successfully passed the Worumbo Project. In a radio telemetry study conducted in 2011, while the spillway rehabilitation was occurring, MDMR documented that 9 of the 21 fish that passed the Brunswick Project passed the Pejepscot Project, and 2 of those 9 (22%) successfully migrated past the Worumbo Project (MDMR 2012b). Individual Atlantic salmon may use existing habitat and tributaries between dams and may not attempt to pass the next upstream dam. Tributaries exist between the Brunswick Project and the Worumbo Project that may contain Atlantic salmon habitat (MDMR 2010). Individual Atlantic salmon may migrate to these tributaries to spawn or seek thermal refuge, instead of migrating further upstream past the Worumbo Project.

Table 14: The number of Atlantic salmon passing the Brunswick and Worumbo Projects between 2003 and 2015

Year	Brunswick Project	Worumbo Project	Proportion that Pass the Worumbo Project
2003	3	1	33%
2004	12	1	8%
2005	10	0	0%
2006	6	2	33%
2007	21	7	33%
2008	18	2	11%
2009	24	1	4%
2010	9	5	56%
2011	44	3	7%
2012	0	1	-
2013	2	1	50%
2014	3	1	33%
2015	2	0	0%
Average	**12**	**2**	**22%**

Smolts from the Androscoggin River have to navigate through multiple dams on their migrations to the estuary every spring. The route that a salmon smolt takes when passing a project is a major factor in its likelihood of survival. Fish that pass through a properly designed downstream bypass have a better chance of survival than a fish that goes over a spillway, which, in turn, has a better chance of survival than a fish swimming through the turbines. It can be assumed that close to 100% of smolts will survive when passing through a properly designed downstream bypass. Survival over a spillway has been estimated at 97.1% (Normandeau Associates 2011). Survival through turbines varies significantly based on numerous factors, but can be significantly lower than the other two routes.

Beginning in 2013, three years of study were conducted to assess the survival of smolts migrating past dams in the Androscoggin River (Table 15). Although these data do not definitively reveal sources of mortality, these losses are likely attributable to the direct and indirect effects of the dams (e.g., physical injury, predation).

Table 15: Percent survival by study year of Atlantic salmon smolts at three dams on the Androscoggin River (ISPP annual reports, 2013-2015)

Project	**Percent Survival of Smolts by Study Year**			
	2013	2014	2015	Average
Worumbo	70.7%	95.8%	93.5%	86.7%
Pejepscot	-	91.3%	86.3%	88.8%
Brunswick	82.8%	94.9%	83.8%	87.2%

Atlantic salmon kelts move downstream after spawning in November or, alternatively, overwinter in freshwater and outmigrate early in the spring (mostly mid-April through late May). Lévesque *et al.* (1985) and Baum (1997) suggest that 80% of kelts overwinter in freshwater habitat prior to returning to the ocean. No kelt survival studies have been conducted on the Androscoggin River, however, downstream passage success at dams on the Penobscot has been studied. Kelt passage occurred during periods of spill at most dams, and a large portion of study fish used the spillage. Kelt attraction to, and use of, downstream passage facilities was highly variable depending on facility, year of study, and hydrological conditions (e.g., spill or not). Shepard (1989) documented that kelts relied on spillage flows to migrate past the Milford and Veazie Dams on the Penobscot River during a study conducted in 1988. In fact, some kelts spent hours to days searching for spillway flows to complete their downstream migration during the 1988 study.

Alden Lab (2012) has modeled the current survival rates of kelts at the dams on the Penobscot River, based on turbine entrainment, spill mortality estimates and bypass efficiency. Alden Lab's analysis accounted for both immediate and delayed mortality associated with dam passage. Through the three months of outmigration, Alden Lab indicates that mean survival rates at 14 of the dams (Medway is excluded) on the Penobscot range between 61% and 93%.

Predation

In addition to direct mortality during downstream passage, kelts and smolts are exposed to indirect mortality caused by sub-lethal injuries, increased stress, and/or disorientation. A large proportion of indirect mortality is a result of disorientation caused by downstream passage, which can lead to elevated levels of predation immediately downstream of the project (Mesa 1994).

Smallmouth bass and chain pickerel are each important predators of Atlantic salmon within the range of the GOM DPS (Fay *et al.* 2006). Smallmouth bass are a warm-water species whose range now extends through north-central Maine and well into New Brunswick (Jackson 2002). Smallmouth bass are very abundant in the Androscoggin River—smallmouth bass inhabit much of the main stem migratory corridor and areas containing juvenile Atlantic salmon. Smallmouth bass likely feed on fry and parr though little quantitative information exists regarding the extent of bass predation upon salmon fry and parr. Smallmouth bass are important predators of smolts in main stem habitats, although bioenergetics modeling indicates that bass predation is insignificant at 5°C and increases with increasing water temperature during the smolt migration (Van den Ende 1993).

Chain pickerel are known to feed upon smolts within the range of the GOM DPS and certainly feed upon fry and parr, as well as smolts, given their piscivorous feeding habits (Van den Ende 1993). Chain pickerel feed actively in temperatures below 10°C (Van den Ende 1993, MDIFW 2002). Smolts were, by far, the most common item in the diet of chain pickerel observed by Barr (1962) and Van den Ende (1993). However, Van den Ende (1993) concluded that, "daily consumption was consistently lower for chain pickerel than that of smallmouth bass", apparently due to the much lower abundance of chain pickerel.

Northern pike were illegally stocked in Maine, and their range now includes portions of the lower Androscoggin River. Northern pike are ambush predators that rely on vision and thus, predation upon smolts occurs primarily in daylight with the highest predation rates in low light conditions at dawn and dusk (Bakshtansky *et al.* 1982). Hatchery smolts experience higher rates of predation by fish than wild smolts, particularly from northern pike (Ruggles 1980, Bakshtansky *et al.* 1982).

Many species of birds prey upon Atlantic salmon throughout their life cycle (Fay *et al.* 2006). Blackwell *et al.* (1997) reported that salmon smolts were the most frequently occurring food items in cormorant sampled at main stem dam foraging sites. Common mergansers, belted kingfishers cormorants, and loons prey would likely prey upon Atlantic salmon in the Androscoggin River. The abundance of alternative prey resources such as upstream migrating alewife, likely minimizes the impacts of cormorant predation on the GOM DPS (Fay *et al.* 2006).

Contaminants and Water Quality

Pollutants discharged from point sources affect water quality within the action area of this consultation. Common point sources of pollutants include publicly operated waste treatment facilities, overboard discharges (OBD), a type of waste water treatment system), and industrial sites and discharges. The Maine Department of Environmental Protection (MDEP) issues permits under the National Pollutant Discharge Elimination System (NPDES) for licensed point source discharges. Conditions and license limits are set to maintain the existing water quality classification. Generally, the impacts of point source pollution are greater in the larger rivers of the GOM DPS.

Poor water quality within segments of the Androscoggin River is of particular concern for fisheries restoration. MDEP (2014) classifies the portion of the Androscoggin River in which the action area occurs as Class C waters. The classification system "…should be viewed as a hierarchy of risk, more than one of use or quality, the risk being the possibility of a breakdown of the ecosystem and loss of use due to either natural or human-caused events…[Class C waters] are still good quality, but the margin for error before significant degradation might occur in these waters in the event of an additional stress being introduced (such as a spill or a drought) is the least" (MDEP 2016).

5.4.4 Summary of Information on Atlantic Salmon and Critical Habitat in the Action Area

Adult returns for the GOM DPS remain well below conservation spawning escapement (CSE). For all GOM DPS rivers in Maine, current Atlantic salmon populations (including hatchery contributions) are well below CSE levels required to sustain themselves (Fay *et al.* 2006), which is further indication of their poor population status. The abundance of Atlantic salmon in the GOM DPS has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is small and displays no sign of growth. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels, but has not contributed to an increase in the overall abundance of salmon and has not been able to halt the decline of the naturally reared component of the GOM DPS.

A number of activities within the Merrymeeting Bay SHRU will likely continue to impact the biological and physical features of spawning, rearing, and migration habitat for Atlantic salmon. These include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-crossings and other instream activities (such as alternative energy development), mining, dams, dredging, and aquaculture.

Dams, along with degraded substrate and cover, water quality, water temperature, and biological communities, have reduced the quality and quantity of habitat available to Atlantic salmon populations within the Merrymeeting Bay SHRU. Hydroelectric dams, in particular, have a significant negative effect on listed Atlantic salmon, as well as critical habitat, within the Androscoggin River, and the action area. Ongoing effects of the lower three projects in the river (including the Brunswick Project), particularly passage inefficiencies and migratory delay, negatively impact the species as well as the physical and biological features of critical habitat present in the action area.

Expected Seasonal Distribution of Atlantic Salmon in the Action Area
The discussion below summarizes the expected seasonal distribution of Atlantic salmon in the action area.

Atlantic salmon adult and smolt life stages move through the action area during their spawning and outmigration periods. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July (Meister 1958; Baum 1997), but may enter at any time between early spring and late summer. Peak upstream migration movements in the Androscoggin River occur in the month of June (Fay *et al.* 2006).

After spawning, male and female Atlantic salmon (kelts) either return to sea immediately or remain in fresh water until the following spring before returning to the sea (Fay *et al.* 2006). No kelt outmigration data exists for the Androscoggin River; however, Baum (1997) reported that 20% of kelts outmigrated to the ocean in the fall, with the remaining 80% migrating to the ocean in the spring.

After hatching, salmon fry remain in their natal river for three years. Once smoltification occurs, smolts begin their downstream migration between April and June. In 2015, smolt trapping studies on the Sheepscot River in the Merrymeeting Bay SHRU indicated a median migration date of May 12 with a migration duration of 33 days (USASAC 2016).

Table 16: Timing of Atlantic salmon lifestages and behaviors in the action area

Lifestage	Time of Year Present in Action Area	Behavior in Action Area
Adults	April 1-November 30	Migration of spawning adults in the spring-fall; outmigration of kelts in the fall and spring.
Smolts	April 1-June 30	Outmigration to marine waters

Physical and Biological Features of Atlantic Salmon Critical Habitat in the Action Area
As detailed in Section 4.2, we have designated critical habitat for Atlantic salmon in the Androscoggin River, including the section of river that comprises the project action area.

The listed PBFs for Atlantic salmon considered essential to the conservation of the species include physical and biological features of (1) spawning and rearing and (2) migration requirements. As described above, spawning sites are most often positioned at the head of a riffle (Beland et al. 1982), the tail of a pool, or the upstream edge of a gravel bar where water depth is decreasing and water velocity is increasing (McLaughlin and Knight 1987; White 1942). Table 5 describes fully functioning spawning habitat as having a depth of 17-30 cm, with limited function at 30-76 cm. Similarly, optimal habitat for embryo, larval, fry, and parr development occur at depths less than or equal to 30 cm. To date, based on the best available information, we believe all potential salmon spawning habitat in the Androscoggin River occurs upstream of the Brunswick Dam. Though parr are typically stream dwellers, they also use pools within rivers and streams, dead-waters (sections of river or stream with very little to no gradient), and lakes within a river system as a secondary nursery area after emergence; however, we expect any of these non-stream habitats used by parr to occur upstream of the Brunswick Dam, closer to possible spawning habitat. As discussed below, any downstream movement of non-adult salmon into the action area would indicate that parr had gone through smoltification and begun their emigration to marine waters. In sum, we do not expect physical and biological features for spawning and rearing habitat to occur.

Within the action area, the PBFs for Atlantic salmon migration for the juvenile (smolt) and adult life stages are present. These PBFs are:

Migration PBF M1. *Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.*

Migration PBF M2*. Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.*
Migration PBF M3*. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.*
Migration PBF M4*. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.*

Any smolts entering the action area past the Brunswick Dam have already experienced the water temperature, flows, and diurnal cues to stimulate their migration, because once in the action area, their downstream migration to the lower estuary is nearly complete. Therefore, we do not expect any further smolt migration stimulation to occur or be needed, and Migration PBF 5 does not occur in the action area (i.e., freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration). Similarly, we expect freshwater migration sites with the water chemistry to support sea water adaption of smolts to occur upstream of the Brunswick Dam, because once in the action area, they are only 15 rkm upstream from the upper limit of salt water intrusion (where Merrymeeting Bay meets the lower Kennebec estuary). As smolts may travel up to 60 km in a day (Aaresrup et al. 2002 in Aas et al. 2011), their sea water adaptation would need to be complete by the time they reach the action area, as they are potentially hours from entering a predominantly saline environment. Therefore, we do not expect Migration PBF 6 to occur in the action area (i.e., freshwater migration sites with water chemistry needed to support sea water adaptation of smolts).

Viewing the discussion above of migratory barriers for returning adults and outmigrating smolts and threats faced by both life stages in the Merrymeeting Bay SHRU through the lens of the matrix in Table 5, we have determined that migration habitat in the action area has limited function or is not functioning properly (Table 17).

Table 17: Current conditions of essential features of Atlantic salmon critical habitat in the action area having limited function or not properly functioning

Pathway/ Indicator	Life Stages Affected	Essential Features Affected	Effect	Population Viability Attributes Affected
Passage/Access to Historical Habitat	Adult, juvenile, smolt	Freshwater migration	Impeded upstream passage delays access to spawning habitat. Impeded downstream passage will result in direct and delayed mortality of smolts and kelts.	Adult abundance and productivity.

5.5 Status of Shortnose Sturgeon in the Action Area

5.5.1 Shortnose Sturgeon in the Kennebec River System

The Kennebec system includes the Kennebec, Androscoggin and Sheepscot Rivers. Shortnose sturgeon occur in the estuarine complex formed by the Sheepscot, Kennebec, and Androscoggin rivers. Atkins (1887) documented the presence of sturgeon in Maine rivers, though they were identified as common sturgeon (*Acipenser sturio*). Fried and McCleave (1973) discovered shortnose sturgeon within Montsweag Bay in the Sheepscot River in 1971 and 1972. This was the first reported occurrence of shortnose sturgeon in Maine. Shortnose were subsequently found in the Kennebec River by ME DMR in 1977 and 1978 (Squiers and Smith 1979). Historically, the upstream extent of shortnose sturgeon in the Kennebec is thought to have been Ticonic Falls (rkm 103)(NMFS & USFWS 1998).

Sturgeon were tagged with Carlin tags from 1977 to 1981, with recaptures in each of the following years. A Schnabel estimate of 7,222 (95% CI, 5,046 to 10,765) adults for the combined estuarine complex was computed from the tagging and recapture data from 1977 through 1981 (Squiers *et al.* 1982). A Schnabel estimate using tagging and recapture data from 1998 - 2000 indicates a population estimate of 9,488 (95% CI, 6,942 to 13,358) for the estuarine complex (Squiers 2003). The average density of adult shortnose sturgeon/hectare of habitat in the estuarine complex of the Kennebec River was the second highest of any population studied through 1983 (Dadswell *et al*., 1984). The Schnabel estimate from 1998-2000 is the most recent population estimate for the Kennebec River System shortnose sturgeon population; however, does not include an estimate of the size of the juvenile population. A comparison of the population estimate for the estuarine complex from 1982 (Squiers *et al.* 1982) to 2000 (Maine DMR 2003) suggests that the adult population has grown by approximately 30% in that twenty year period. Assuming that this trend continued past 2000, we would expect the shortnose sturgeon population in the Kennebec River system to be increasing; however, without more information on the status of more recent year classes it is not possible to determine if this trend has been sustained.

Spawning in the Kennebec

In 1999, the Edward's Dam (rkm 74), which represented the first significant impediment to the northward migration of shortnose sturgeon in the Kennebec River, was removed. The Lockwood Dam continues to operate, though it is not thought to impede shortnose access to historic habitat given its location at Ticonic Falls (rkm 103), the presumed historic upstream extent of shortnose in the Kennebec River. Thus, with the removal of the Edwards dam almost 100% of historic habitat is now accessible. Since the removal of the Edwards Dam, shortnose sturgeon have been documented just downstream of the Lockwood Dam (rkm 103) indicating this habitat is being utilized (Wippelhauser *et al.* 2015).

Wippelhauser and Squiers (2015) summarized field studies on shortnose and Atlantic sturgeon from 1977-2001 in the Kennebec River system that sought to produce population estimates and documentation of spawning, overwintering, and foraging habitat. Based on the capture of 172 adult shortnose sturgeon between May 1-31 over a period of 22 years (including two ripe males releasing sperm during handling) from rkm 47.5-74 in the Kennebec River, they identified spawning run timing and potential spawning habitat. ME DMR conducted ichthyoplankton surveys from 1996 through 2001. Sampling sites were located both above and below the dam and were surveyed using surface tows with plankton nets and stationary sets with D-shaped plankton nets. Through these efforts, researchers captured 54 eggs and 10 larvae at two sampling locations (rkm 65 and 72.7), confirming that spawning occurs in that 9 rkm stretch below the former Edwards Dam (Wippelhauser and Squiers 2015).

Between 2007 and 2013, Wippelhauser *et al.* 2015 tagged 134 adult shortnose sturgeon throughout the Gulf of Maine (Penobscot, Kennebec, Saco, Merrimack). Twenty-one (20%) of 104 shortnose sturgeon tagged in the Penobscot River, two (50%) of four tagged in the Kennebec system, one (50%) of two tagged in the Saco River, and 16 (37%) of 43 tagged in the Merrimack River moved into the Kennebec system and made suspected spawning runs. These adults displayed two distinct pre-spawning behaviors. Some (~35%) emigrated to the Kennebec system in the summer or fall and overwintered one to two seasons before participating in a spring spawning run, while the majority (~65%) migrated to the Kennebec system in the early spring and participated in a spawning run that same year. Tagged shortnose were detected in spawning areas from April 7 through June 6 as water temperatures increased and discharge decreased. During this time, bottom temperatures in the Kennebec River ranged from 5.8-17.6°C and fish spent an average of 9.9-12.5 days in the spawning sites (varied by Kennebec location). Discharge when shortnose sturgeon were at the spawning areas was typically ≤558 m^3/s; however, flows reached as high as 1,487 m^3/s in some years). Spawning was documented for the first time in the restored portion of the Kennebec (above the former Edwards Dam (rkm 74)) between May 17-19, 2010, as two larvae were captured below the Lockwood Dam at rkm 102 using D-nets. Spawning was again confirmed below the former Edwards Dam with the capture of 23 larvae between rkm 64-72 in a sampling period from May 19-June 15, 2009, as well as the capture of seven larvae between rkm 67-73 in a sampling period from May 3-June 6, 2011 (Wippelhauser *et al.* 2015).

Spawning in the Androscoggin River

In the Androscoggin River, shortnose sturgeon migration, and thus spawning location, was likely limited historically by the natural falls located at the Brunswick Dam (rkm 8.4). From 1979-1982, MEDMR conducted gillnet studies to identify spawning areas. During this period large numbers of shortnose sturgeon were captured between Brunswick and Topsham, approximately 400m downstream of the Frank J. Wood Bridge. Water temperatures during this time ranged between 8.5 and 14.5°C (late April until the end of May), many of the males captured were freely expressing milt and several females were ripe (Squiers *et al.* 1982). Tracking studies to delineate spawning habitat were performed on the Androscoggin River during 1993 (Squiers *et al.* 1993). Gill nets were used to capture study animals and catch rates were recorded. Gill net catch-per-unit-effort during this study was the highest recorded in this area, suggesting that the population in the Androscoggin has increased since last surveyed. Using cement blocks fitted with plastic mesh, this study also confirmed spawning by collecting eggs at two different discrete spawning areas (May 13 and 19) at approximately rkm 7.7. One larval shortnose sturgeon was also captured in the same general area (May 28) using a plankton net. This study indicated that spawning was concentrated in the reach of river between approximately rkm 7.7 and 8.4 (the Brunswick Dam).

Adding to this research, Wippelhauser *et al.* 2015 (discussed above) used telemetry data to record 14 spawning events (presence of late-stage females in known spawning grounds during the spawning season) from early April to early June. In data provided to MaineDOT for their BA, Wippelhauser (2016) stated that shortnose spawning below the Brunswick Dam (rkm 7.7-8.4) occurs from April 7 – June 11. During spawning, bottom temperatures in the spawning area ranged from 8.8-16.4^{0}C, and spawning adults spent an average of 4 days at the spawning site (range 0.1-7.8 days)(Wippelhauser *et al.* 2015).

Foraging
Foraging areas have been identified in the Sasanoa River entrance[10] and in the mainstem of the Kennebec River below Bath, from mid-April through November or early December (Squiers 1982, Normandeau 1999). Between June and September, shortnose sturgeon forage in shallow waters on mud flats that are covered with rooted aquatic plants. In the summer months, concentrations of shortnose sturgeon have also been known to move up into the freshwater reaches of the Kennebec River and foraging shortnose sturgeon have also been seen in Montsweag and Hockomock Bays in the Sheepscot River, which is located near the eastern end of the Sasanoa River (NMFS 1996). McCleave *et al.* (1977) examined several stomachs from shortnose sturgeon captured in Montsweag Bay and found crangon shrimp (*Crangon septemspinosous*); clams (*Mya arenaria*); and small winter flounder (*Pseudopleuronectes americanus*) were common prey items.

In the late summer (August 10 to September 2, 1993), Squiers *et al.* 1993 looked between rkm 7.0 and 8.4 for foraging young of the year and juvenile shortnose sturgeon. No young of the year or juvenile shortnose sturgeon were captured in sampling with an otter trawl. The authors concluded that it was likely that the larval shortnose sturgeon would have emigrated further downstream prior to August and that the juveniles would be associated with deep channel areas with rugged substrate and not in the area surveyed (including the action area).

Overwintering
Studies indicate that at least a portion of the shortnose sturgeon population in the Kennebec River overwinters in Merrymeeting Bay (Squiers and Robillard 1997). The seasonal migrations of shortnose sturgeon are believed to be correlated with changes in water temperature. In 1999, when a tracking study was performed by Normandeau Associates, the water temperature near Bath Iron Works (BIW) reached the 8-9ºC threshold (believed to be the trigger prompting spawning fish to migrate to the spawning area) in mid-April. Also during the tracking study, several fish presumed to be non-spawning sturgeon, were documented in the Chops Point and Swan Island areas (north of Doubling Point) in late March and then were found to have migrated south to the BIW region (e.g., north and south of the BIW Pier and Museum Point) early in April.

Until a study aimed at specifically determining overwintering locations was conducted by the MDMR in 1996 for the MaineDOT, the sites thought to be the most likely overwintering sites were deep pools below Bluff Head, and possibly in adjacent estuaries such as the Sheepscot (Squiers and Robillard 1997). The 1996 study of overwintering activity suggests that at least one overwintering site is located above Bath. This is based on tracking 15 shortnose sturgeon collected and released in the vicinity of the Sasanoa River (Pleasant Cove), Winnegance Cove

[10] The Sasanoa River entrance is located directly across the Kennebec River from the Bath Iron Works facility. The river is less than ½ mile wide at this point.

(near the Doubling Point reach), and Merrymeeting Bay (north of Bath and the Sasanoa River entrance). Tracking was done from October through January. Eleven of these fish were relocated in Merrymeeting Bay. Two of the fish from Pleasant Cove were never found in Merrymeeting Bay; one Pleasant Cove fish moved to Winnegance Cove and back to Pleasant Cove and another moved to Days Ferry (half way between Bath and Merrymeeting Bay). All of the fish that continued to transmit after November were only found in upper Merrymeeting Bay on the east-side of Swan Island (~rkm 40-42). Fish departed the wintering site between April 7-25, with most moving downstream toward the lower Kennebec estuary (Wippelhauser and Squiers 2015). This is consistent with the trends for movement of shortnose sturgeon in the Delaware River (O'Herron *et al.* 1993). Overwintering sturgeon in the Delaware River are found in the area of Newbold Island, in the Trenton to Kinkora river reach, in an area geographically similar to the area around Swan Island.

Expected Seasonal Distribution of Shortnose Sturgeon in the Action Area
The discussion below summarizes the expected seasonal distribution of shortnose sturgeon in the action area.

Adult shortnose sturgeon move into the action area to spawn in early April, departing by mid-June. As described above (section 4.3.1), eggs and yolk-sac larvae remain near the spawning site (rkm 7.7-8.4). Once the last adults have spawned, we add 25 days to accommodate the egg development, hatching, and yolk-sac larvae (YSL) stage. Post yolk-sac larvae (PYSL, a phase which ends ~12-40 days post hatch), could be in the action area from approximately mid-April until early August (i.e., 53 days from the latest spawning date, August 7, all shortnose sturgeon PYSL will become young of the year); however, only those larvae whose eggs were fertilized near the end of the spawning period (mid-June) could possibly be present this late in the season (Table 18). We expect all shortnose sturgeon to have entered the PYSL stage by approximately July 10, at which point they will begin to move downstream away from the current and proposed bridge and out of the action area, which is practically at the upstream limit of the spawning area. Based on the information above, we do not expect any shortnose sturgeon to be in the action area once the adults and early life stages have moved downstream following the spawning season (i.e., shortnose sturgeon will not be present from August 8 – March 31).

Table 18: Timing of shortnose sturgeon lifestages and behaviors in the action area

Lifestage	Time of Year Present in Action Area	Behavior in Action Area
Adults	April 1-June 15	Migration of spawning adults in the spring to and from spawning site.
Eggs & Yolk-Sac Larvae (YSL)	April 1-July 10	Eggs adhere to the substrate quickly after being deposited. Hatch times range from approximately 8-13 days post spawn. The YSL phase lasts approximately 8-12 days and is characterized by "swim up and drift" behavior. YSL are photonegative and seek cover in hard substrate. YSL remain near the spawning site.

Post Yolk-Sac Larvae (PYSL)	April 16-August 7	PYSL begin feeding (on aquatic insects, insect larvae and other invertebrates) and are free-swimming; they disperse downstream of the spawning/rearing area. The PYSL phase ends at about 12-40 days post-hatch. PYSL are typically found in the deepest water available

5.6 Status of Atlantic Sturgeon in the Action Area

5.6.1 Atlantic Sturgeon in the Kennebec River System

As noted above, historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers *et al.* 1979). Following the 1880s, the sturgeon fishery was almost non-existent due to a collapse of the sturgeon stocks. While directed fishing and retention as by-catch has been prohibited since 1998, the GOM DPS of Atlantic sturgeon remains threatened. Based on the NEAMAP survey data, we estimate an ocean population of 7,455 adult and subadult GOM DPS Atlantic sturgeon. In the marine range, GOM DPS Atlantic sturgeon are still incidentally captured in federal and state managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.*, 2004; ASMFC 2007). Habitat disturbance and direct mortality from anthropogenic sources are primary concerns. Due to the lack of recaptures, to date, we do not have a population estimate for adult Atlantic sturgeon in the Kennebec River system (Wippelhauser and Squiers 2015). For a summary of threats faced by the GOM DPS of Atlantic sturgeon, see section 4.4.4.

Coastal Movements

As part of a study to assess coastal movements of Atlantic sturgeon in the Gulf of Maine, Wippelhauser *et al.* 2017 captured 681 sub-adult and adult Atlantic sturgeon within four study rivers (Merrimack, Saco, Kennebec, Penobscot). Approximately 25% (169) were tagged with acoustic transmitters for tracking using a series of acoustic receiver arrays in each of the rivers, as well as compatible arrays in the marine coastal environment. Of the 169 tagged sturgeon, 20 were captured and tagged in the Merrimack, 51 in the Saco, 55 in the Kennebec, and 43 in the Penobscot. Fifty-nine (59) individuals tagged elsewhere were detected in the Kennebec system. Nonspawning Atlantic sturgeon entered the Kennebec system in late May (median date of May 30) and departed early in the late summer or early fall (median date of August 25).

Foraging

While in the Kennebec system, adult and subadult Atlantic sturgeon that did not enter spawning grounds spent the majority of their time between rkm 0 and 45, likely foraging (Wippelhauser *et al.* 2017). From 1977-2001, between May and the end of November, Wippelhauser and Squiers (2015) also captured 304 juvenile Atlantic sturgeon (described as “early, intermediate, and late stage”) in the upper Kennebec estuary, Merrymeeting Bay, lower Kennebec estuary, and the Sasanoa River. Over half of the juveniles (146) were caught in October and September (67), and the majority were captured in the lower Kennebec estuary (212) and Merrymeeting Bay (67), indicating the likely presence of foraging grounds.

Spawning in the Kennebec River System
To date, despite captures of sturgeon in the Merrimack, Penobscot and Piscataqua/Salmon Falls/Cocheco rivers, as well as the necessary physical and biological features to support spawning in each of those rivers, the only confirmed spawning locations for the GOM DPS of Atlantic sturgeon are in the Kennebec River system (upper Kennebec River estuary and the Androscoggin River).

As reported in Wippelhauser *et al.* 2017, between 2010 and 2014, most tagged Atlantic sturgeon entered the Kennebec system during April and May (May 6 on average, with a range of April 11-June 17). They then moved to the spawning grounds mostly in June (average of June 14, range May 8-July 20), and remained at the spawning grounds through July (average of July 13, range of June 12-August 20). Water temperatures were typically over 16°C when Atlantic sturgeon occupied spawning areas, and freshwater discharge was usually less than 399 m^3/s. After spawning, some tagged individuals from the 2009-2011 study remained in Merrymeeting Bay or the lower Kennebec estuary for approximately 60 days before departing the system in October (Wippelhauser *et al.* 2017).

Spawning in the Kennebec River
As described above in section 4.7, from 1977-2001, Atlantic sturgeon in spawning condition were caught between rkm 52.8 and rkm 74 of the Kennebec River during the months of June and July, the likely spawning season. The removal of the Edwards Dam (rkm 74) in 1999 allowed Atlantic sturgeon to access 21 rkm of historic spawning habitat, up to Ticonic Falls/Lockwood Dam (rkm 103). From 2009 to 2011, 31 Atlantic sturgeon, including 6 ripe males, were caught in the Kennebec River between rkm 70 and rkm 75 (Wippelhauser 2012; Wippelhauser and Squiers 2015). Spawning was confirmed in the restored Kennebec River habitat (above the former Edwards Dam) when two larvae were captured (July 11-12, 2011) in the Upper Kennebec Estuary, 1 to 1.6 rkms upstream of the former Edwards Dam site (rkm 74). One larva was also captured at rkm 72 during the same time span (Wippelhauser 2012; Wippelhauser *et al.* 2017).

Spawning in the Androscoggin River
From 2009-2017, 11 adult Atlantic sturgeon have been captured and/or detected in the Androscoggin River near rkm 7.7. One of the sturgeon (captured on June 21, 2011) was a spawning condition (i.e., ripe) male (188.5 cm TL). Two of the sturgeon, including the ripe male, had been caught and PIT tagged in the Saco River the previous year (Wippelhauser *et al.* 2017; Wippelhauser pers. comm. 2018). With one exception, all of the sturgeon had left the spawning area by the end of July (one left on August 7). While these captures confirm likely spawning, Atlantic sturgeon eggs and larvae have not yet been recovered in the Androscoggin (Wippelhauser pers. comm. 2018).

Expected Seasonal Distribution of Atlantic Sturgeon in the Action Area
The discussion below summarizes the expected seasonal distribution of Atlantic sturgeon in the action area.

Adult Atlantic sturgeon move into the action area to spawn in early June, departing by the end of July. While adult Atlantic sturgeon do enter non-natal rivers, we only expect natal fish to occur on the spawning grounds during the spawning season. As such, , all Atlantic sturgeon in the action area will be from the GOM DPS (ASSRT 2007). As described above (section 4.4.2), eggs and yolk-sac larvae remain near the spawning site (rkm 7.7-8.4). Once the last adults have spawned, we add 18 days to accommodate the egg development, hatching, and yolk-sac larvae (YSL) stage. Post yolk-sac larvae (PYSL, a phase which ends ~40 days post hatch), could be in the action area from approximately mid-June until mid-September (i.e., 46 days from latest spawning date, September 15, all Atlantic sturgeon PYSL will become young of the year); however, only those larvae whose eggs were fertilized near the end of the spawning period (end of July) could possibly be present this late in the season (Table 19). We expect all Atlantic sturgeon to have entered the PYSL stage by approximately August 18, at which point they will begin to move downstream away from the current and proposed bridge and out of the action area, which is practically at the upstream limit of the spawning area. Based on the information above, we do not expect any Atlantic sturgeon life stages to be in the action area once the adults and early life stages have moved downstream following the spawning season (i.e., Atlantic sturgeon will not be present from September 16 – May 31).

Table 19: Timing of Atlantic sturgeon lifestages and behaviors in the action area

Lifestage	Time of Year Present in Action Area	Behavior in Action Area
Adults	June 1-July 31	Migration of spawning adults in the spring to and from spawning site.
Eggs & Yolk-Sac Larvae (YSL)	June 1-August 18	Eggs adhere to the substrate quickly after being deposited. Hatching occurs ~3-6 days after egg deposition and fertilization. The YSL phase lasts approximately 8-12 days and is characterized by “swim up and drift” behavior. YSL are photonegative and seek cover in hard substrate. YSL remain near the spawning site.
Post Yolk-Sac Larvae (PYSL)	June 11-September 15	PYSL begin feeding (on aquatic insects, insect larvae and other invertebrates) and are free-swimming; they disperse downstream of the spawning/rearing area. The PYSL phase ends at about 40 days post-hatch. PYSL are typically found in the deepest water available

5.7 Status of Atlantic Sturgeon Critical Habitat in the Action Area

As noted in section 3.4, the action area considered in this Opinion extends from rkm 7.2 to rkm 8.4. The Androscoggin River critical habitat unit extends from the point where the Androscoggin River empties into Merrymeeting Bay to the Brunswick Dam, which was also likely the natural upstream limit for Atlantic sturgeon (i.e., Pejepscot Falls).[11]

[11] The final rule designating Atlantic sturgeon critical habitat states that the Androscoggin River critical habitat unit extends from the Brunswick Dam approximately 10 rkms downstream to the confluence of the Kennebec and

The Androscoggin River is entirely freshwater (salinity <0.5ppt); therefore, PBF 2 of Atlantic sturgeon critical habitat, or aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.*, sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development, is not present in the action area. The other three PBFs are found in the action area, and we discuss their status below.

5.7.1 PBF 1

Hard bottom substrate in low salinity waters suitable for the settlement of fertilized eggs, refuge, growth, and development of early life stages (i.e., PBF 1) is present within the action area.

The channel topography below the Brunswick Dam is highly variable and significantly influences the flow and bottom habitat. Just below the dam, the flow splits into two channels that then flow together under the Frank J. Wood Bridge. Substrate in the river below the existing Frank J Wood Bridge is less scoured by high velocities and diversifies into hard bottom boulder and cobble substrate with pockets of sand. The dominant flow channel moves water through the powerhouse and downstream tailrace. Substrate within the tailrace is scoured ledge (FHWA 2017).

Information from Squiers *et al.* 1993 can be used to understand the habitat present in the action area. Divers participating in the study swam several transects. On one transect, from an area just below the Route 201 Bridge (Frank J. Wood Bridge) up to the bridge, the depth was approximately 2.4m and they reported that the substrate consisted of ledge, boulders, and rocks interspersed with sand and gravel. MaineDOT provided us with a video from this transect, confirming the substrate as characterized in the report. Slightly further downstream, they describe the substrate at the shortnose spawning area around rkm 7.7 as graduating from ledge, boulders, cobbles, pebbles, and gravel on the Brunswick shore to sand in the middle of the channel, with silt on the Topsham shore. Further downstream still, around rkm 7 (just below the action area), divers observed sand and silt, and no hard substrate.

The capture and detection of 11 adult Atlantic sturgeon, including a ripe male, at rkm 7.7 during the spawning season (June-July) confirms that Atlantic sturgeon also use the hard bottom substrate in the action area.

We do not have substrate maps for the action area, but based on the collection of resources referenced above, we have a general picture of the substrate in the action area. Hard bottom habitat exists from below the Brunswick Dam (rkm 8.4) to approximately rkm 7.7. Within that reach, some of the habitat is scoured ledge (particularly where flows are strongest coming out of the tailrace) without the interstitial spaces needed for settlement of eggs and larvae that is essential for successful development of eggs and larvae. There are also pockets of sand that would not be selected for by spawning sturgeon or used for the settlement of eggs and larvae. Based on the limited data we have (from diving transects and the lack of capture and detection success), below rkm 7.7, as the river stretches toward the lower portion of the action area, it

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Androscoggin rivers (82 FR 39160). For ease of reference to papers describing sturgeon use of the Androscoggin River and identify the Brunswick Dam as rkm 8.4 instead of 10.0, we are using the former delineation of rkms (i.e., Brunswick Dam at rkm 8.4) to describe sturgeon behavior and habitat.

appears that the substrate may switch from primarily hard bottom substrate to predominantly sand and silt. Therefore, we have estimated that the action area above rkm 7.7, and removing the upper pool on the Topsham side above the Frank J. Wood Bridge (which is inaccessible to sturgeon), has approximately 11.8 acres of habitat meeting the criteria of PBF 1 (Figure 12). The areas directly below the existing bridge, extending toward rkm 7.7, have less scoured ledge from the tailrace flows, and therefore, likely have the most conservation value for Atlantic sturgeon.

Figure 12: Portion of the action area with potential spawning habitat meeting criteria for PBF 1

5.7.2 PBF 3

PBF 3 consists of water of appropriate depth and absent physical barriers to passage between the river mouth and spawning sites necessary to support:

(i) Unimpeded movement of adults to and from spawning sites;
(ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary
(iii) Staging, resting, or holding of subadults or spawning condition adults.

PBF 3 also consists of water depths in main river channels deep enough (*e.g.,* at least 1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Following these criteria, PBF 3 is present throughout the action area, except for in the upper pool on the Topsham side of the river above the existing Frank J. Wood Bridge, as this area is inaccessible to sturgeon.

Both historically and today, the location of the Brunswick Dam (Pejepscot Falls), also the upper limit of the action area, is the upstream limit for Atlantic sturgeon in the Androscoggin River. Aside from the dam, the existing Frank J. Wood Bridge support piers, and some exposed boulders, there are no physical obstructions preventing passage in the action area. In addition to navigating around existing structures, sturgeon movements can also be impacted by gear set in the river, vessel traffic, and in-water stressors from ongoing construction projects (e.g., turbidity from dredging, sound pressure waves from pile driving, etc.). We are not aware of any construction projects in the action area. The boat ramp where project vessels will be launched is available for the public, so there is some recreational vessel traffic and fishing in the action area, but this likely is mainly in the lower portion of the action area, away from the bridge and dam.

The width of the River in the action area varies from about 75m (just below the existing bridge) to approximately 300m around rkm 7.2. The depth in the main channel varies from approximately 2.4-6.7m (8-22ft)(FHWA 2017; Squiers *et al.* 1993). The Androscoggin River discharges through the Brunswick Dam at several points including the tailrace on the Brunswick side, the flood gates on the Topsham side, and the mid-channel spillway. The various release points depend on several factors including water levels, turbine maintenance, or management agreements with regulatory agencies. At lower flows, the majority of water flows through the powerhouse into the tailrace. During times of increased flows, or scheduled maintenance, water may flow over the spillway, or through opened flood gates.

Given these various discharge points, velocities under the existing and proposed bridge vary depending on the stage of river flow and which release points are flowing. At the lowest flows, the ponded area may be nearly stagnant and the majority of flow moves through the powerhouse and tailrace. River velocities patterns change during moderate and high flows. At increased flows, water may discharge into the river over the spillway causing flow through the pond. At the highest flows, the flood gates on the Topsham side open causing increased flows and higher velocity through the left side of the river. At normal flows, velocities in the tailrace range from approximately 6.0 to 8.0 feet per second, which diminishes the suitability of habitat within and directly downstream of the tailrace, as these velocities are too fast for Atlantic sturgeon spawning and rearing behavior (optimal flows for spawning are 1.5-2.5 ft/s, NMFS 2017). Velocities lessen as the river extends toward the lower portion of the action area.

5.7.3 PBF 4

PBF 4 (water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment), is present throughout the action area; however, we do not expect juvenile or subadult development to occur in the action area.

Spawning sites for the Atlantic sturgeon DPSs are well-oxygenated areas with flowing freshwater at the time of spawning, ranging in temperature from 13°C to 26°C (NMFS 2017). Water quality factors of temperature, salinity and dissolved oxygen are interrelated environmental variables, and are constantly changing from influences of the tide, weather, season, etc. Dissolved oxygen concentrations in water can fluctuate given a number of factors including water temperature (e.g., cold water holds more oxygen than warm water) and salinity (e.g., the amount of oxygen that can dissolve in water decreases as salinity increases). This means that, for example, the dissolved oxygen levels that support growth and development will be different at different combinations of water temperature and salinity. Similarly, the dissolved oxygen levels that we would expect Atlantic sturgeon to avoid would also vary depending on the particular water temperature, salinity, and life stage. As dissolved oxygen tolerance changes with age, the conditions that support growth and development and likewise, the dissolved oxygen levels that would be avoided, change (82 FR 39160; NMFS 2017).

Before the Clean Water Act of 1972, textile, pulp and paper, and municipalities discharged directly into the Androscoggin River causing it to be one of the most heavily polluted rivers in the United States. Pollution caused reductions in fish and other aquatic organisms due to anoxic conditions during the summer months. However, even with this pollution, dissolved oxygen levels in the Androscoggin River just above the Brunswick Dam were measured at ~6 mg/L in the 1930s (Brennan et al. 1931 in Moore and Reblin 2010). With the implementation of legal mandates on pollution discharge, dissolved oxygen levels have continued to improve in the Kennebec and Androscoggin Rivers (Moore and Reblin 2010). Dissolved oxygen levels from below the dam within the action area in July and August ranged from 7.1 to 7.9 mg/L (MDEP 2011).

At the present time, water quality in the action area is affected by pollutant discharge from urban and industrial non-point and point sources. Upstream land-use practices such as urban development and agricultural run-off contribute to non-point sources. Common point-source pollutants include upstream publicly operated waste treatment facility outfalls, industrial sites, and other discharges. The State of Maine classifies the portion of the Androscoggin River in which the project area occurs as Class C waters. Class C waters are of such quality that they are suitable for the designated uses of drinking water supply after treatment, fishing, agriculture, recreation in and on the water, industrial process and cooling water supply, hydroelectric power generation, navigation, and as a habitat for fish and other aquatic life. Maine's Water Classification Program criterion requires that dissolved oxygen content for Class B waters may not to be less than 7 parts per million (mg/L) or 75% saturation, whichever is higher (MDEP 2011). Therefore, despite the 2010 measurements that showed DO levels above 7.0 mg/L, waters in the action area must at least occasionally dip below one or both of those thresholds to warrant the Class C status.

Based on known water quality parameters of the action area (12-28°C between May and August (Wippelhauser *et al*. 2017); salinity below 0.5 ppt; dissolved oxygen levels at or above approximately 7 mg/L), as well as past captures of shortnose sturgeon eggs and larvae, and the capture and tracking of adult shortnose and Atlantic sturgeon during the spawning season, suggest that water quality in the action area is adequate to support Atlantic sturgeon spawning and the survival of early life stages (eggs and larvae).

6.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change on listed species and critical habitat in the action area over the lifespan of the proposed project (2018-2021). Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion, below.

6.1 Background Information on Global climate change

In its Fifth Assessment Report (AR5) from 2014, the Intergovernmental Panel on Climate Change (IPCC) stated that the globally averaged combined land and ocean surface temperature data has shown a warming of 0.85°C (likely range: 0.65° to 1.06°C) over the period of 1880-2012. Similarly, the total increase between the average of the 1850-1900 period and the 2003-2012 period is 0.78°C (likely range: 0.72° to 0.85°C). On a global scale, ocean warming has been largest near the surface, with the upper 75 meters of the world's oceans having warmed by 0.11°C (likely range: 0.09° to 0.13°C) per decade over the period of 1971-2010 (IPCC 2014). In regards to resultant sea level rise, it is very likely that the mean rate of global averaged sea level rise was 1.7 millimeters/year (likely range: 1.5 to 1.9 millimeters/year) between 1901 and 2010, 2.0 millimeters/year (likely range: 1.7 to 2.3 millimeters/year) between 1971 and 2010, and 3.2 millimeters/year (likely range: 2.8 to 3.6 millimeters/year) between 1993 and 2010.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next several decades. The global mean surface temperature change for the period 2016-2035 relative to 1986-2005 will likely be in the range of 0.3° to 0.7°C (medium confidence). This assessment is based on multiple lines of evidence and assumes there will be no major volcanic eruptions or secular changes in total solar irradiance. Relative to natural internal variability, near-term increases in seasonal mean and annual mean temperatures are expected to be larger in the tropics and subtropics than in mid- and high latitudes (high confidence). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has also resulted in increased river discharge and glacial and sea-ice melting (Greene *et al.* 2008). The strongest ocean warming is projected for the surface in tropical and Northern Hemisphere subtropical regions. At greater depths, the warming will be most pronounced in the Southern Ocean (high confidence). Best estimates of ocean warming in the top 100 meters are about 0.6° to 2.0°C, and about 0.3° to 0.6°C at a depth of about 1,000 meters by the end of the 21st century (IPCC 2014).

Under Representative Concentration Pathway (RCP) 8.5, the projected change in global mean surface air temperature and global mean sea level rise for the mid- and late 21st century relative to the reference period of 1986-2005 is as follows. Global average surface temperatures are likely to be 2.0°C higher (likely range: 1.4° to 2.6°C) from 2046-2065 and 3.7°C higher (likely range: 2.6° to 4.8°C) from 2081-2100. Global mean sea levels are likely to be 0.30 meters higher (likely range: 0.22 to 0.38 meters) from 2046-2065 and 0.63 meters higher (likely range: 0.45 to 0.82 meters) from 2081-2100, with a rate of sea level rise during 2081-2100 of 8 to 16 millimeters/year (medium confidence).

The past three decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (IPCC 2007; Greene *et al.* 2008). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the Earth's atmosphere caused by anthropogenic forces (IPCC 2007). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC 2007). Data from the 1960s through the 2000s showed that the NAO index increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2007). This warming extends over 1,000 meters deep and is deeper than anywhere in the world's oceans and is particularly evident under the Gulf Stream/North Atlantic Current system (IPCC 2007). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (IPCC 2007; Greene *et al.* 2008). There is evidence that the NADW has already freshened significantly (IPCC 2007). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the entire world (Greene *et al.* 2008).

There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007). These trends have been most apparent over the past few decades, although this may also be due to increased research. Information on future impacts of climate change in the action area is discussed below.

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

Expected consequences of climate change for river systems could be a decrease in the amount of dissolved oxygen 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 along the U.S. Atlantic coast 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 will experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2^{o}C per decade; and 3) a rise in sea level (NAST 2000). Sea level is expected to continue rising; during the 20th century global sea level has increased 15 to 20 centimeters. It is also important to note that ocean temperature in the U.S. Northeast Shelf and surrounding Northwest Atlantic waters have warmed faster than the global average over the last decade (Pershing *et al.* 2015). New projections for the U.S. Northeast Shelf and Northwest Atlantic Ocean suggest that this region will warm two to three times faster than the global average and thus existing projections from the IPCC may be too conservative (Saba *et al.* 2015).

6.2 Anticipated Effects to Atlantic Salmon and Critical Habitat

Atlantic salmon may be especially vulnerable to the effects of climate change in New England, since the areas surrounding many watersheds where salmon are found are heavily populated and have already been affected by a range of stresses associated with agriculture, industrialization, and urbanization (Elliot *et al.* 1998). Climate effects related to temperature regimes and flow conditions determine juvenile salmon growth and habitat (Friedland1998). One study conducted in the Connecticut and Penobscot rivers, where temperatures and average discharge rates have been increasing over the last 25 years, found that dates of first capture and median capture dates for Atlantic salmon have shifted earlier by about 0.5 days/ year, and these consistent shifts are correlated with long-term changes in temperature and flow (Juanes *et al.* 2004). Temperature increases are also expected to reduce the abundance of salmon returning to home waters, particularly at the southern limits of Atlantic salmon spatial distribution (Beaugrand and Reid 2003).

A study conducted in the United Kingdom that used data collected over a 20-year period in the Wye River found Atlantic salmon populations have declined substantially and this decline was best explained by climatic factors like increasing summer temperatures and reduced discharge more than any other factor (Clews *et al.* 2010). Changes in temperature and flow serve as cues for salmon to migrate, and smolts entering the ocean either too late or too early would then begin their post-smolt year in such a way that could be less optimal for opportunities to feed, predator risks, and/or thermal stress (Friedland 1998). Since the highest rate of mortality affecting Atlantic salmon occurs in the marine phase, both the temperature and the productivity of the coastal environment may be critical to survival (Drinkwater *et al.* 2003). Temperature influences the length of egg incubation periods for salmonids (Elliot *et al.* 1998) and higher water temperatures could accelerate embryo development of salmon and cause premature emergence of fry.

Since fish maintain a body temperature almost identical to their surroundings, thermal changes of a few degrees Celsius can critically affect biological functions in salmonids (NMFS and USFWS 2005). While some fish populations may benefit from an increase in river temperature for greater growth opportunity, there is an optimal temperature range and a limit for growth after which salmonids will stop feeding due to thermal stress (NMFS and USFWS 2005). Thermally stressed salmon also may become more susceptible to mortality from disease (Clews *et al.* 2010). A study performed in New Brunswick found there is much individual variability between Atlantic salmon and their behaviors and noted that the body condition of fish may influence the temperature at which optimal growth and performance occur (Breau *et al.* 2007).

The productivity and feeding conditions in Atlantic salmon's overwintering regions in the ocean are critical in determining the final weight of individual salmon and whether they have sufficient energy to migrate upriver to spawn (Lehodey *et al.* 2006). Survival is inversely related to body size in pelagic fishes, and temperature has a direct effect on growth that will affect growth-related sources of mortality in post-smolts (Friedland 1998). Post-smolt growth increases in a linear trend with temperature, but eventually reaches a maximum rate and decreases at high temperatures (Brett 1979 in Friedland 1998). When at sea, Atlantic salmon eat crustaceans and small fishes, such as herring, sprat, sand-eels, capelin, and small gadids, and when in freshwater, adults do not feed but juveniles eat aquatic insect larvae (FAO 2012). Species with calcium carbonate skeletons, such as the crustaceans that salmon sometimes eat, are particularly susceptible to ocean acidification, since ocean acidification will reduce the carbonate availability necessary for shell formation (Wood *et al.* 2008). Climate change is likely to affect the abundance, diversity, and composition of plankton, and these changes may have important consequences for higher trophic levels like Atlantic salmon (Beaugrand and Reid 2003).

In addition to temperature, stream flow is also likely to be impacted by climate change and is vital to Atlantic salmon survival. In-stream flow defines spatial relationships and habitat suitability for Atlantic salmon and since climate is likely to affect in-stream flow, the physiological, behavioral, and feeding-related mechanisms of Atlantic salmon are also likely to be impacted (Friedland 1998). With changes in in-stream flow, salmon found in smaller river systems may experience upstream migrations that are confined to a narrower time frame, as small river systems tend to have lower discharges and more variable flow (Elliot *et al.* 1998). The changes in rainfall patterns expected from climate change and the impact of those rainfall patterns on flows in streams and rivers may severely impact productivity of salmon populations (Friedland 1998). More winter precipitation falling as rain instead of snow can lead to elevated winter peak flows which can scour the streambed and destroy salmon eggs (Battin *et al.* 2007, Elliot *et al.* 1998). Increased sea levels in combination with higher winter river flows could cause degradation of estuarine habitats through increased wave damage during storms (NSTC 2008). Since juvenile Atlantic salmon are known to select stream habitats with particular characteristics, changes in river flow may affect the availability and distribution of preferred habitats (Riley *et al.* 2009). Unfortunately, the critical point at which reductions in flow begin to have a damaging impact on juvenile salmonids is difficult to define, but generally flow levels that promote upstream migration of adults are likely adequate to encourage downstream movement of smolts (Hendry *et al.* 2003).

Humans may also seek to adapt to climate change by manipulating water sources, for example in response to increased irrigation needs, which may further reduce stream flow and biodiversity (Bates *et al.* 2008).Water extraction is a high level threat to Atlantic salmon, as adequate water quantity and quality are critical for all life stages of Atlantic salmon (NMFS and USFWS 2005). Climate change will also affect precipitation, with northern areas predicted to become wetter and southern areas predicted to become drier in the future (Karl *et al.* 2009). Droughts may further exacerbate poor water quality and impede or prevent migration of Atlantic salmon (Riley *et al.* 2009).

We anticipate that these climate change effects could significantly affect the functioning of the Atlantic salmon critical habitat. Increased temperatures will affect the timing of upstream and downstream migration and make some areas unsuitable as temporary holding and resting areas. Higher temperatures could also reduce the amount of time that conditions are appropriate for migration (<23^{o} Celsius), which could affect an individual's ability to access suitable spawning habitat. In addition, elevated temperatures will make some areas unsuitable for spawning and rearing due to effects to egg and embryo development.

6.2.1 Anticipated Effects to Atlantic Salmon and Critical Habitat in the Action Area

Information on how climate change will impact the action area is extremely limited. According to Fernandez *et al.* (2015), the Intergovernmental Panel on Climate Change (IPCC) models predict that Maine's annual temperature will increase another 3.0–5.0 °F (1.7–2.8 °C) by 2050. The IPCC models predict that precipitation will continue to increase across the Northeast by 5–10% by 2050, although the distribution of this increase is likely to vary across the climate zones (Fernandez *et al.* 2015); model predictions show greater increases in precipitation in interior Maine. Total accumulated snow is predicted to decline in Maine especially along the coast where total winter snow loss could exceed 40% relative to recent climate (Fernandez *et al.* 2015). Since 2004, sea surface temperatures in the Gulf of Maine have accelerated to 0.41 °F (0.23 °C) per year; a rate that is faster than 99% of the world's oceans (Fernandez *et al.* 2015).

According to the most recent National Climate Assessment (Melillo *et al.* 2014), a global sea level is projected to rise an additional 0.5 to 2.0 feet (0.2 to 0.6 meters) or more by 2050. Rising sea levels would likely shift the salt wedge in the Kennebec River and other rivers in the GOM DPS; however the action area is relatively far from the current upper limits of the salt wedge where Merrymeeting Bay empties into the lower Kennebec River estuary (at least 15 rkm), and is buffered to some extent by Merrymeeting Bay. As there is significant uncertainty in the rate and timing of change as well as the effect of any changes that may be experienced in the action area due to climate change, it is difficult to predict the impact of these changes on Atlantic salmon.

In the action area, it is possible that changing seasonal temperature regimes could result in changes in the timing of seasonal migrations for the GOM DPS of Atlantic salmon in Maine. There could be shifts in the timing of spawning; presumably, if water temperatures stay warm further in the fall, and water temperature is a primary spawning cue, spawning migrations could occur earlier in the year and spawning events could occur later. However, because salmon spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature or river flow alone will affect the seasonal movements of salmon throughout the action area.

Atlantic salmon are cold water fish and have a thermal tolerance zone where activity and growth is optimal (Decola 1970). Temperature can be a stimulant for salmon migration, spawning, and feeding (Elson 1969). Temperature can also significantly influence egg incubation success or failure, food requirements and digestive rates, growth and development rates, vulnerability to disease and predation, and may be responsible for direct mortality (Garside 1973; Spence *et al.* 1996; Peterson *et al.* 1977, Whalen *et al.* 1999). When temperatures exceeded 23°C, adult Atlantic salmon can cease upstream movements. Salmon mortalities were associated with daily average temperatures of 26°C to 27°C.

As described above, over the long term, global climate change may affect Atlantic salmon and critical habitat by affecting the location of the salt wedge, distribution of prey, water flows, temperature and quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced over the short-term of the proposed action (i.e., 2018-2021). While we can make some predictions on the likely effects of climate change on this species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of this species which may allow them to deal with change better than predicted.

6.3 Anticipated Effects of Climate Change in the Action Area to Atlantic and shortnose sturgeon and the Androscoggin River Critical Habitat Unit

As stated above for Atlantic salmon, information on how climate change will impact the action area is extremely limited, but we generally expect Maine's annual temperature and total precipitation (especially in the form of rain) to increase, and we expect the salt wedge may shift up further in the Kennebec River estuary (see section 6.2.1 for more details).

Water availability, either too much or too little, as a result of global climate change is expected to have an effect on the features essential to successful sturgeon spawning and recruitment of the offspring to the marine environment (for Atlantic sturgeon). The increased rainfall predicted by some models in some areas may increase runoff, scour spawning areas, and create flooding events that dislodge early life stages from the substrate where they refuge in the first weeks of life. High freshwater inputs during juvenile development can influence juveniles to move further downriver and, conversely, lower than normal freshwater inputs can influence juveniles to move further upriver potentially exposing the fish to threats they would not typically encounter. Increased number or duration of drought events (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spawning season(s) may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to stranding or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues including effects to the combined interactions of dissolved oxygen, water temperature, and salinity. Elevated air temperatures can also impact dissolved oxygen levels in the water, particularly in areas of low water depth, low flow, and elevated water temperature. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems affecting dissolved oxygen and temperature.

The action area is approximately 15 rkm upstream from the present upper limit of salt water intrusion. The relatively short timeframe of the proposed action (2018-2021) makes any prediction of large scale and long-term climate change effects difficult. That said, over the next three years, we do not expect the salt front to shift far enough upstream to change the salinity of the action area and result in any restriction of spawning or nursery habitat.

In the action area, it is possible that changing seasonal temperature regimes could result in shifts in the timing of seasonal migrations through the area as sturgeon move throughout the river. Atlantic sturgeon prefer water temperatures up to approximately 28 °C (82.4 °F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28 °C are experienced in larger areas, Atlantic sturgeon may be excluded from some habitats. Additionally, temperature cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey.

Spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change). It is difficult to predict how any change in water temperature or river flow will affect the seasonal movements of sturgeon through the action area. However, it seems most likely that spawning would shift to earlier in the year.

Any forage species that are temperature dependent may also shift in distribution as water temperatures warm. However, because we do not know the adaptive capacity of these individuals or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict how these changes may affect foraging sturgeon. If sturgeon distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sturgeon shifted to areas where different forage was available and sturgeon were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sturgeon shifted to an area or time where insufficient forage was available; however, the likelihood of this happening is low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

Limited information on the thermal tolerances of Atlantic and shortnose sturgeon is available. Atlantic sturgeon have been observed in water temperatures above 30°C in the south (see Damon-Randall *et al.* 2010); in the wild, shortnose sturgeon are typically found in waters less than 28°C. In the laboratory, juvenile Atlantic sturgeon showed negative behavioral and bioenergetics responses (related to food consumption and metabolism) after prolonged exposure to temperatures greater than 28°C (82.4°F) (Niklitschek 2001). Tolerance to temperatures is thought to increase with age and body size (Ziegweid *et al.* 2008 and Jenkins *et al.* 1993), however, no information on the lethal thermal maximum or stressful temperatures for subadult or adult Atlantic sturgeon is available. Shortnose sturgeon, have been documented in the lab to experience mortality at temperatures of 33.7°C (92.66°F) or greater and are thought to experience stress at temperatures above 28°C. For purposes of considering thermal tolerances, we consider Atlantic sturgeon to be a reasonable surrogate for shortnose sturgeon given similar geographic distribution and known biological similarities. Rising temperatures could meet or exceed the preferred temperature of shortnose and Atlantic sturgeon (28°C) on more days and/or in larger areas. This could result in shifts in the distribution of sturgeon out of certain areas during the warmer months. Information from southern river systems suggests that during peak summer heat, sturgeon are most likely to be found in deep water areas where temperatures are coolest. Thus, we could expect that over time, sturgeon would shift out of shallow habitats on the warmest days. This could result in reduced foraging opportunities if sturgeon were foraging in shallow waters.

As described above, over the long term, global climate change may affect shortnose and Atlantic sturgeon by affecting the location of the salt wedge, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which shortnose or Atlantic sturgeon will be able to successfully adapt to any such changes. Any activities occurring within and outside the action area that contribute to global climate change are also expected to affect shortnose and Atlantic sturgeon in the action area. While we can make some predictions on the likely effects of climate change on these species, without modeling and additional scientific data these predictions remain speculative. Additionally, these predictions do not take into account the adaptive capacity of these species which may allow them to deal with change better than predicted.

Additional modeling for climate change impacts, particularly salt water intrusion, are needed for the action area, to better assess the potential effects on shortnose and Atlantic sturgeon, as well as Atlantic sturgeon critical habitat. Effects are further complicated due to the action area's location directly below the Brunswick Dam, which could serve to regulate some of the impacts depending on its operation (e.g., scheduled discharges of water).

7.0 EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR § 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR § 402.02). This Opinion examines the likely effects (direct, indirect, and interrelated/interdependent) of the proposed action on the GOM DPS of Atlantic salmon, critical habitat designated for the GOM DPS of Atlantic salmon, shortnose sturgeon, Atlantic sturgeon (GOM DPS), and the Androscoggin River Unit of critical habitat designated for Atlantic sturgeon (GOM DPS). We consider these effects on the species and their habitat within the context of the species status now and projected over the course of the action, the environmental baseline and cumulative effects.

As explained in the "Description of the Proposed Action" section (3.0), the action under consideration in this Opinion is the construction of a new bridge to replace the existing Frank J. Wood Bridge, which carries US 201/ME 24 over the Androscoggin River between the Towns of Brunswick and Topsham. After the new bridge is constructed, MaineDOT will remove the existing Frank J. Wood Bridge. MaineDOT expects all work to occur between September 2018 and March 2021.

In our effects analysis below, we consider the co-occurrence of each species, lifestage, behavior and critical habitat physical and biological features (PBFs) with the in-water work window (August 1 to March 15) (Table 20) and the timing of each potential project-related effect as indicated by the task matrix (Table 2). We also consider the long-term direct and indirect effects associated with the permanent structures resulting from the proposed action We have divided the following sections by the project related stressors we have identified that may have an effect on listed species or critical habitat.

Table 20: Anticipated overlap of ESA-listed species (by lifestage) with in-water work for the Frank J. Wood Bridge project

Species	Life Stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Atlantic Salmon	Egg												
	Larvae												
	Parr												
	Smolt												
	Adult												
Atlantic Sturgeon	Egg/YSL												
	PYSL												
	Juvenile												
	Sub-adult												
	Adult												
Shortnose Sturgeon	Egg/YSL												
	PYSL												
	Juvenile												
	Adult												

Dark green shading indicates that species/lifestage may be present in the action area

Light green shading indicates in-water work period

7.1 Sedimentation and Turbidity

7.1.1 Proposed activities that may produce sedimentation and turbidity

During the Frank J. Wood Bridge replacement project, several activities associated with construction of the new structure and demolition of the existing structure have potential to disturb sediments and increase turbidity. These actions include:

- Construction and removal of the temporary work trestle;
- Construction and removal of the cofferdams; and,
- Removal of existing pier structure.

Construction of the temporary trestle will begin with the installation of a temporary access point from the Topsham bank (within the upper pool to which sturgeon do not have access). MaineDOT proposes to construct this access point on 2,000 square feet of temporary fill, consisting of non-erodible material that will remain stable at high flows; however, they will use a turbidity curtain. MaineDOT estimates the temporary work trestle may require 13 bents (support sections) spaced 50 feet apart and consisting of up to 5 piles per bent. Driving the piles into the bedrock is not possible, so the contractor will either pin the piles by drilling into the bedrock or securing the piles to the bedrock using a plate (also drilled into the bedrock). Removal methods for the trestle piles and associated stressors vary based on the approach used to install them. If plates are attached to bedrock with large anchors they will be removed by unbolting or cutting the bolts flush at the attachment points. Alternatively, piles that are pinned into the ledge will be freed and pins will be cut flush with the surrounding substrate. Removal of bolted or pinned trestles may require boats and divers to unbolt, or cut trestle connections to the bedrock. Excavators will stabilize the piles while they are cut free and will lift the piles from the attachment points. Once the piles are removed the remaining pins or bolts will be cut or ground flush with the bedrock.

MaineDOT is proposing to install sheet pile cofferdams around each of the three proposed in-water bridge piers. Construction of the southern (Brunswick) abutment will also occur within a cofferdam (the abutment is above the high water line, but the area still may be inundated during high flow events). Because the substrate in the project area is predominantly exposed bedrock; sheetpiles for cofferdams cannot be driven into substrate as per typical installation. Sheet pile cofferdams will be cut to fit the contour of the bedrock, braced with internal structural supports, and then sealed with concrete. Any in-river rock excavation will occur behind a cofferdam (e.g., blasting, hoe ram). MaineDOT will remove the cofferdams using a vibratory extractor (hammer) once the pier concrete has cured and all necessary in-the-dry work is completed.

For demolition of the existing pier nearest the Brunswick shore, MaineDOT plans to use a hydraulic breaker or blast the structure to rubble. If blasting is deemed necessary, a blasting plan will be submitted to us at least 150 days prior to blasting (see AMMs 8 – 10). Contractors will use an excavator to remove pier debris from the river bottom. MaineDOT anticipates up to 2 to 4 weeks for the demolition of the pier, and has proposed to do this portion of the work between December (2020) and January (2021) (Table 2).

As described above, substrate within the project area is predominately bedrock, with some rubble and cobble materials in the vicinity of the existing bridge pier, as well as some pockets of coarse sand. As a result, we expect that impacts from sedimentation and increased turbidity to be lower at this location than project locations with heavy loads of mud or silt sediment. Given the low anticipated levels of sedimentation from in-water activities and relatively high velocity conditions in the action area (due to water management at Brunswick Dam), we anticipate that any suspended solids will be quickly transported and dissipated downstream. To further reduce the potential effects from sedimentation and turbidity, Maine DOT will require contractors to comply with AMMs #2, #3, #5 and #14, which require erosion control measures, exclude in-water turbidity producing work from occurring between March 15 and July 31, require turbidity curtains around areas planned for in-water fill (associated with construction of the temporary trestle), and control devices to prevent superstructure demolition debris from entering the water (Table 3).

The attachment and removal of piles for the trestle and cofferdams, though mainly occurring on exposed bedrock, may disturb some smaller cobbles, gravel, and coarse sand. Using available information collected from a project in the Hudson River, we expect pile driving activities in soft substrates (clays, silt, fine sand) to produce total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 feet (91 meters) of the pile being driven (FHWA 2012). Here, despite the lack of fine substrates, we conservatively rely on this estimate because we do not have better information for the project site conditions. Blasting or hoe ram activities to set the new piers, as well as construction and removal of the temporary access point in the upper pool area, will occur behind cofferdams, and therefore, suspended sediments or turbidity from these activities will not affect listed species or critical habitat. The removal of the substructure using a hoe ram or blasting and subsequent clean up with an excavator will not occur when listed species are present (April 1 – November 30); however, these activities may result in suspended sediments and turbidity. Similar to the pile and cofferdam placement/removal above, we do not expect significant sedimentation or turbidity plumes to occur from the removal of substructure debris from underlying bedrock, cobble, and coarse sand, as the dense disturbed material will quickly be dissipated by downstream flows and settle back on the riverbed in less than an hour (likely in a matter of several minutes). Given these conditions, and that existing turbidity and TSS estimates for mechanical dredging are predominantly in soft substrates that would overestimate the stressor in this environment, we again rely on the pile driving proxy from above, and expect total suspended sediment (TSS) concentrations of approximately 5.0 to 10.0 mg/L above background levels within approximately 300 feet of the excavation work. Due to relatively high flows (velocities in the tailrace range from approximately 6.0 to 8.0 feet per second) and the dominant substrate of bedrock and exposed boulders, cobble, and gravel, we expect background TSS levels below the Brunswick Dam (where increases in turbidity/TSS from the project may occur) to be less than 10 mg/L (Moore and Reblin 2010).

7.1.2 Effects of Turbidity and Suspended Sediments on Salmon and Sturgeon

Studies of the effects of turbid water on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute toxic reaction is expected (Burton 1993). The TSS levels expected for all of the proposed activities (ranging up to 10 mg/L above background conditions) are below those shown to have adverse effect on fish (580 mg/L for the most sensitive species, with 1,000 mg/L more typical; see summary of scientific literature in Burton 1993) and benthic communities (390 mg/L (EPA 1986)).

TSS is most likely to affect mobile sturgeon (post yolk-sac larvae and older) if a plume causes a barrier to normal behaviors. The life stages of sturgeon most vulnerable to increased sediment are eggs and non-mobile yolk-sac larvae which are subject to burial and suffocation.

The in-water work window of August 1 – March 15 avoids construction activity when shortnose sturgeon are present in the action area. While we expect adult Atlantic sturgeon to have exited the action area by August 1, their eggs, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) are likely to occur in the action area into the in-water work window. All YSL will have transitioned to the PYSL life stage by August 18, at which point we expect all PYSL to quickly move downstream out of the action area (most will have already done so earlier in the spawning season, as these PYSL would only be moving downstream in mid-August if they came from eggs fertilized at the very end of the spawning season in July). To protect these early lifestages, particularly immobile eggs and YSL, you have agreed to delay in-river construction of the temporary cofferdam and trestle until September 1, 2018 (AMMs 5 & 7, Table 3). With these AMMs in place, we do not expect increases in sedimentation or turbidity to have any effect on Atlantic sturgeon adults or early life stages.

Effects to Atlantic salmon worsen with increased levels of turbidity (Newcomb 1994). Juveniles and adults salmonids show minor physiological stress and sublethal effects at suspended sediment concentrations of 7 mg/L for a six-day exposure and at 55 mg/L for a seven-hour exposure (Newcomb and Jensen 1996). MaineDOT's Programmatic Biological Assessment

(ATS PBA 2016) outlined biological responses for Atlantic salmon and classified them into three major categories. The three categories are behavioral responses, sub-lethal effects, and potential mortality, as defined below.

Behavioral response - The range of turbidity releases expected to result in behavioral reactions ranging from a startle response to avoidance.

- 1-20 mg/L for 1 hour
- 1 mg/L for 24 hours

Sub-lethal effects – The ranges of turbidity releases expected to result in sub-lethal effects including stress, reduction in feeding rates, and increased respiration rates.

- 20-22026 mg/L for 1 hour
- 1 mg/L for 6 days

Potential mortality - A higher range of releases has the potential to result in fish mortality.

- >22026 mg/L for 1 hour
- 7 mg/L for 30 months

Because of the in-water work window, we do not expect any Atlantic salmon smolts to be exposed to increased levels of TSS or turbidity. Adults could potentially be migrating through the action area during in-water work from August 1 – November 30. Based on the categories above, we expect TSS levels of 5-10 mg/L above baseline conditions (i.e., a maximum temporary exposure of 20 mg/L) to potentially cause a behavioral response. We do not expect exposure to 20 mg/L for one hour or longer, and therefore, no sub-lethal effects will occur. Over the last decade for which we have data (2007-2016), very few adult Atlantic salmon have returned to the Androscoggin River. Over this period, an average of 12.5 fish have returned each season; however, over the past five years, the average returns have dropped to 2.4 fish. As explained above, we expect all turbidity and TSS to quickly dissipate from the water column in less than an hour (likely in several minutes). Therefore, given the infrequent returns of adult salmon, the in-water work window, and the ephemeral nature of the stressor, we expect any adverse effects to adult salmon migration (i.e., migratory delay) to be extremely unlikely to occur, and therefore, discountable.

7.2 Underwater Noise

Three in-water activities may result in elevated underwater sound pressure during construction; (1) drilling, (2) hydraulic rock breaker (hoe ram) and (3) blasting.

7.2.1 Available Information on Effects of Sound Pressure on Fish

Sturgeon rely primarily on particle motion to detect sounds (Lovell *et al.* 2005). While there are no data either in terms of hearing sensitivity or structure of the auditory system for Atlantic and shortnose sturgeon, there are data for the closely related lake sturgeon (Lovell *et al.* 2005; Meyer *et al.* 2010), which serve as a good surrogate for Atlantic and shortnose sturgeon when considering acoustic impacts due to the biological similarities among the species. The available data suggest that lake sturgeon can hear sounds from below 100 Hz to 800 Hz (Lovell *et al.* 2005, Meyer *et al.* 2010). However, since these two studies examined responses of the ear and did not examine whether fish would behaviorally respond to sounds, it is hard to determine the level of noise that would trigger a behavioral response (that is, the lowest sound levels that an animal can hear at a particular frequency) using information from these studies. The best available information indicates that Atlantic and shortnose sturgeon are not capable of hearing noise in frequencies above 1,000 Hz (1 kHz) (Popper 2005). Sturgeon are categorized as hearing "generalists" or "non-specialists" (Popper 2005). Sturgeon do not have any specializations, such as a coupling between the swim bladder and inner ear, to enhance their hearing capabilities, which makes these fish less sensitive to sound than hearing specialists. Low-frequency impulsive energies, including pile driving, cause swim bladders to vibrate, which can cause damage to tissues and organs as well as to the swim bladder (Halvorsen *et al.* 2012a).

Sturgeon and salmon have a physostomous (open) swim bladder, meaning there is a connection between the swim bladder and the gut (Halvorsen *et al.* 2012a). Fish with physostomous swim bladders are able to expel air, which can diminish tension on the swim bladder and reduce damaging effects during exposure to impulsive sounds. Fish with physostomous swim bladders are expected to be less susceptible to injury from exposure to impulsive sounds, such as pile driving, than fish with physoclistous (no connection to the gut) swim bladders (Halvorsen *et al.* 2012a).

If a noise is within a fish's hearing range and is loud enough to be detected, effects can range from mortality to a minor change in behavior (e.g., startle), with the severity of effects increasing with the loudness and duration of the exposure to the noise (Hastings and Popper 2005). The actual nature of effects and the distance from the source at which they could be experienced will vary and depend on a large number of factors. Factors include fish hearing sensitivity, source level, how the sounds propagate away from the source, and the resultant sound level at the fish, whether the fish stays in the vicinity of the source, the motivation level of the fish, etc.

7.2.1.1 Criteria for Assessing the Potential for Physiological Effects to Sturgeon and Salmon

The Fisheries Hydroacoustic Working Group (FHWG) was formed in 2004 and consists of biologists from NMFS, USFWS, FHWA, and the California, Washington, and Oregon DOTs, supported by national experts on sound propagation activities that affect fish and wildlife species of concern. In June 2008, the agencies signed a Memorandum of Agreement documenting criteria for assessing physiological effects of pile driving on fish. The criteria were developed for the acoustic levels at which physiological effects to fish could be expected. It should be noted that these are onset of physiological effects (Stadler and Woodbury 2009), and not levels at which fish are necessarily mortally damaged. These criteria were developed to apply to all species, including listed green sturgeon and Pacific salmon, which are biologically similar to Atlantic and shortnose sturgeon and Atlantic salmon, respectively, and for these purposes, we consider them a surrogate. The interim criteria are:

- Peak Sound Pressure Level (SPL): 206 decibels relative to 1 micro-Pascal (dB re 1 µPa) (206 dB_{Peak}).
- Cumulative Sound Exposure Level (cSEL): 187 decibels relative to 1 micro-Pascal-squared second (dB re 1µPa^2-s) for fishes above 2 grams (0.07 ounces) (187 dB cSEL).
- cSEL: 183 dB re 1µPa^2-s for fishes below 2 grams (0.07 ounces) (183 dB cSEL).

At this time, these criteria represent the best available information on the thresholds at which physiological effects to sturgeon from exposure to impulsive noise, such as pile driving, are likely to occur. It is important to note that physiological effects may range from minor injuries from which individuals are anticipated to completely recover with no impact to fitness, to significant injuries that will lead to death. The severity of injury is related to the distance from the pile being installed and the duration of exposure. The closer the fish is to the source, and the greater the duration of the exposure, the higher likelihood of significant injury.

Since the FHWG criteria were published, two papers relevant to assessing the effects of pile driving noise on fish have been published. Halvorsen *et al.* (2011) documented effects of pile driving sounds (recorded by actual pile driving operations) under simulated free-field acoustic conditions where fish could be exposed to signals that were precisely controlled in terms of number of strikes, strike intensity, and other parameters. The study used Chinook salmon and determined that onset of physiological effects that have the potential of reduced fitness, and thus a potential effect on survival, started at above 210 dB re 1µPa^2-s cSEL. Smaller injuries, such as ruptured capillaries near the fins, which the authors noted were not expected to impact fitness, occurred at lower noise levels.

Halvorsen *et al.* (2012b) exposed lake sturgeon to pile driving noise in a laboratory setting. Lake sturgeon were exposed to a series of trials beginning with a cSEL of 216 dB re 1uPa^2-s (derived from 960 pile strikes and 186 dB re 1uPa^2-s sSEL). Following testing, fish were euthanized and examined for external and internal signs of barotrauma. None of the lake sturgeon died as a result of noise exposure. Lake sturgeon exhibited no external injuries in any of the treatments but internal examination revealed injuries consisting of hematomas on the swim bladder, kidney, and intestines (characterized by the authors as “moderate” injuries) and partially deflated swim bladders (characterized by the authors as “minor” injuries). The author concludes that an appropriate cSEL criteria for injury is 207 dB re 1uPa^2-s. Chinook salmon are hearing generalists with physostomous swim bladders. Results from Halvorsen *et al.* (2012a) suggest that the overall response to noise between chinook salmon and lake sturgeon is similar.

It is important to note that both Halvorsen papers (2012a, 2012b) used a response weighted index (RWI) to categorize injuries as mild, moderate, or mortal. Mild injuries (RWI 1) were determined by the authors to be non-life threatening. The authors made their recommendations for noise exposure thresholds at the RWI 2 level and used the mean RWI level for different exposures. We consider even mild injuries to be physiological effects and we are concerned about the potential starting point for physiological effects and not the mean. Therefore, for the purposes of carrying out section 7 consultations, we will use the FHWG criteria to assess the potential physiological effects of noise on Atlantic and shortnose sturgeon and Atlantic salmon and not the criteria recommended by Halvorson *et al.* (2012a, 2012b). Following the FHWG criteria, we will consider the potential for physiological effects upon exposure to impulsive noise of 206 dB_{Peak}. Use of the 187 dBcSEL and 183 dBcSEL threshold (for sturgeon/salmon 2 grams or smaller) is a cumulative measure of cumulative impulsive sound (such as impact pile driving) and is not appropriate for blasting. As explained here, physiological effects from noise exposure can range from minor injuries that a fish is expected to completely recover from with no impairment to survival to major injuries that increase the potential for mortality or result in death.

7.2.1.2 Criteria for Assessing the Potential for Behavioral Effects to Sturgeon and Salmon

Results of empirical studies of hearing of fishes, amphibians, birds, and mammals (including humans), in general, show that behavioral responses vary substantially, even within a single species, depending on a wide range of factors, such as the motivation of an animal at a particular time, the nature of other activities that the animal is engaged in when it detects a new stimulus, the hearing capabilities of an animal or species, and numerous other factors (Brumm and Slabbekoorn 2005). Thus, it may be difficult to assign a single criterion above which behavioral responses to noise would occur.

In order to be detected, a sound must be above the "background" level. Additionally, results from some studies suggest that sound may need to be biologically relevant to an individual to elicit a behavioral response. For example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable, but not very loud, the shad will not respond (Plachta and Popper 2003). But, if the sound level is raised an additional eight or ten dB, the fish will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied series of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were those recognized by the American shad as being from very distant predators, and thus, not worth a response. At somewhat higher levels, the shad recognized that the predator was closer and then started to swim away. Finally, the loudest sound was thought to indicate a very near-by predator, eliciting maximum response to avoid predation. Similarly, results from Doksaeter *et al.* (2009) suggest that fish will only respond to sounds that are of biological relevance to them. This study showed no responses by free-swimming herring (*Clupea* spp.) when exposed to sonars produced by naval vessels; but, sounds at the same received level produced by major predators of the herring (killer whales) elicited strong flight responses. Sound levels at the fishes from the sonar in this experiment were from 197 dB to 209 dB re 1 µPa RMS at 1,000 to 2,000Hz.

For purposes of assessing behavioral effects of pile driving at several West Coast projects, NMFS has employed a 150dB re 1 µPa RMS SPL criterion at several sites including the San Francisco-Oakland Bay Bridge and the Columbia River Crossings. For the purposes of this consultation we will use 150 dB re 1 µPa RMS as a conservative indicator of the noise level at which there is the potential for behavioral effects. That is not to say that exposure to noise levels of 150 dB re 1 µPa RMS will always result in behavioral modifications or that any behavioral modifications will rise to the level of "take" (i.e., harm or harassment) but that there is the potential, upon exposure to noise at this level, to experience some behavioral response. Behavioral responses could range from a temporary startle to avoidance of an ensonified area.

7.2.2 Underwater Noise from Drilling

The bedrock substrate located throughout the project area will require contractors to use a pin system to install the piles forming the base of the temporary work trestle. Trestles may either be directly pinned to the bedrock using rock dowels or installation will include a plate system to affix the trestle piles. Installation of each pin set includes drilling a hole into the bedrock that corresponds to the base of the trestle piles. A rock dowel is inserted into each drill hole which is mortared into the bedrock forming a secure anchor point for the temporary trestle. Once mortar has cured, trestle piles are lowered onto the anchor points and bolted in place. Preliminary construction schedule includes installation of the temporary work trestle over an estimated 60 day period from September to November, 2018, but may occur any time within the in-water work window.

Drilling is a continuous noise source that generates vibrations as a result of friction and/or percussion between the drill bit and the bored material. Noise generated from the drill produces sound waves that traverse the sediment above the boring to the river bottom. As sound waves propagate from the inlet bottom, noise attenuates as the distance from the source increases. Noise attenuation is dependent on site-specific bottom composition, bathymetric profile, absorption of the sound by water, and scattering due to air bubbles or suspended sediment (Transit Link Consultants 2008 as cited by NMFS 2012). Spreading loss rates for large boring drills, such as a ground tunnel boring machine, range from a 3 dB to 6 dB decrease per doubling of distance and from 10 dB to 20 dB per 10-fold increase in distance (Transit Link Consultants 2008 as cited by NMFS 2012). Installation of steel piles for temporary work trestle will likely be completed with much smaller drilling equipment, so spreading loss rates may be even greater as the vibrations produced from a smaller drill will be much smaller in magnitude, and may dissipate more quickly. However, if we consider the known noise levels from a tunnel boring machine and the corresponding spreading loss rate as reference points for assessing the impacts of drilling on fish, the sound levels produced by drilling are likely below the range that could negatively affect fish. Reported dB RMS levels from in-water drilling activities using large boring drills are lower than 150 dB RMS (Caltrans 2015). Noise levels anticipated from the smaller drills (which will likely be used to install the temporary trestle attachments) are expected to be even less, remaining well below the behavioral effects threshold.

7.2.2.1 Effects of Drilling Underwater Noise on Salmon and Sturgeon

As we do not expect the noise from drilling to rise to the behavioral (150 dB RMS) or physiological (206 dB Peak; 183 or 187 dB cSEL), we do not expect drilling noise to adversely affect sturgeon or salmon in the action area.

7.2.3 Underwater Noise from Hydraulic Rock Breaker

Hydraulic breakers, or hoe rams, are used to fracture bedrock or concrete structures into small pieces. Typical applications include removal of underlying bedrock during bridge construction, or the demolition of concrete elements of decommissioned bridges. It is likely that the selected contractors may use hoe rams during construction of the new bridge and demolition of the existing Frank J. Wood Bridge substructure.

MaineDOT has not conducted hydroacoustic monitoring during bridge demolition activities with a hoe ram. To date, there is conflicting literature on the effects of hoe ram use on fish. Historic observations suggested that it was not likely to result in adverse effects while more recent literature indicates potential adverse effects from the activities (ATS PBA 2016). Washington State Department of Transportation (WSDOT) conducted sound monitoring during demolition of two bridge piers using a hoe ram. Underwater sound levels were recorded for two different sized hoe rams during the demolition of the above-water portion of two concrete water-based piers on the Manette Bridge in Bremerton, WA at 10 m from the source (Escude 2012; Table 21). Peak sound pressure levels for the two hoe rams reached 189 and 205 dBpeak respectively, average RMS reached 173 and 186 dB re 1 µPa, and cumulative sound levels were 195 and 196 dB SELcum. The recorded hoe ram waveforms were nearly identical to impact pile driving waveforms.

Table 21: Results from monitoring of Manette Bridge Demolition (WSDOT)

	Peak (dB)	Average Peak	Average RMS	Single Strike SEL	Number of record	Cumulative SEL (dB)
Hoe	189	183	173	160	3022	195
Hoe	205	197	186	171	707	196

Hydroacoustic monitoring data from a bridge demolition conducted by Caltrans at Ten Mile Bridge (Illingworth and Rodkin 2010) reached a similar conclusion in determining that hoe ram activity at or below the water line will result in sound levels similar to impact pile driving. Monitoring at other Caltrans bridge locations indicates that demolition work on elevated structures or outside of the wetted channel does not result in potentially injurious noise levels for fish. The sample size for monitoring data for this activity is small compared to impact pile driving and results have been variable depending on multiple site-specific factors.

A hoe ram may be used to remove bedrock and shape the pier footprints prior to pier construction. All or portions of the three proposed piers are below the normal high water line. The two northernmost piers will be constructed adjacent to the bedrock ridge that forms the lower extent of the ponded area on the Topsham side of the channel upstream of the proposed bridge. The southernmost pier will be attached to bedrock at the base of Shad Island, extending into the wetted channel. Duration of hoe ram use will be dependent on the volume of bedrock required to be removed, which will be determined in the final construction plans. MaineDOT assumes that site preparation for a single pier using a hoe ram can be accomplished in approximately 5 days, equaling a total of 15 days of hoe ram use for pier construction. Hoe rams may also be used during demolition of the center pier of the existing bridge. Recent inspections of the center pier reported crumbling concrete with portions of stacked granite blocks. Therefore, if hoe rams are used for demolition, it is estimated that the center pier can be removed flush to the surrounding substrate in approximately 2 to 4 weeks. Although the preliminary construction schedule in Table 2 identifies the period of greatest probability of hoe ram use as occurring from mid-November through December, it may be used as needed between November 8 and March 15 (AMM 8).

7.2.2.2 Effects of Hydraulic Breaker Underwater Noise on Salmon and Sturgeon

Because MaineDOT has agreed to only conduct bedrock leveling and substructure removal using hydraulic breakers (or hoe rams) from November 8 to March 15, we do not expect any Atlantic or shortnose sturgeon to be present; therefore, those two species will not be affected by underwater noise produced by hydraulic breakers.

While outmigrating Atlantic salmon adults (kelts) could be in the action area through November, the occurrence of kelts in the action area after November 7 would be extremely rare. As explained above, Lévesque *et al.* (1985) and Baum (1997) suggest that 80% of kelts overwinter in freshwater habitat prior to returning to the ocean. Very few adult Atlantic salmon return to the Androscoggin each year. Again, prior to 2007, MDMR stated that there were no indications that the Androscoggin River had a reproducing population of Atlantic salmon (letter from MDMR to

FERC dated March 25, 2010) and there is no documentation of successful spawning in the Androscoggin River (MDMR 2012). This situation further reduces the likelihood of kelts entering the action area during the period of time when a hydraulic breaker would be operating. Therefore, adverse effects to salmon from exposure to injurious levels of noise, or noise that would disrupt migratory behavior, are extremely unlikely to occur, and are therefore, discountable.

7.2.4 Underwater Noise from Blasting

The project timeline for construction of the new bridge piers will be constrained by limitations imposed by the in-water work window. As a result, contractors may petition for use of blasting to prepare footings for piers rather than the more time-consuming hoe ram chipping. Based on geotechnical evaluations of bedrock, it is possible that bedrock blasting may be more efficient to remove rock to provide suitable bearing surface for the cofferdam seals or fill concrete at the pier and abutments. In addition to preparation of the footing areas, blasting may also be used to demolish the center pier of the existing Frank J. Wood Bridge (which is currently scheduled to occur between December 16, 2020 and January 19, 2020). In accordance to AMM 8, if blasting is required, any blasting to achieve bedrock leveling and substructure removal will occur from November 8 to March 15.

Furthermore, you will submit any plans for any project-related blasting to us 150 days before the activity is to take place, and you plan design all blasts to remain below potential fish injury limits (206 dB Peak (2.89 PSI))(AMM 9). Also, in accordance to AMM 10, any blasting activities between November 8 and November 30 will incorporate the following minimization measures to reduce potential impacts to adult Atlantic salmon which may still be present in the area.

- Active acoustic monitoring of the action area for any tagged fish potentially present in the Androscoggin River.
- Minimize charge sizes and the number of days of exposure to blasting.
- Deploy scare charges prior to the main blast.
- Conduct visual inspection of the action area post-blast to document any impacts to fish.

7.2.3.1 Available Information on Effects of Blasting on Fish

There have been numerous studies that have assessed the direct impact of underwater blasting on fish. While not all of the studies have focused exclusively on shortnose or Atlantic sturgeon, the results demonstrate that blasting does have an adverse impact on fish. Teleki and Chamberlain (1978) found that several physical and biological variables were the principal components in determining the magnitude of the blasting effect on fish. Physical components include detonation velocity, density of material to be blasted, and charge weight, while the biological variables are fish shape, location of fish in the water column, and swimbladder development. Composition of the explosive, water depth, and bottom composition also interact to determine the characteristics of the explosion pressure wave and the extent of any resultant fish kill. Furthermore, the more rapid the detonation velocity, the more abrupt the resultant hydraulic pressure gradient, and the more difficulty fish appear to have adjusting to the pressure changes.

The strength of the wave depends on the type and amount of explosives, the manner and depth at which the charges are placed, and the proximity of the detonation to the rock/water interface. As detonation velocity (i.e., burn rate) differs for explosive types, so does the corresponding pressure wave. A slower burning explosive "pushes" the substrate and generates a reduced pressure wave compared to a faster burning explosive that "shatters" the substrate and produces a much stronger pressure wave. Rates of sound transmission loss and attenuation for a specific site depend on water depth, temperature, substrate composition, bathymetric profile, and scattering due to air bubbles or suspended sediment (Transit Link Consultants 2008 as cited in NMFS 2012).

The effects of blasting on shortnose sturgeon was conducted in Wilmington Harbor, North Carolina, in December 1998 and January 1999 in order to adequately assess the impacts of blasting on shortnose sturgeon, the size of the LD1 area (the lethal distance from the blast where 1% of the fish died). As explained in Moser 1999, the test blasting consisted of 32-33 blasts (3 rows of 10 to 11 blast holes per row with each hole and row 10 feet apart), about 24 to 28 kg of explosives per hole, stemming each hole with angular rock, and an approximate 25 m/sec delay after each blast. During test blasting, 50 hatchery reared juvenile striped bass and shortnose sturgeon were placed in 0.25" plastic mesh cylinder cages (2 feet in diameter by 3 feet long) 3 feet from the bottom (worst case scenario for blast pressure as confirmed by test blast pressure results) at 35, 70, 140, 280, and 560 feet upstream and downstream of the blast location. For each test, 200 caged shortnose sturgeon were held at a control location 0.5 mi from the test blast area. The caged fish had a mean weight of 55 grams. The cages were enclosed in a 0.6" nylon mesh sock to prevent the escape of any sturgeon if the cage was damaged during blasting. The caging experiments were conducted during a total of seven blasts between December 9, 1998 and January 7, 1999. Three test blasts were conducted with an air curtain in place, and four were conducted without an air curtain. The air curtain (when tested) was 50 feet from the blast. The caged fish were visually inspected for survival just after the blast and after a 24-hour holding period. Mortality rates for control fish were generally low, with 15 fish dead or mortally injured on inspection (out of a total of 1,400 samples). The numbers of injured, dead, and mortally injured sturgeon varied greatly between tests. Of the 500 fish tested during each blast, mortalities (dead or mortally injured) ranged from one to 89 fish. Mortality rates for shortnose sturgeon as compared to the other species tested were low, with the author of the report concluding that this was likely due to the larger size of shortnose sturgeon tested (approximately 30cm average) as compared to the size of the other species (3cm – 20cm).

In addition to the external examinations of fish immediately following the blast and 24 hours later, a sample of 10 randomly selected, apparently unaffected, sturgeon from each of seven cages nearest the blasts were sacrificed and later necropsied (Moser 1999). After the necropsy was completed, the total extent of injury was scored on a scale of 0-10, with 10 being the most severe level of injury observed. It is important to note that all of the fish necropsied were alive 24 hours following the blast and appeared to be uninjured based on the initial external observations. Fish scored at 7 or higher were thought to be unlikely to survive and function normally with the injuries they sustained. Injuries ranged from no sign of external injury to extensive internal hemorrhaging and ruptured swim bladders.

All fish necropsied were in apparently normal condition when sacrificed 24 hours after the blast. The fish were swimming normally in their cages and exhibited no outward signs of stress or physical discomfort (Moser 1999). However, internal examinations revealed extensive damage in many of the fish necropsied. Of the 70 sturgeon necropsied, ten had an index of injury of 7 or higher, meaning that they likely would not have survived the injuries sustained during blasting. While sturgeon had relatively little damage to their swim bladders, they more often had distended intestines with gas bubbles inside and hemorrhage to the body wall lining. In the fish caged 70 feet away, there was no sign of hemorrhage or swim bladder damage but two of the fish exhibited distended intestines, which may have been caused by the blast. Moser (1999) speculated that sturgeon fared better than striped bass because their air bladder has a free connection to the esophagus, allowing gas to be expelled rapidly without damage to the swim bladder. Additionally, there was no clear relationship between size and the Index of Injury, size and gut fullness, or Index of Injury and gut fullness. The author notes that external observation of the fish following blasting was not sufficient to identify all blast-related injuries and that many of the internal injuries observed in fish that externally appeared unaffected would have resulted in eventual mortality.

Sturgeon appear to be able to withstand some degree of blasting at a certain distance from the detonation, but it is apparent from the study results outlined above that blasting may injure the species both internally and externally. Any sturgeon within 500 feet of the blasts could experience injury or mortality. Based on the information presented above, listed species in the action area occurring within 500 feet of a detonation resulting in peak pressures of 120 psi (~238 dB re 1 µPa) and average pressure of 70 psi (~234 dB re 1 µPa) would be exposed to noise and pressure levels that could cause adverse effects. These effects could range from avoidance behaviors, temporary stunning, external or internal injury with full recovery, injury with delayed mortality or injury sufficient to cause immediate mortality.

Alaska Department of Fish and Game recommends keeping peak pressure to no more than 7.3 PSI (~214 dB re 1 µPa) to avoid injury and mortality to salmonids and state that their “2013 blasting standard is based on 20 years of research and technological advances that provide accurate data on pressures and vibrations generated by an explosion” (Alaska Department of Fish and Game 2013).

Based on the information above, we conservatively rely on the 206 dB re 1 µPa peak noise threshold (or its PSI equivalent of 2.89 PSI) as the blasting injury threshold for both species of sturgeon as well as Atlantic salmon.

7.2.3.2 Effects of Underwater Noise from Blasting on Salmon and Sturgeon

Because MaineDOT has agreed to only conduct bedrock leveling and substructure removal using blasting from November 8 to March 15, we do not expect any Atlantic or shortnose sturgeon lifestages to be present; therefore, those two species will not be affected by underwater noise produced by blasting

As discussed above for the effects of hydraulic breakers, we would not expect kelts to enter the action area during the period of time when blasting would occur. Even though we would not expect salmon in the action area from November 8 through November 30, you have proposed AMM 9 and 10. AMM 9 requires that you submit to us a blasting plan for approval, and commits to designing blasts that will remain below the injury threshold for listed species (206 dB Peak; 2.89 PSI). AMM 10 calls for active acoustic monitoring for tagged fish, minimizing the charge size and number of days of blasting exposure, the use of scare charges prior to blast detonation, and a visual inspection of the 500-foot radius of the blast area to document any impacts to fish.

The extreme rarity of kelts in the action area from November 8-30, combined with these additional protection measures, makes adverse effects to salmon from blasting noise extremely unlikely, and therefore, discountable.

7.3 Construction Related Boat Traffic

The majority of new bridge construction will occur from the temporary work trestle and within cofferdams. However, you have indicated that the contractor is likely to use some vessels to support in-water work during construction. Divers may be used for portions of that construction, including inspection, placement of temporary trestle attachment points, and removal of trestle pins during trestle removal, which would occur during the in-water work window (August 1-March 15). Divers may require boat access to construction sites using one to two ‘work boats’ that are approximately 20 feet long with outboard motors that draft between 2 and 3 feet. Use of these boats would be sporadic and could range from 3 or 4 trips per day to the construction site from a downstream boat landing (~ 1.2 rkm downstream) to no boat traffic for weeks during construction. It is not anticipated that larger vessels or an increased frequency of trips beyond the suspected maximum of 3-4 per day will occur during construction.

A construction barge may be used during the demolition of the existing pier. Typical barge sizes range from 6,000 to 9,600 square feet (150’ X 40’ to 160’ X 60’) with a ~4 foot draw. The barge would be pushed into the work area with a tug boat during the in-water work window (August 1-March 15) and provide a work platform for construction equipment during the removal of the existing center pier and collection of the demolition debris.

Installation of the piles for the base of the temporary work trestle is proposed to occur during September-November 2018 with an overall duration of approximately 60 days and the removal of the existing pier structure is slated to occur between mid-December 2020 and mid-January 2021 (Table 2). Construction activities with the greatest likelihood of incorporating boat traffic (e.g., the movement of a barge, diving crews) will occur between August 1 and March 15. However, it may be necessary to have a limited amount of boat traffic for project related tasks (e.g., a safety boat) outside of the in-water work window period of August 1 to March 15.

The use of boats through the action area will follow AMMs #16 and #17. These protection measures require crews to monitor for ESA-listed fish from barges and report any sightings to MaineDOT staff, as well requiring all vessels in the action area to travel at 6 knots or less.

7.3.1 Background Information on the Risk of Vessels to Salmon and Sturgeon

The factors relevant to determining the risk to Atlantic and shortnose sturgeon from vessel strikes are currently unknown, but based on what is known for other species we expect they are related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). Geographic conditions (e.g. narrow channels, restrictions, etc.) may also be relevant risk factors. Large vessels have been typically implicated because of their deep draft relative to smaller vessels, which increases the probability of vessel collision with demersal fishes like sturgeon, even in deep water (Brown and Murphy 2010). Larger vessels also draw more water through their propellers given their large size and therefore may be more likely to entrain sturgeon in the vicinity. Miranda and Killgore (2013) estimated that the large towboats on the Mississippi River, which have a propeller diameter of 2.5 meters, a draft of up to nine feet, and travel at approximately the same speed as tugboats (less than ten knots), kill a large number of fish by drawing them into the propellers. They indicated that shovelnose sturgeon (*Scaphirhynchus platorynchus*), a small sturgeon (~50-85 cm in length) with a similar life history to shortnose sturgeon, were being killed at a rate of 0.02 individuals per kilometer traveled by the towboats.

As the Mississippi and Androscoggin River systems differ significantly, and as we do not have the data necessary to compare shovelnose sturgeon densities in the Mississippi to shortnose or Atlantic sturgeon populations in the Androscoggin, this estimate cannot directly be used for this analysis. We also cannot modify the rate for this analysis because we do not know (a) the difference in traffic on the Mississippi and Androscoggin rivers; (b) the difference in density of shovelnose sturgeon and shortnose and/or Atlantic sturgeon; and, (c) if there are risk factors that increase or decrease the likelihood of strike in the Androscoggin. However, this information does suggest that large vessel traffic can be a major source of sturgeon mortality. In larger water bodies it is less likely that fish would be killed since they would have to be close to the propeller to be drawn in. In a relatively shallow or narrow area a big vessel with a deep draft and a large propeller would leave little space for a nearby fish to maneuver.

Although smaller vessels have a shallower draft and entrain less water, they often operate at higher speeds, which is expected to limit a sturgeon's opportunity to avoid being struck. There is evidence to suggest that small fast vessels with shallow draft are a source of vessel strike mortality on Atlantic and shortnose sturgeon. On November 5, 2008, in the Kennebec River, Maine, Maine Department of Marine Resources (MDMR) staff observed a small (<20 foot) boat transiting a known shortnose sturgeon overwintering area at high speeds. When MDMR approached the area after the vessel had passed, a fresh dead shortnose sturgeon was discovered. The fish was collected for necropsy, which later confirmed that the mortality was the result of a propeller wound to the right side of the mouth and gills. In another case, a 35-foot recreational vessel travelling at 33 knots on the Hudson River was reported to have struck and killed a 5.5 foot Atlantic sturgeon (NYSDEC sturgeon mortality database (9-15-14)). Given these incidents, we conclude that interactions with vessels are not limited to large, deep draft vessels.

Vessel strikes are not known to be a major threat to Atlantic salmon in the Gulf of Maine. However, that relative lack of risk may also be connected to the small number and density of returning adults and outmigrating smolts in areas where vessels transit, including the action area.

7.3.2 Effects of Project Vessel Traffic on Salmon and Sturgeon

In summary, we anticipate that project construction will require the movement of a barge, to be pushed via tugboat, and one to two work boats transporting crew from rkm 7.2 to the construction site, taking as many as 3 or 4 trips per day. Based on your construction plan and the in-water work window, we expect this vessel traffic to occur between August 1 and March 15. You have also indicated that sporadic use of an additional vessel may be necessary between March 16 and July 31, but that this is likely to be limited to the use of a safety boat, when necessary. All vessel traffic will abide by AMMs #16 and #17.

Based on this information, the vast majority of construction related vessel traffic will occur when no adult Atlantic or shortnose sturgeon are present. Atlantic sturgeon eggs and yolk-sac larvae (YSL) could be present until approximately August 18; at which point we expect all YSL to have made the transition to post yolk-sac larvae (PYSL). While YSL display a swim up and drift down behavior, they are also photo-negative and seek refuge in interstitial spaces of hard bottom habitat (Mohler 2003). PYSL are free swimming, and while based on the length of the life stage (up to 40 days after hatching) they could be in the action area until September 15, we expect PYSL to quickly exit the action area as they move toward downstream rearing habitat. PYSL occur in the water column but feed at the bottom of the water column and use interstitial spaces in hard bottom substrate as refugia as they move downstream and forage for aquatic insects, insect larvae, and other invertebrates (Mohler 2003; Richardson *et al.* 2007). Therefore, during the brief period of overlap (August 1-18) between the majority of construction traffic and these early life stages, we expect the larvae to remain near the bottom of the river during daylight hours. Therefore, the risk of an interaction between sturgeon and construction vessels is extremely unlikely, and discountable.

The occasional use of a small (~20’) safety vessel between March 16 and July 31 will overlap with the time of year when adult sturgeon are present. The safety vessel has a small draft, will be operating at less than 6 knots in waters 15-20’ in depth, and will have crew monitoring for ESA-listed fish. As previously mentioned, the boat ramp where construction vessels will launch is a public boat ramp, and we expect 5-13 recreational motor boats, as well as 5 or more non-motorized recreational vessels to be operating in the action area from the spring through the fall. Given the extremely small increase in vessel traffic above baseline conditions while adult sturgeon are present, the corresponding increase in the risk of strike is very small and cannot be meaningfully measured, detected, or evaluated and therefore, effects are insignificant.

Adult Atlantic salmon may be in the action area from April 1-November 30 and smolts may be in the action area from April 1-June 30; however, as described in several sections above, we expect the presence of Atlantic salmon of either life stage, particularly smolts, to be rare and infrequent. Also, given the lack of reported or confirmed vessel strike injuries, vessel traffic is not known to be a major threat to Atlantic salmon. Therefore, given the infrequent presence of Atlantic salmon in the action area, their low numbers and density if they were to occur, and the small numbers of proposed vessels which will also be following AMMs #16 and 17, the risk of a vessel interaction with a salmon is extremely unlikely, and therefore, discountable.

7.4 Exposure to Contaminants

Use of heavy equipment in or near a water body increases the risk of introducing contaminants (e.g., fuel, oil, etc.). Chemical contaminants can enter into waterbodies through direct contact with contaminated surfaces or by the introduction of storm or washwater runoff and can remain in solution in the water column or deposit on the existing substrate. Research has shown that exposure to contaminants can reduce reproductive capacity, growth rates, and resistance to disease, and may lead to lower survival rates for salmon (Arkoosh *et al.* 1998). Exposure to toxic chemicals would also pose a risk to both species of sturgeon, particularly sensitive early life stages. The risk for contaminants entering the Androscoggin River may potentially increase during construction.

As noted in AMM #4, MaineDOT will require the contractor to follow several BMPs to reduce the potential for introducing contaminants into the river during construction activities including:

- no equipment, materials, or machinery shall be stored, cleaned, fueled, or repaired within any wetland or watercourse;
- dumping of oil or other deleterious materials on the ground will be forbidden;
- the contractor shall provide a means of catching, retaining, and properly disposing of drained oil, removed oil filters, or other deleterious material; and
- all oil spills shall be reported immediately to the appropriate regulatory body.

With the protection measures proposed by MaineDOT, we believe any exposure of listed species to harmful contaminants to be extremely unlikely; therefore, effects are discountable.

7.5 Habitat Modification from In-River Structures

As described in Section 3, a number of activities associated with the replacement of the Frank J. Wood Bridge will require the placement of structures (either permanent or temporary) into aquatic habitat. These structures include the three new bridge piers and their associated temporary cofferdams, the series of piles associated with the temporary work trestle and fill associated with work trestle access on the Topsham side. Table 22 provides a summary of each structure, its status (permanent or temporary), and the estimated area of impact to habitat both above and below the high water elevation.

Proposed in-water construction will cause both temporary and permanent effects to the upper pool portion of the action area, along with the lower in-river area. The upper pool, or ponded area, is part of a natural bedrock cascade, and due to high flows and elevation, was likely never accessible to Atlantic and shortnose sturgeon, even before the construction of the Brunswick Dam. Since the construction of the dam, a 21-foot concrete wall and sections of concrete caps filling the low spots were added to further prevent fish from moving into the pond during moderate to low flows, as upstream passage from the pond is not possible. Theoretically, Atlantic salmon could have historically accessed the upper pool, but under current conditions with the dam, further upstream passage is not possible. Depending on flow conditions, outmigrating kelts or smolts could pass downstream through the falls, using the pond as part of their downstream migratory corridor during high flows.

As part of the current project design, three new permanent piers will be installed, covering a total area of 3,400 ft^2. Two of those piers (representing 2,100 ft^2 of area) will be placed in the ponded portion of the channel on the Topsham side and upstream of the point where sturgeon can access. The southernmost pier will be placed on the edge of Shad Island. Of the total footprint for that pier, approximately 31% (400 ft^2) will set on ledge at elevations greater than the high water elevation with the remainder on ledge habitat in the channel leading to the Brunswick hydroelectric tailrace area. The temporary work trestle will necessitate the installation of approximately 65, 24-48" piles (covering ~800 ft^2 of riverbed to the west of the new alignment). These will be pinned or plate-mounted to bedrock substrate. Prior to commencement of trestle construction, installation of a temporary access point from the Topsham bank will be required. The footprint for this access may include up to 2,000 ft^2 (a 40 foot by 50 foot area) of temporary fill below the normal high water line upstream from the new abutment. Fill will consist of non-erodible material, appropriately sized to remain stable at high flows and will sit in the ponded portion of the channel on the Topsham side and upstream of the point where sturgeon can access.

It should be noted that the center pier for the existing Frank J. Wood Bridge will be removed down to bedrock during the demolition phase of the project (AMM #15). Following removal of this pier, a total of approximately 800 ft^2 of bottom substrate previously supporting the Frank J. Wood Bridge will become available. This will result in a net loss of approximately 100 ft^2 of in-river habitat following construction of the new pier structures and removal of the existing FJW Bridge.

Table 22: Approximate area and location (in-river versus in ponded and bedrock falls area) of temporary and permanent in-river structures associated with the Frank J. Wood Bridge replacement project

Impact Type	Temporary Impacts	Permanent Impacts	Ponded and Bedrock Falls Habitat	In-River Habitat	Restored In-River Habitat
Temporary Work Trestle Piles	≤ 800 ft^2	0	740 ft^2	60 ft^2	--
Temporary Trestle Access Fill	2,000 ft^2	0	2,000 ft^2	0	--
Cofferdam/New Pier 1	0	1,300 ft^2	400 ft^2	900 ft^2	--
Cofferdam/New Pier 2	0	1,200 ft^2	1,200 ft^2	0	--
Cofferdam/New Pier 3	0	900 ft^2	900 ft^2	0	--
Rip Rap Scour Protection (Brunswick abutment)	0	400 ft^2	--	--	
Existing Pier Removal	--	--	--	--	800 ft^2
~Total Temporary Impacts	2,800 ft^2	--	2,740 ft^2	60 ft^2	--
~Total Permanent Impacts	--	3,800 ft^2	2,500 ft^2	900 ft^2	800ft^2

7.5.1 Effects of Habitat Modification on Sturgeon Spawning

Per the discussion above, this section on effects to sturgeon will focus on habitat impacts occurring in the in-river portion of the action area, and will not consider the ponded and bedrock falls habitat.

The in-water work window of August 1 – March 15 avoids construction activity when shortnose sturgeon are present in the action area. While we expect adult Atlantic sturgeon to have exited the action area by August 1, their eggs, yolk-sac larvae (YSL), and post yolk-sac larvae (PYSL) may persist in the action area into the in-water work window. All YSL will have transitioned to the PYSL life stage by August 18, at which point we expect all PYSL to quickly move downstream out of the action area (most will have already done so earlier in the spawning season, as these PYSL would only be moving downstream in mid-August if they came from eggs fertilized at the very end of the spawning season in July). To protect these early lifestages, particularly immobile eggs and YSL, you have agreed to delay in-river construction of the temporary cofferdam and trestle until September 1, 2018 (AMMs 5 & 7, Table 3). Therefore, the placement of these structures, which will collectively impact 960 ft^2 of in-river spawning habitat, will not affect any sturgeon spawning activity or early life stages in 2018.

Sturgeon spawning activity in 2019 and 2020 may be affected by the 960 ft^2 loss of spawning habitat; however, you are not proposing any additional in-river construction that will result in temporary or permanent habitat loss. In the Environmental Baseline section, we concluded that within the action area spawning habitat for both sturgeon species exists between rkm 7.7 and the Brunswick Dam (removing the upper pool on the Topsham side above the Frank J. Wood Bridge, which is inaccessible to sturgeon)(Figure 12). This 11.8 acre area consists of exposed bedrock, intermingled with boulders, rocks, cobbles, and pockets of gravel and sand. The areas directly below the existing bridge, extending toward rkm 7.7, have less scoured ledge from the tailrace flows, and therefore, because of the presence of habitat with interstitial spaces necessary to support the settlement of eggs and to provide cover for larvae, are likely to have the most conservation value for sturgeon spawning. While the areas in which you are proposing to construct the temporary trestle (60 ft^2) and cofferdam/pier 1 (900 ft^2) are closer to the tailrace and are more likely to be exposed bedrock, they still may have smaller hard substrates that create the necessary interstitial spaces for spawning and rearing. Given that we expect the areas where the temporary cofferdam and trestle will be placed could be used for the settlement of eggs and larvae, we anticipate the placement of these structures to result in the temporary loss of 960 ft^2 of spawning habitat, or 0.19% of the total estimated spawning habitat in the action area for two spawning seasons.

MaineDOT is proposing to remove the temporary trestle (60 ft^2) and the center pier for the existing Frank J. Wood Bridge (restoring 800 ft^2 of hard bottom, bedrock habitat) during the in-water work window between September 1, 2020 and March 15, 2021. Once these structures are removed, MaineDOT has proposed to restore potential natural spawning substrate for sturgeon species (see AMM 15). With these structures removed, and pier 1 complete (900 ft^2), the proposed project will result in a permanent net loss of 100 ft^2 of sturgeon spawning habitat, or 0.02% of the estimated spawning habitat in the action area.

For the 2019 and 2020 spawning seasons, impacts to sturgeon from the placement of the temporary structures are limited to the loss of 960 ft^2 of potential habitat for settlement of eggs and refuge for larvae. Beginning in 2021, this impact will be limited to the permanent loss of 100 ft^2 for settlement of eggs and refuge for larvae. Given the amount of habitat available for spawning, we do not expect the placement of the temporary or permanent structures to result in any decrease in the number of spawning adults or the amount of spawning activity. Therefore, we do not expect there to be any reduction in the number of eggs compared to the number that could be present absent the temporary or permanent structures. Eggs are demersal and adhesive; spawning females select locations that have relatively low velocity and deposit eggs very close to the river bottom – the combination of these factors means that eggs are present only in very close proximity to where spawning occurred. Because sturgeon will spawn where there is space for their eggs and those eggs will remain where they were spawned, we do not expect the presence of the temporary or permanent structures to impact the development of any eggs. After a period of time, the larvae will move downstream from where the eggs were deposited. We expect that any larvae upstream of the temporary structures will drift around the structures, just as they would any other structure present in the water column. Given the relatively small footprint of these structures, we do not expect the additional distance that a larvae may need to move to find substrate with appropriate cover would have any impact on the health or development of that larvae or result in any increased risk of predation or exposure to any other threat. These effects would be the same for shortnose and Atlantic sturgeon given the overlap of spawning and egg-larvae developmental habitat and similarities in spawning behavior and egg-larvae development. Based on this analysis, effects to shortnose and Atlantic sturgeon spawning and early life stages will be so small that they can not be meaningfully measured, detected or evaluated and are therefore, insignificant.

While this discussion has focused on the effects of habitat modification on both species of sturgeon, section 7.8.2 will analyze the effects of this modification to the conservation function of the critical habitat features designated for the Gulf of Maine DPS of Atlantic sturgeon.

7.5.2 Effects of Habitat Modification on Salmon and Sturgeon Migration

To demonstrate the impacts of the proposed structure on the hydrodynamic flow conditions in the construction area, you provided us with flow models to compare the existing conditions (with the Frank J. Wood Bridge) to the conditions after the construction of the proposed replacement bridge and removal of the Frank J. Wood Bridge (Figure 13 and Figure 14).

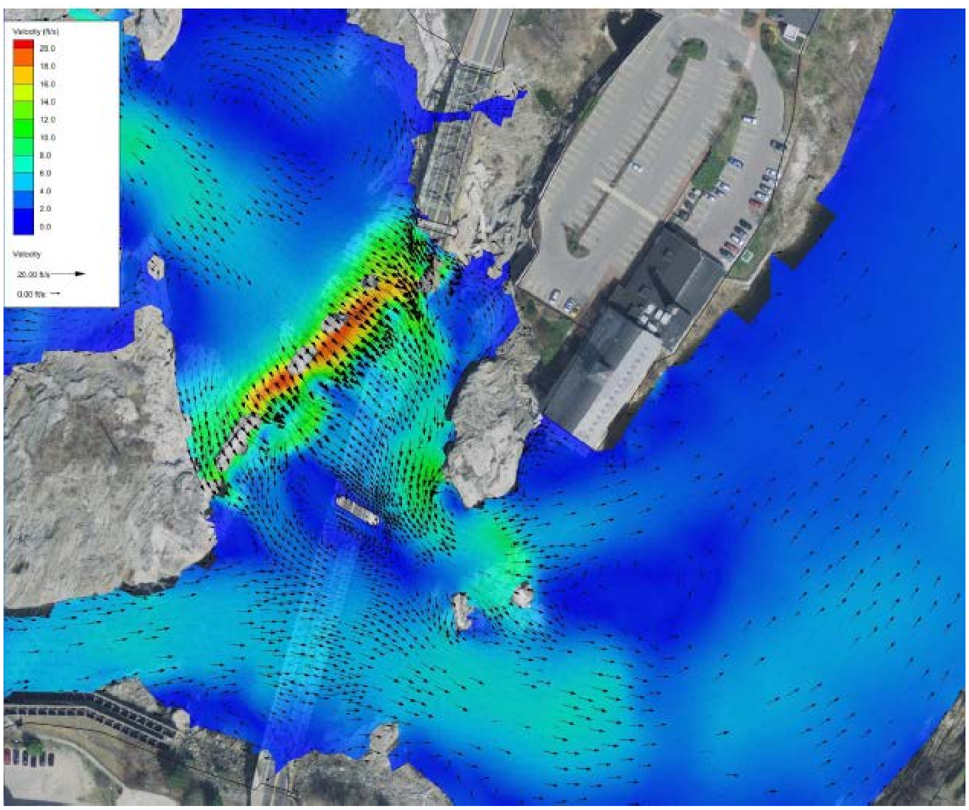

Figure 13: Modeled Hydrodynamic Flow Conditions with Current Frank J. Wood Bridge

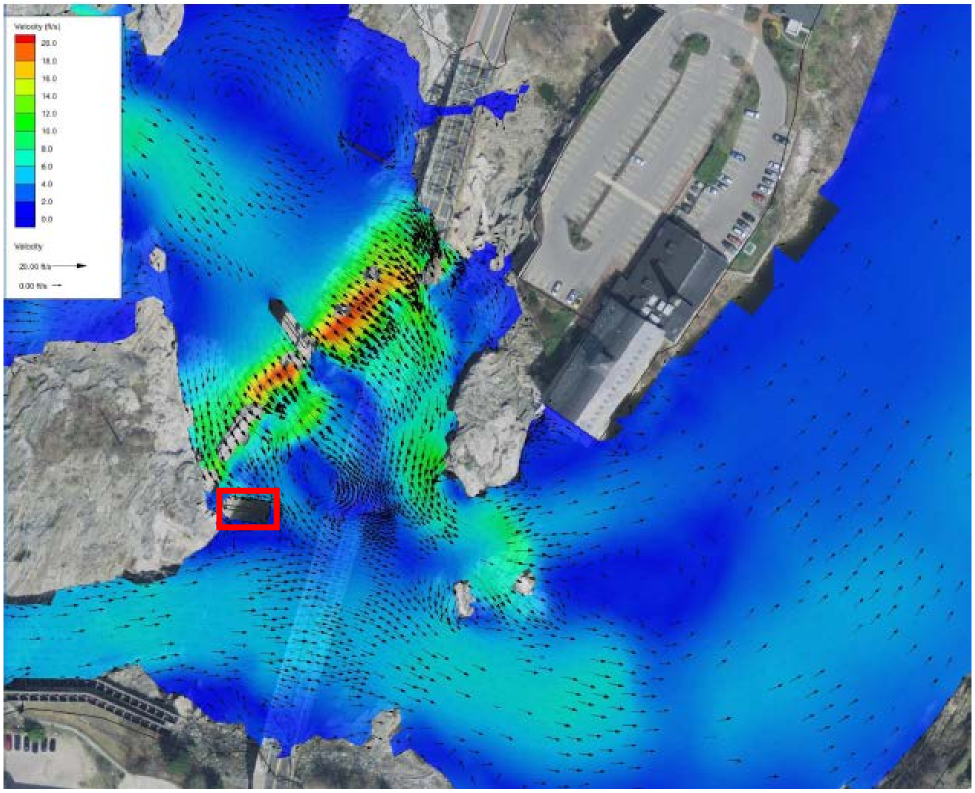

Figure 14: Modeled Hydrodynamic Flow Conditions with Proposed Replacement Bridge

The main difference between the models is the construction of Pier 1 (see the red rectangle in Figure 14) for the replacement bridge, and the removal of the center pier from the existing bridge. As shown, changes in flow regime are extremely small, with no major redirection of water or velocity in any direction. Therefore, any hydrodynamic effects to sturgeon movement above the existing bridge to or from spawning habitat, or salmon migration to the fishway or outmigration from the action area, will be too small to be meaningfully measured, detected, or evaluated, and are insignificant.

During and after construction of the replacement bridge, there will be temporary and permanent added obstructions (i.e., temporary trestle, cofferdam/Pier 1) to passage in the river. In an email sent February 14, 2018, MaineDOT estimated that a maximum of four linear feet of river will be unavailable due to the presence of temporary trestle piles. The Pier 1 cofferdam is located directly below the upstream bedrock falls, which form a natural barrier for migrating fish, and will not affect passage. At its narrowest point (where the rock peninsula extends into the river from the Topsham side), the river is approximately 220 feet wide. Any effect on migrating sturgeon or salmon from the temporary loss of four feet (1.8%) of passage will be too small to be meaningfully measured, detected, or evaluated, and is therefore, insignificant.

7.6 Entrapment in Cofferdams

Sheetpile cofferdams are required for construction of the in-water piers planned for the replacement bridge. The two northernmost piers will be constructed on a bedrock ridge that forms the lower containment of the ponded area below the spillway on the Topsham side of the river. You have proposed to construct Pier 1 in the in-river portion of the action area, which is accessible to sturgeon and salmon (see the red rectangle in Figure 14). As discussed above, we do not expect either species of sturgeon to occur in the upper pond area. Atlantic salmon may enter the pond during high flows, but given the low numbers of returning salmon in years past, along with the concrete wall designed to further discourage passage into the pond, we expect any salmon in the ponded area to be extremely rare and transient (i.e., quickly outmigrating from the pond).

All cofferdam construction and removal will occur within the in-water work window. However, to avoid impacts to Atlantic sturgeon early life stages, you have agreed to delay construction and removal of the Pier 1 cofferdam until September 1. Because you have proposed to place the cofferdam for Pier 1 immediately below and adjacent to the natural upstream limit for sturgeon, i.e., the bedrock fall barrier, we expect little to no water from the accessible portion of the in-river habitat to flow into the cofferdam area (see arrows indicating modeled flow regime in Figure 14). Furthermore, MaineDOT has indicated that the contractor will design the cofferdam height to withstand predictable high flow events to prevent water overtopping the sheetpile walls, because overflow events cause costly delays to construction. However, given water releases from the dam in high flow events, they cannot guarantee overtopping of the cofferdams will not occur. Therefore, given the design of the cofferdams, along with the lack of accessible sturgeon habitat upstream of the Pier 1 cofferdam, entrapment of sturgeon in the cofferdam is extremely unlikely to occur. Similarly, we only expect rare, transient salmon to enter the upstream ponded area, and for the same reasons described for sturgeon, their entrapment in any cofferdam is also extremely unlikely. Therefore, effects of cofferdam entrapment on listed species are discountable.

7.7 Effects on the Brunswick Upstream Fishway

Upstream passage at the Brunswick hydroelectric project occurs via a vertical slot fishway located adjacent to the powerhouse and on the western bank upstream of the existing Frank J. Wood Bridge. Passage at this facility was considered when evaluating direct effects on the target species. Neither Atlantic nor shortnose sturgeon are known to use the upstream fishway at Brunswick and thus potential effects on upstream passage from sound, vibration and shadowing are not considered for those two species. Potential effects presented here are applicable to Atlantic salmon only.

7.7.1 Impacts of Sound and Vibration on Atlantic Salmon Passage

As discussed in section 7.2, underwater noise has the potential to cause behavioral disturbances, hearing impairment or threshold shifts, physical injury, or morality to fish species. Given the proximity of the proposed alignment of the new bridge structure to the existing upstream fishway we are considering the potential impacts associated with the transference of traffic noise to the vicinity of the upstream fishway (i.e., underwater noise and vibrations).

Vibrations associated with traffic crossing the new bridge are expected to be at a more constant, low level (i.e., a “continuous” source) as opposed to a sudden and more intense burst associated with blasting or pile driving (i.e., an “impulsive” source). The bridge design consultant provided the following information about the potential for vibration from the new bridge:

- Vibration from traffic crossing the superstructure will need to travel through pot bearings, which the new superstructure will sit on. Each pot bearing has a rubberized elastomer designed to significantly dampen the transfer of vibrations from superstructure to substructure. This is a substantial upgrade from the existing structure which is constructed with a steel on steel design which offers little to no vibration dampening.

- Any vibration energy that does transfer through the rubberized pot bearing will then need to travel through concrete, water, the walls of the fish ladder, and then water again before it can be detected by any fish within the fishway. Each change in medium will result in a continued dampening of the vibrations.
- In addition, the flowing water (river and fish ladder) is quite turbulent with its own ‘white noise’ and will help to further dampen and vibrations related to the bridge structure.

At present, Atlantic salmon passing upstream or downstream through the action area are subjected to vibrations associated with traffic crossing the existing Frank J. Wood Bridge. The replacement structure will feature construction enhancements designed to reduce vibration in the form of rubberized pot bearings which will eliminate the current construction of steel on steel contact. The Brunswick abutment of the new bridge will be slightly closer to the fishway than the existing abutment; however, we do not expect this minor change in proximity to result in significantly more noise or vibrations entering the fishway, especially with the vibration dampening modifications in the new design.

Based on what we expect to be a comparable traffic load across the new bridge, we anticipate that the effects of underwater noise or vibrations from the new bridge on Atlantic salmon’s use of the upstream fishway will be too small to be meaningfully measured or detected, and are therefore, insignificant.

7.7.2 Effects of Shadows on Atlantic Salmon Passage

Although it is understood that the presence of shadows can affect fish behavior (Schilt 2007), there is no published literature on shadow effects as related to successful passage via an upstream fishway. MaineDOT’s design consultant evaluated the scope of static and dynamic shadowing from the existing Frank J. Wood Bridge as well as the proposed alignment of the replacement structure (See Shadow Model Memo in Appendix B). Under the existing conditions, anadromous fish species ascending the fishway are exposed to some level of dynamic and static shadowing. MaineDOT’s design consultant estimated the duration of shadowing from the existing structure at approximately 1 hour per day of static shadow (resulting from the bridge superstructure) and a few minutes per day of dynamic shadowing (resulting from passing traffic). Dependent on the model month the shadows from the existing structure are present between the hours of approximately 0700 to 0945. MaineDOT’s design consultant predicted shadowing from the new bridge alignment would increase the duration of static shadowing to 2.25 hours per day and of dynamic shadowing to 1.5-2 hours per day. The timing of shadowing predicted for the proposed alignment was between 0645 and 0945.

Despite the increase in time that the fishway will be exposed to dynamic shadowing from passing traffic, there is not currently any information to suggest that the shadows will prevent or delay Atlantic salmon from using the upstream fishway. Therefore, we do not expect shadowing to affect Atlantic salmon migration.

7.8 Effects of the Proposed Action on Critical Habitat

In this analysis, we consider the direct and indirect effects of the action, on the critical habitat PBFs we determined to be in the action area in the Environmental Baseline (section 5.0). For each PBF, we identify those activities that may affect the PBF. For each feature that may be affected by the action, we then determine whether any negative effects to the feature are insignificant, discountable, or entirely beneficial and if not, consider the consequences of those adverse effects. In making this determination, we consider the action's potential to affect how each PBF supports Atlantic salmon or Atlantic sturgeon's conservation needs in the action area. Part of this analysis is consideration of the conservation value of the habitat and whether the action will have effects on the ability of Atlantic salmon or Atlantic sturgeon to use the feature, temporarily or permanently, and consideration of the effect of the action on the action area's ability to develop the feature over time.

7.8.1 Effects to Critical Habitat Designated for the Gulf of Maine DPS of Atlantic Salmon

In section 5.4.4, we determined that the PBFs for Atlantic salmon in the action area are limited to migration for the juvenile (smolt) and adult life stages. These PBFs are:

Migration PBF M1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
Migration PBF M2. Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
Migration PBF M3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
Migration PBF M4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

7.8.1.1 PBF M1

Migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations

Within the action area, the Brunswick Project partially obstructs upstream migration of Atlantic salmon. Although a fishway is available, it is not 100% effective. Additionally, while there have been very few Atlantic salmon returns in recent years, we expect that the continued existence of the dam delays access to spawning and rearing habitat upriver.

The proposed action will involve in-water construction that has the potential to affect adult salmon's migration to spawning habitat, as well as the outmigration of kelts. These impacts range from temporary to permanent. Temporary impacts include those resulting from sedimentation, turbidity, and habitat modification from bridge construction and removal of the existing bridge. Permanent effects are limited to in-water obstructions (i.e., the piers), as well as vibrations from the bridge entering the fishway. The in-water work window from August 1 – March 15 minimizes adult salmon's exposure to these construction related stressors. In the effects analysis sections above, we conclude that all temporary and permanent effects to adult Atlantic salmon migration are insignificant or discountable.

The proposed action may have temporary negative effects on PBF M1 by creating in water stressors from construction activities, and extremely small permanent effects by creating minor obstructions in the river; however, none of the proposed activities will be barriers to the movement of adult Atlantic salmon. Based on our assessment, these impediments to movement are extremely unlikely to affect the function of PBF M1 to the conservation of the species in the action area; that is, it is extremely unlikely that the habitat alterations in the action area will impede the movement of adults to and from spawning sites; therefore, the effects are discountable.

7.8.1.2 PBF M2

Freshwater and estuary migration sites with pool, lake, and in-stream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
While the action area immediately downstream of the dam does provide cool, oxygenated water with cover items such as boulders, flows are generally higher than the holding and resting areas (pools, lakes, streams) used by adult Atlantic salmon. Some of this habitat may occur further away from the spillway, outside of the immediate construction area (i.e., further downstream, closer to the boat launch). Therefore, the only effect of the action that may overlap and affect these holding and resting areas is vessel traffic. We concluded in section 7.3.2 that effects of vessel traffic on salmon are discountable. We do not expect the small increase in vessel traffic to affect the function of cool, oxygenated water or cover items serving as temporary holding and resting areas for adult salmon migrating upstream.

7.8.1.3 PBF M3

Migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation
Adult alewives, blueback herring and American shad (three unlisted anadromous clupeid species) all move through the project area during their upstream migration period. Alewives generally move upstream in the Androscoggin River during May. American shad and blueback herring tend to run during the latter part of the spring (i.e., late May and June).

The State of Maine has been pursuing restoration of anadromous fish on the Androscoggin River for many years. Historically, alewife reproduced in lake and pond habitat throughout the Little Androscoggin River and the mainstem Androscoggin River basins below Lewiston Falls, while American shad and blueback herring reproduced in the riverine portions of these watersheds (MDMR 2010).

Seasonal counts of resident and anadromous fish species tallied in the upstream fishway at Brunswick for the last three years (2014-2016) are presented in Table 23 (MDMR 2017, 2016, 2015). Anadromous species (in particular alewife) were the most abundant with lesser numbers of resident species such as white sucker, smallmouth bass and fallfish observed.

Table 23: Annual upstream fish passage totals for 2014-2016 at the Brunswick Project fishway

Fish Species	2014	2015	2016
Alewife	55,678	71,887	114,874
American Eel	201	1	4
American Shad	0	53	1,096
Atlantic Salmon	4	2	6
Black Crappie	0	0	1
Brook Trout	9	2	0
Brown Trout	4	1	5
Fallfish	5	0	0
Landlocked Salmon	5	1	0
Sea Lamprey	45	129	240
Smallmouth Bass	99	43	117
Striped Bass	1	1	81
Sunfish species	0	0	1
White Catfish	1	0	0
White Sucker	105	933	1,255

The proposed in-water work window (August 1 – March 15) avoids the spawning migration of the most important native fish communities that serve as a protective buffer against Atlantic salmon predation (i.e., alewife, blueback herring, and American shad). We do not expect the temporary or permanent structures to impede or delay the upstream or downstream passage of these species. While it is possible that increased dynamic shadowing (1.5 – 2 hours) on the fishway could spook some species that are easily deterred from using the fishway (e.g., American shad), we do not have the data to predict this with any certainty. Therefore, we do not expect the proposed project to affect diverse native fish communities' ability to serve as a protective buffer against salmon predation.

7.8.1.4 PBF M4

Migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.
As described in the Environmental Baseline section, smolts from the Androscoggin River have to navigate through multiple dams on their migrations to the estuary every spring. While close to 100% of smolts passing through a properly designed downstream bypass will survive, survival over a spillway has been estimated at 97.1% (Normandeau Associates 2011). Survival through turbines varies significantly based on numerous factors, but can be significantly lower than the other two routes. From 2013-2015, an estimated 87.2% of the smolts passing through the Brunswick Dam into the action area survived (Table 15). Therefore, the Brunswick Dam is an ongoing barrier to smolts emigrating to the marine environment.

The in-water work window for the proposed action avoids construction impacts on outmigrating smolts (April 1 – June 30). We do not expect any temporary and permanent structures to impede downstream migration. The only permanent net loss of migratory habitat for salmon is the 100 ft^2 in-river habitat from Pier 1, and the 2100 ft^2 area in the upper pond. As previously explained, any salmon presence in the upper pond is expected to be rare and transient, as access to the area is limited to high flow events, and very few salmon have returned in recent years. Even if the Brunswick Dam were to be removed and normal flows returned, making this habitat fully accessible to salmon the piers would not impede the outmigration of smolts, as they could make minor movements around them in a sufficiently wide reach of the river (220 ft. at its narrowest point). Therefore, any effects of the proposed action on the function of the habitat to support smolt emigration to the marine environment are too small to be meaningfully measured or detected, and are therefore, insignificant.

7.8.1.5 Summary of Effects of Proposed Activities on Atlantic Salmon Critical Habitat
We have determined that all of the effects of the proposed replacement and removal of the Frank J. Wood Bridge on Atlantic salmon critical habitat PBFs M1, M2, M3, and M4 are insignificant or discountable.

7.8.2 Effects to Critical Habitat Designated for the Gulf of Maine DPS of Atlantic Sturgeon
As noted above, the action area extends from rkm 7.2 to rkm 8.4. The Androscoggin River critical habitat unit extends from the point where the Androscoggin River empties into Merrymeeting Bay to the Brunswick Dam, which was also likely the natural upstream limit for Atlantic sturgeon (i.e., Pejepscot Falls).

The Androscoggin River is entirely freshwater (salinity <0.5ppt); therefore, PBF 2 of Atlantic sturgeon critical habitat, or aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (*e.g.,* sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development, is not present in the action area. The other three PBFs are found in the action area, and we discuss effects of the proposed action on those PBFs below.

7.8.2.1 PBF 1

Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages

In considering effects to PBF 1, we consider whether the proposed action will have any effect on areas of hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages. Therefore, we consider how the action may affect hard bottom substrate and salinity and how any effects may change the value of this feature in the action area. We also consider whether the action will have effects on access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

As explained above, the entirety of the Androscoggin River is tidal freshwater, where salinity levels are consistent with the requirements of PBF 1. The action area is approximately 15 rkm upstream from the typical limit of salt water intrusion, which is the southern end of Merrymeeting Bay, where the Bay meets the lower Kennebec estuary at the Chops (Moore and Reblin 2008). Within the Androscoggin River, PBF 1 occurs where there is hard bottom substrate for settlement of fertilized eggs, refuge, growth, and development of early life stages. From tagging and tracking studies, as well as the collection of shortnose sturgeon eggs and larvae, we know that Atlantic and shortnose sturgeon spawning may occur the action area between rkm 7.7 and 8.4 (Squiers *et al.* 1993; Wippelhauser 2012; Wippelhauser and Squiers 2015; Wippelhauser *et al.* 2015; Wippelhauser *et al.* 2017).

We do not have substrate maps for the action area; however, diving transects reported by Squiers *et al.* 1993, as well as video provided by MaineDOT, confirm the presence of hard bottom substrate meeting the criteria for PBF 1 in this reach. Based on the limited data we have below, below rkm 7.7, as the river stretches toward the lower portion of the action area, it appears that the substrate may switch from primarily hard bottom substrate to predominantly sand and silt. Therefore, we have estimated that the action area above rkm 7.7, and removing the upper pool on the Topsham side above the Frank J. Wood Bridge (which is inaccessible to sturgeon), has approximately 11.8 acres of habitat meeting the criteria of PBF 1 (Figure 12). As discussed in section 5.7.3, baseline conditions of PBF 1 in the action area vary. Areas directly below the existing bridge, extending toward rkm 7.7, have less scoured ledge from the tailrace flows, and therefore, likely have more bedrock and boulders that are interspersed with smaller rocks and cobbles. These areas with greater prevalence of interstitial spaces likely maintain the most conservation value for Atlantic sturgeon spawning and rearing of early life stages.

Our analysis in section 7.0 showed that the in-water work window, combined with MaineDOT's agreement to delay construction and removal of the temporary trestle and cofferdam for Pier 1, until September 1, removes any overlap between in-water construction and the presence of spawning Atlantic sturgeon and their eggs and larvae. We expect all effects to hard bottom substrate from suspended sediment and turbidity to be minor and temporary, not lasting into any season when Atlantic sturgeon would be using the habitat for spawning or rearing. Effects of water contamination from construction equipment are extremely unlikely to occur, and are therefore, discountable. The proposed action will not cause any measureable or permanent changes in the action area's salinity.

MaineDOT is proposing to construct a portion of the temporary trestle (60 ft^2), as well as the permanent Pier 1, along with its temporary cofferdam (900 ft^2), within habitat we have identified as PBF 1. Sturgeon spawning activity in 2019 and 2020 will be affected by this 960 ft^2 loss of PBF 1; however, you are not proposing any additional in-river construction that will result in temporary or permanent habitat loss. MaineDOT is proposing to remove the temporary trestle (60 ft^2) and the center pier for the existing Frank J. Wood Bridge (restoring 800 ft^2 of hard bottom, bedrock habitat) during the in-water work window between September 1, 2020 and March 15, 2021. Once these structures are removed, MaineDOT has proposed to restore potential natural spawning substrate for sturgeon species (see AMM 15). With these structures removed, the proposed project will result in a permanent net loss of 100 ft^2 of sturgeon spawning habitat.

Per our discussion above, we have estimated that the area of PBF 1 in the action area to be 11.8 acres. While the areas in which you are proposing to construct the temporary trestle (60 ft^2) and cofferdam/pier 1 (900 ft^2) are closer to the tailrace and are more likely to be exposed bedrock, they still may have smaller hard substrates that create the necessary interstitial spaces for spawning and rearing. Therefore, we anticipate the loss of 960 ft^2 of spawning habitat and rearing habitat, or 0.19% of the total estimated area of PBF 1 within the action area for two spawning/rearing seasons, and a permanent net loss of 100 ft^2 of sturgeon spawning habitat, or 0.02% of the estimated spawning habitat in the action area.

The number of adult Atlantic sturgeon returning to spawn in the Androscoggin River currently is thought to be very small and we expect that there is sufficient habitat available for settlement of any fertilized eggs and for the refuge, growth, and development of early life stages. However, the action area extends through with the entire reach of the Androscoggin River where we expect spawning to occur (see Figure 12). The amount of spawning habitat available in the Androscoggin River is small compared to nearly all other rivers where spawning habitat has been identified in the Gulf of Maine DPS. Therefore, the spawning habitat in the action area is of great importance to the recovery and conservation of the Androscoggin River population of Atlantic sturgeon. Though the area of permanent habitat loss is small (100 ft^2), this permanent reduction in the availability of hard bottom substrate means that there will be less habitat available for settlement of any fertilized eggs and for the refuge, growth, and development of early life stages. We expect this to result in a measurable impact on the conservation function of the action area for Atlantic sturgeon due to the permanent decrease in the availability of hard bottom substrate for settlement of any fertilized eggs and for the refuge, growth, and development of early life stages. The removal of substrate that could support fertilized eggs or provide shelter to larval sturgeon from predators and higher current velocities will permanently reduce the conservation function provided by the habitat in the action area for the refuge, growth, and development of early life stages. Therefore, this reduction in the availability of PBF 1 is not insignificant or discountable and is an adverse effect to the Androscoggin River Unit of critical habitat designated for the Gulf of Maine DPS of Atlantic sturgeon.

7.8.2.2 PBF 3

Water absent physical barriers to passage between the river mouth and spawning sites

In considering effects to PBF 3, we consider whether the proposed action will have any effect on water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: unimpeded movements of adults to and from spawning sites; seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, and; staging, resting, or holding of subadults or spawning condition adults. We also consider whether the proposed action will affect water depth or water flow, as if water is too shallow it can be a barrier to sturgeon movements, and an alteration in water flow could similarly impact the movements of sturgeon in the river, particularly early life stages that are dependent on downstream drift. Therefore, we consider effects of the action on water depth and water flow and whether the action results in barriers to passage that impede the movements of Atlantic sturgeon. We also consider whether the action will have effects on access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

The Brunswick Dam, which is located at the upstream limit of critical habitat designated for Atlantic sturgeon in the Androscoggin River, impacts water depth and flow in the action area. While Pejepscot Falls, which is located at the site of the dam, is thought to have historically been the upstream limit for sturgeon in the Androscoggin, the dam operators now control releases of water and have greatly influenced the hydrodynamics of the immediate downstream area. As described above, the Androscoggin River discharges through the Brunswick Dam at several points, including: the tailrace on the Brunswick side, the flood gates on the Topsham side, and the mid-channel spillway. Given these various discharge points, velocities under the existing and proposed bridge vary depending on the stage of river flow and which release points are flowing. At normal flows, velocities in the tailrace range from approximately 6.0 to 8.0 feet per second. In general, we expect waters in the in-river portion of the action area, directly below the dam at the site of the proposed and existing bridge to be 15 feet to 20 feet deep.

The proposed action will not result any measurable or detectable changes in river depth. The in-water work window, along with MaineDOT's agreement to delay construction and removal of the temporary trestle and the Pier 1 cofferdam to September 1, avoids the situation where in-water stressors (e.g., underwater noise) cause any behavioral modification to Atlantic sturgeon preparing to spawn or move downstream as larvae. As discussed in section 7.5.2, temporary and permanent construction will create in-river obstructions that sturgeon will need to swim around. The Pier 1 cofferdam is located directly below the upstream bedrock falls, which form a natural barrier for migrating fish, and will not affect passage. At its narrowest point (where the rock peninsula extends into the river from the Topsham side), the river is approximately 220 feet wide. Any effect on migrating sturgeon or salmon from the temporary loss of four feet (1.8%) of passage from the temporary work trestle will be too small to be meaningfully measured, detected, or evaluated. MaineDOT also provided us with hydrodynamic flow models to show the baseline flow conditions in the construction area compared to estimated flow conditions with the proposed replacement bridge and removal of the Frank J. Wood Bridge. Again, as discussed in section 7.5.2, changes in flow regime are extremely small, with no major redirection of water or velocity in any direction (see Figure 13 and Figure 14). Therefore, any hydrodynamic effects to sturgeon movement above the existing bridge to or from spawning habitat will be too small to be meaningfully measured, detected, or evaluated.

In sum, the proposed action may have temporary negative effects on PBF 3 by creating temporary in-water barriers from construction activities (i.e., the work trestle); however, none of the proposed activities will be barriers to the movement of adult or larval Atlantic sturgeon. Based on our assessment, any effects habitat alterations may have on PBF 3's ability to provide conservation function to species in the action area (i.e., support unimpeded movement of adults to and from spawning sites or the seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary, or impede the staging, resting, or holding of subadults or spawning condition adults) are too small to be meaningfully measured, detected, or evaluated; therefore, the effects are insignificant.

7.8.2.3 PBF 4

Water with the temperature, salinity, and oxygen values that, combined, provide for dissolved oxygen values that support successful reproduction and recruitment and are within the temperature range that supports the habitat function

In considering effects to PBF 4, we consider whether the proposed action will have any effect on water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment. Therefore, we consider effects of the action on temperature, salinity and dissolved oxygen needs for Atlantic sturgeon spawning and recruitment. These water quality conditions are interactive and both temperature and salinity influence the dissolved oxygen saturation for a particular area. We also consider whether the action will have effects to access to this feature, temporarily or permanently and consider the effect of the action on the action area's ability to develop the feature over time.

As described above for PBF 3, discharges of water through the Brunswick Dam have a large impact on the volume, frequency, and velocity of water entering the upper portion of the action area. This in turn affects the water quality factors of temperature, salinity and dissolved oxygen, which are also driven in large part by the influences of the tide, weather, season, etc. The area with PBF 4 (water between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that combined support spawning, survival, and larval, juvenile, and subadult development and recruitment), may be present throughout the action area (rkm 7.2-8.4).

Some aspects of the proposed construction of the replacement bridge and removal of the Frank J. Wood bridge (e.g., sedimentation and turbidity from pile installation/removal and the removal of the existing bridge's center pier/substructure) may have minor and temporary effects to the temperature, salinity, and oxygen values in the action area. However, the in-water work window, along with MaineDOT's agreement to delay construction and removal of the temporary trestle and the Pier 1 cofferdam to September 1, avoids the situation where any of these minor and temporary effects co-occur with the presence of Atlantic sturgeon. The proposed action will not cause any permanent effects to temperature, salinity, and oxygen values in the action area. Therefore, the effects of the action on the value of PBF 4 to the conservation of the species (i.e., the current and future development of this feature to provide the temperature, salinity, and oxygen values that, combined, support: spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment) to be too small to be meaningfully measured or detected, and are therefore, insignificant.

7.8.2.4 Summary of Effects of Proposed Activities on Atlantic sturgeon Critical Habitat
We have determined that the proposed replacement and removal of the Frank J. Wood Bridge will have permanent adverse effects on PBF 1. In the Integration and Synthesis section (9.0), below, we analyze whether the adverse effects to PBF 1 will appreciably diminish the value of the Androscoggin River critical habitat unit for the conservation of the Gulf of Maine DPS of

Atlantic sturgeon. We then consider whether or not the action will not destroy or adversely modify the critical habitat designated for the Gulf of Maine DPS.

Effects to PBFs 3 and 4 will be so small that they are not able to be meaningfully measured, detected or evaluated and are therefore, insignificant.

8.0 CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR §402.02 as those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. The effects of future state and private activities in the action area that are reasonably certain to occur are continuation of recreational fisheries and the discharge of pollutants. It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects.

Impacts to Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon from non-federal activities are largely unknown in the Androscoggin River. It is possible that occasional recreational fishing for anadromous fish species may result in the illegal capture of these species. Within the action area, despite strict state and federal regulations, both juvenile and adult Atlantic salmon and adult sturgeon remain vulnerable to injury and mortality due to incidental capture by recreational anglers.

Evidence suggests that Atlantic salmon are also targeted by poachers (NMFS and USFWS 2005). MDMR reported that one of the Atlantic salmon that was radio tagged during the 2011 telemetry study was poached near the confluence with the Little River, upstream of the Pejepscot Project (MDMR 2012b). Commercial fisheries for elvers (juvenile eels) and alewives may also capture Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon as bycatch. No estimate of the numbers of these ESA-listed species caught incidentally in recreational or commercial fisheries exists.

Pollution from point and non-point sources has been a major problem in this river system, which continues to receive discharges from sewer treatment facilities and paper production facilities (metals, dioxin, dissolved solids, phenols, and hydrocarbons). Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon are vulnerable to impacts from pollution and are likely to continue to be impacted by water quality impairments in the Androscoggin River and its tributaries.

Contaminants associated with the action area are directly linked to industrial development along the waterfront. PCBs, heavy metals, and waste associated with point source discharges and refineries are likely to be present in the future due to continued operation of industrial facilities. In addition, many contaminants such as PCBs remain present in the environment for prolonged periods of time and thus would not disappear even if contaminant input were to decrease. It is likely that Atlantic salmon, Atlantic sturgeon, and shortnose sturgeon will continue to be affected by contaminants in the action area in the future.

Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from development, groundwater discharges, and industrial development.

Chemical contamination may have an effect on listed species reproduction and survival. As noted above, impacts to listed species from all of these activities are largely unknown. However, we have no information to suggest that the effects of future activities in the action area will be any different from effects of activities that have occurred in the past.

9.0 INTEGRATION & SYNTHESIS

In the effects analysis outlined above, we considered potential effects from the following sources: (1) construction and removal of a temporary work trestle; (2) the construction and removal of temporary cofferdams; (3) construction of the replacement bridge piers; (4) removal of the existing Frank J. Wood Bridge; (5) vessel traffic.

As analyzed in section 7.0, we expect all effects of the proposed action on the Gulf of Maine DPS of Atlantic salmon, critical habitat designated for the GOM DPS of Atlantic salmon, the Gulf of Maine DPS of Atlantic sturgeon, and shortnose sturgeon to be insignificant or discountable. Therefore, the proposed action is not likely to adversely affect any ESA-listed species or critical habitat designated for the GOM DPS of Atlantic salmon.

We do, however, expect habitat modification resulting from the construction of the new replacement bridge to adversely affect PBF 1 (hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0–0.5 ppt range) for settlement of fertilized eggs, refuge, growth, and development of early life stages) of the Androscoggin River critical habitat unit as designated for the Gulf of Maine DPS of Atlantic sturgeon.

In the discussion below, we consider whether effects of the action will lead to an alteration of the quantity or quality of the essential physical or biological features critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species. Because we do not anticipate any adverse effects to listed-species to occur, no take is anticipated or exempted, and the action will not directly or indirectly reduce the likelihood of survival or recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the listed species.

The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of any listed species in the action area or result in destruction or adverse modification of critical habitat. In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, 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 species with a sufficient 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." Recovery is defined as, "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."

Below, for the critical habitat that may be affected by the proposed action, we summarize the status of the critical habitat and its essential physical and biological features (PBFs) and consider whether the proposed action will appreciably diminish the value of the Androscoggin River critical habitat unit for the conservation of the Gulf of Maine DPS of Atlantic sturgeon. We then consider whether or not the action will destroy or adversely modify the critical habitat designated for the Gulf of Maine DPS, as those terms are defined for purposes of the Federal Endangered Species Act.

9.1 Androscoggin River Critical Habitat Unit (Gulf of Maine DPS)

We consider the impacts of the proposed actions on the Androscoggin River Critical Habitat Unit and whether the proposed actions are likely to result in the destruction or adverse modification of critical habitat designated for the Gulf of Maine DPS. On February 11, 2016, NMFS and USFWS published a revised regulatory definition of "destruction or adverse modification" (81 FR 7214). Destruction or adverse modification "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." As described in the preamble to the proposed rule for the revised definition (79 FR 27060, May 12, 2014), the ''destruction or adverse modification'' definition focuses on how federal actions affect the quantity and quality of the physical or biological features in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, on any impacts to the critical habitat itself. Specifically, the Services will generally conclude that a federal action is likely to ''destroy or adversely modify'' designated critical habitat if the action results in an alteration of the quantity or quality of the essential physical or biological features of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species.

As explained in section 7.8.2, PBF 2 does not occur in the action area and all effects of the action on PBFs 3 and 4 are insignificant and discountable.

Construction of a portion of the temporary trestle (60 ft^2), as well as the permanent Pier 1, along with its temporary cofferdam (900 ft^2), will occur within habitat we have identified as PBF 1. There will be a 960 ft^2 loss of PBF 1 during the 2019 and 2020 spawning period. MaineDOT is proposing to remove the temporary trestle (60 ft^2) and the center pier for the existing Frank J. Wood Bridge (restoring 800 ft^2 of hard bottom, bedrock habitat) during the in-water work window between September 1, 2020 and March 15, 2021. With these structures removed, the proposed project will result in a permanent net loss of 100 ft^2 of sturgeon spawning habitat. As explained in section 7.8.2, this permanent loss of this hard bottom substrate for settlement of fertilized eggs, refuge, growth, and development of early life stages is an adverse effect. Here, we consider whether the adverse effects to PBF 1 in the action area result in a direct or indirect alteration of the critical habitat that appreciably diminishes the value of critical habitat for the conservation of the Gulf of Maine DPS of Atlantic sturgeon (i.e., we determine whether the proposed action is likely to result in the destruction or adverse modification of critical habitat). This analysis takes into account the geographic and temporal scope of the proposed action, recognizing that "functionality" of critical habitat necessarily means that it must now and must continue in the future to support the conservation of the species and progress toward recovery. The analysis takes into account any changes in amount, distribution, or characteristics of the critical habitat that will be required over time to support the successful recovery of the species. Destruction or adverse modification does not depend strictly on the size or proportion of the area adversely affected, but rather on the role the action area and the affected critical habitat serves with regard to the function of the overall critical habitat designation, and how that role is affected by the action.

We have not yet issued a recovery plan for Atlantic sturgeon. However, the 2018 Recovery Outline identifies a Recovery Vision which identifies what we believe to be necessary for recovery as restated here (NMFS 2018):

> Subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and that increased recruitment must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future.

The conservation objective identified in the critical habitat designation is to increase the abundance of each DPS by facilitating increased successful reproduction and recruitment to the marine environment. Critical habitat has been designated for the Gulf of Maine DPS in the Penobscot, Kennebec, Androscoggin, Piscataqua and Merrimack rivers. In the critical habitat designation, we determined that the protection of this habitat is necessary for the recovery of the Gulf of Maine DPS. Here, we consider the loss of 100 square feet of PBF 1 in the Androscoggin River critical habitat unit in the context of the conservation value provided by the critical habitat designated for the DPS to determine if this alteration of the quantity of PBF 1 appreciably diminishes the value of critical habitat for the conservation of the species.

We have determined that the permanent loss of 100 square feet of PBF 1 in the Androscoggin River critical habitat unit will not appreciably diminish the value of critical habitat for the Gulf of Maine DPS because: (1) the amount of habitat lost is a very small proportion of the amount of PBF1 available for the Gulf of Maine DPS (less than 0.02% of PBF 1 in the Androscoggin River critical habitat unit and an even smaller percentage of the amount of PBF 1 in the critical habitat designated for the Gulf of Maine DPS) and is not expected to result in a reduction in the amount of spawning or a reduction in the number of eggs or larvae that successfully develop; (2) the action will not impede the conservation objective identified in the critical habitat designation because it will not result in a reduction in the amount of successful reproduction or result in a reduction in the number of Atlantic sturgeon that could potentially recruit to the marine environment; (3) the action will not interfere with the necessary conservation identified in the Recovery Vision; and, (4) the effects of the action are limited to the Androscoggin River critical habitat unit and will have no effect on the value of critical habitat in the other units. Therefore, because the proposed action will not appreciably diminish the value of critical habitat for the conservation of the Gulf of Maine DPS, it is not likely to result in the destruction or adverse modification of critical habitat designated for the Gulf of Maine DPS of Atlantic sturgeon.

10.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our biological opinion that the proposed action is not likely to adversely affect shortnose sturgeon, the Gulf of Maine DPS of Atlantic sturgeon, the Gulf of Maine DPS of Atlantic salmon, or critical habitat designated for the Gulf of Maine DPS of Atlantic salmon. The proposed action may adversely affect, but is not likely to adversely modify or destroy critical habitat designated for the Gulf of Maine DPS of Atlantic sturgeon.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. "Fish and wildlife" is defined in the ESA "as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. §1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. On December 21, 2016, we issued *Interim Guidance on the Endangered Species Term "Harass"*[12]. For use on an interim basis, we interpret "harass" to mean to "…create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering". Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. § 1538(g). See also 16 U.S.C. § 1532(13)(definition of "person").

It is our biological opinion that the proposed action is not likely to adversely affect the Gulf of Maine DPS of Atlantic salmon, Atlantic sturgeon, or shortnose sturgeon. Therefore, no take is anticipated or exempted, and any incidental take of a listed species resulting from the proposed action would require reinitiation (see section 13.0).

12.0 CONSERVATION RECOMMENDATIONS

In addition to Section 7(a)(2), which requires agencies to ensure that all projects will not jeopardize the continued existence of listed species, Section 7(a)(1) of the ESA places a responsibility on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species." Conservation Recommendations are discretionary agency activities to minimize or avoid adverse effects of a

[12] http://www.nmfs.noaa.gov/op/pds/documents/02/110/02-110-19.pdf

proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. As such, we recommend that you, consistent with your authorities, consider implementing the following Conservation Recommendations:

1. FHWA should work to improve the ability of sturgeon researchers to detect the timing, frequency, and duration of Atlantic and shortnose sturgeon movements in the action area (e.g., funding the purchase of VEMCO receivers and developing a plan to install and monitor the receivers over the lifetime of the proposed action (2018-2021)).

2. FHWA should work with MaineDOT and Brookfield Renewable to develop and fund a plan to monitor the impacts of the proposed Frank J. Wood Bridge replacement and removal on fish passage in the Brunswick Dam fishway.

13.0 REINITIATION OF CONSULTATION

This concludes formal consultation on your proposal for the replacement and removal of the Frank J. Wood Bridge. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the action that may not have been previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to listed species; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

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15.0 APPENDICES

Appendix A

Summary of Avoidance and Minimization Measure (AMMs)

Avoidance and Minimization Measure (AMMs)	Description of AMM
Soil Erosion and Water Pollution Control Plan (SEWPCP)	
1	Contractors will submit a SEWPCP for review and approval of MaineDOT staff prior to the start of work. The plan includes the review of the implementation of any AMMs proposed.
2	Prior to soil disturbance, the erosion control portion of the SEWPCP will be reviewed and in place.
In-water Work Window	
3	In-water work window. MaineDOT and FHWA commit to avoiding all activities that could result in in-water noise that could result in fish disturbance (louder than 150 dB RMS) and turbidity producing activities between March 16 and July 31.
Contaminant Releases	
4	No equipment, materials, or machinery shall be stored, cleaned, fueled, or repaired within any wetland or watercourse; dumping of oil or other deleterious materials on the ground will be forbidden; the contractor shall provide a means of catching, retaining, and properly disposing of drained oil, removed oil filters, or other deleterious material; and all oil spills shall be reported immediately to the appropriate regulatory body.
Construction of Temporary Work Trestle	
5	Contractors are required to install turbidity curtains around areas planned for in-water fill associated with construction of the temporary trestle access point. All in-water trestle construction will occur between August 1 and March 15. In-river (i.e., not the ponded/bedrock falls habitat on the Topsham side) trestle construction and removal (~60 sq. ft footprint) will occur between September 1 and March 15.
6	Removal of the fourth pier (leaving three in-water piers) from preliminary design to avoid impacts to critical habitat as well as potential effects to fishway function.
In-Water Pier and Cofferdam Construction	
7	All four cofferdams shall be constructed and removed during the in-water work window, between August 1 and March 15, with the exception of the cofferdam for Pier 1, which will occur between September 1 and March 15.
8	Bedrock leveling and substructure removal using hydraulic breakers (or hoe rams), blasting, or other methods generating underwater noise above 150 dB RMS will occur from November 8 to March 15.
9	Plans for any project-related blasting will be submitted with 150 days

	for NOAA to review and will be designed to remain below potential fish injury limits (206 dB Peak (2.89 PSI)).
10	Any blasting activities between November 8 and November 30 will incorporate the following minimization measures to reduce potential impacts to adult Atlantic salmon which may still be present in the area: • Active acoustic monitoring of the action area for any tagged fish potentially present in the Androscoggin River. • Minimize charge sizes and the number of days of exposure to blasting. • Deploy scare charges prior to the main blast. • Conduct visual inspection of the action area post-blast to document any impacts to fish.
11	Fresh concrete will be poured inside of cofferdams and will not come into contact with flowing water.
12	MaineDOT will deploy a diver into the cofferdams to visually search for endangered fish species. Should a salmon or sturgeon be observed within a cofferdam structure, MaineDOT will coordinate with the resource agencies for evacuation of those individuals prior to proceeding with construction.
13	Water pumped out of the cofferdam will be within one pH unit of background (MaineDOT standard specifications). A representative of the MaineDOT Surface Water Quality Unit will periodically evaluate pH to determine whether the water is within the allowable tolerance to be pumped directly back into the river or whether it needs to be treated prior to discharge.
Demolition of Existing Bridge	
14	Superstructure demolition debris will be contained using control devices and cannot enter the water.
15	The existing pier structure will be removed down to the underlying bedrock and debris from the structure will be removed from the river to restore potential natural spawning substrate for sturgeon species.
Vessel Use	
16	Construction crews will visually monitor for ESA-listed fish in equipment and on barges and report any sightings to MaineDOT environmental staff.
17	Vessels will travel at “slow speeds, typically less than 6 knots” (6.9 miles per hour) in the construction zone.

Appendix B

Frank J. Wood Bridge – Modeling Shadows on Brunswick Fish Ladder

Memo describing T.Y. Lin International's shadow modeling study, as provided in FHWA's 2017 Biological Assessment